



NIGERIA

STRATEGY SUPPORT PROGRAM | WORKING PAPER 68

OCTOBER 2021

Subnational public expenditures, short-term household-level welfare, and economic resilience

Evidence from Nigeria

**Hiroyuki Takeshima, Bedru Balana, Jenny Smart, Hyacinth Edeh,
Motunrayo Ayowumi Oyeyemi, and Kwaw S. Andam**

CONTENTS

Abstract	iv
1. Introduction	1
2. Conceptual discussion	2
Subnational public expenditures	2
Social sector public expenditures – health, education, social welfare.....	3
Public expenditures for agriculture	3
3. Data	5
4. Empirical approach	6
Effects on consumption, poverty, private investment, and household dietary diversity	6
Effects on flexibility in shifting between farm and nonfarm income-earning activities.....	9
5. Descriptive statistics.....	10
6. Results	14
Effects on welfare outcomes	14
Effects on agricultural outcomes	18
Effects on economic flexibility in shifting between farm and nonfarm income-earning activities	19
7. Conclusions	20
References	22
Appendices	26
Appendix A: Econometric models for estimation of effects of public expenditure on households' flexibility in shifting between farm and nonfarm activities.....	26
Appendix B: Detailed analytical results	28

FIGURES

Figure 1. Illustration of estimation methods – effects of changes in public expenditures on household flexibility in shifting between farm and nonfarm income-earning activities	10
--	----

TABLES

Table 1. Descriptive statistics of public expenditure variables among all households, average over the three years leading up to each wave of Nigeria LSMS-ISA survey	11
Table 2. Descriptive statistics of government revenue values per household, by type of revenue .	11
Table 3. Descriptive statistics of key outcome variables of interest	12
Table 4. Other control variables, all waves combined (all households, including nonagricultural households)	12
Table 5. Effects of public expenditure share and size on household-level outcomes, full household sample	15
Table 6. Effects of public expenditure share and size on household-level outcomes, rural household sample.....	15
Table 7. Effects of public expenditure share and size on household-level outcomes, disaggregated between LGA and state expenditures	17
Table 8. Effects of public expenditure share and size on household-level outcomes, disaggregated between recurrent (R) and capital (C) expenditures	17
Table 9. Effects of public expenditure share and size on household-level agricultural outcomes, agricultural households only.....	18
Table 10. Effects of public expenditure share and size on household-level agricultural outcomes, disaggregated between LGA and state expenditures, agricultural households only	19
Table 11. Effects of public expenditure shares on flexibility of a household shifting between farm and nonfarm income-earning activities.....	19
Table 12. Effects of public expenditure shares and size on household-level outcomes, when the PE figures are averaged over the two years preceding the respective survey year (instead of three years including the survey year)	28
Table 13. Effects of public expenditure shares and size on household-level outcomes, when the expenditure figures from neighboring LGAs are excluded	28
Table 14. Signs of statistically significant coefficients for control variables in the primary analytical specifications for key household output variables of interest	29

ABSTRACT

Public expenditures (PE) are critical for key public sector functions that contribute to development and welfare improvements, including the provisions of necessary public goods and the mitigation of market failures. PE in social sectors, such as health, education, and social welfare, and in agriculture have been increasingly recognized as potentially important for income growth, poverty reduction, fostering increased private investment, improved nutritional outcomes, and greater economic resilience. Furthermore, the importance of the impact of subnational PE on these outcomes has also been recognized, as appropriately decentralized PE systems can potentially achieve greater effectiveness by enabling public sector support that is tailored more to local needs. However, direct evidence of these developmental effects of decentralized PE in developing countries like Nigeria has been relatively limited. This study attempts to fill this knowledge gap by estimating the effects of shares of total subnational PE for agriculture, health, education, and social welfare, as well as PE size, on household-level outcomes using nationally-representative panel household data and both local government area and higher state-level PE data for Nigeria.

We find that greater shares of total PE for agriculture, health, and social welfare, conditional on PE size, generally have positive effects on consumption, poverty reduction, and non-farm business capital investments. A greater share of total PE for agriculture benefits a broader range of outcomes than do greater shares of total PE for health and social welfare. These include improving certain nutritional outcomes, like household dietary diversity across seasons, and economic flexibility between farm and non-farm activities, which may be particularly important for building resilience in today's rapidly changing socioeconomic environment due to shocks, including COVID-19. Such multi-dimensional benefits of greater PE for agriculture are particularly worthy of attention in countries like Nigeria, which have historically allocated a lower share of total PE to agriculture than to health and other social welfare sectors and a lower share of total PE to agriculture compared to that allocated to agriculture in similar countries in Africa and elsewhere.

Keywords: subnational public expenditures, social sectors, agriculture, welfare, flexibility, Nigeria, Africa

1. INTRODUCTION

The importance of improving human well-being in multiple dimensions is increasingly recognized around the world. In addition to poverty reduction and consumption growth, these dimensions have expanded to include facilitating private investment in household businesses, improved nutritional status for all, and enhanced household livelihood resilience, among others. Capital for private investment in business is critical for labor productivity growth and rural livelihood diversification (e.g., Haggblade et al. 2010). Improved nutrition, including greater dietary diversity, is recognized as important to achieving a healthy and productive life (Hoddinott & Yohannes 2002; Fan et al. 2019). Resilience against a variety of shocks has become another important dimension in today's world of growing socioecological uncertainty (Barrett & Constanas 2014). The recent COVID-19 pandemic and resultant economic disruptions have reminded us of how economic resilience and the other dimensions of well-being continue to be insufficient for a significant share of the global population (IFPRI 2020).

Public expenditures (PE) by governments remain an important instrument for carrying out key public sector functions that contribute to achieving many of these human welfare goals. PE enables the provisions of necessary public goods, which are not readily provided by private sector investments alone, and helps in mitigating market failures. Certain social sector PE, including those for health, education, and social welfare, have long been considered influential in contributing to these welfare outcomes (e.g., Anderson et al. 2018). These areas of PE can potentially raise human capital, labor productivity, or help to reallocate private-spending towards health, risk mitigation, or more productive resource uses.

Another important PE category has been that for agriculture. The role of agricultural development in poverty reduction and in overall economic development is well documented (Bustos et al. 2016; McArthur & McCord 2017; Gollin et al. 2018; Lee 2018; McArthur & Sachs 2019; Loizou et al. 2019). The potential importance of PE in agriculture for poverty reduction and economic development has been repeatedly advocated (Fan et al. 2000; Fan & Zhang 2008; Mogues & Benin 2012). Several Africa-wide initiatives emphasize the importance of public investment in agriculture, including the Comprehensive Africa Agriculture Development Programme and the Malabo Declaration.

The importance of subnational PE also has been increasingly highlighted as important for improving welfare. This is because appropriately decentralized PE systems can potentially achieve greater effectiveness by better tailoring public support to meet local needs (World Bank 2007; Mogues & Benin 2012). A growing literature also sheds light on the nature of subnational PE in countries like Nigeria, including the political economy and institutional determinants of decision-making processes around such expenditures (e.g., Mogues & Olofinbiyi 2020).

However, direct evidence of the impact of subnational PE on household-level development and welfare outcomes in developing countries is relatively limited. This study aims to help fill this evidence gap by using the data from Nigeria on PE in social sectors (health, education, and social welfare) and in agriculture by both state and lower-level local government areas (LGA) over time. The administrative data is coupled with nationally representative household-level panel data to estimate the effects of PE on various household-level development outcomes, including consumption, poverty, private investment levels, and dietary diversity. We also estimate the effects of PE on the economic flexibility of households in their ability to switch between nonfarm activities and farm activities, which is an indicator of resilience that has been used in the recent production economics literature (e.g., Renner et al. 2014).

Nigeria is a suitable case for this study. The country has a federal system of government in which subnational governments at state and LGA levels have relatively more autonomy than would be the case in unitary system. In consequence, we see significant intra-country variation in patterns of PE. Furthermore, Nigeria continues to suffer from persistently high poverty, relatively slow economic transformation, and allocates a relatively lower share of its PE to the agricultural sector than do neighboring countries (Takeshima et al. 2020b). In consequence, the potential for poverty reduction and broader welfare improvements through increased PE for agriculture, in combination with appropriate PE in the social sectors, are worth investigating.

This study contributes to various strands of literature. First, the study contributes to recent literature on role of social sector PE in general (e.g., Almanzar & Torero 2017; Anderson et al. 2017, 2018) as to that on PE for agriculture (Fan et al. 2000; Fan & Zhang 2008; Mogues & Benin 2012; Mogues & Olofinbiyi 2020) by providing micro-level evidence from the most populous African country, Nigeria. By directly estimating the effects of subnational PE, the study also contributes to the literature on fiscal decentralization and economic growth in developing countries (e.g., Martinez-Vazquez & McNab 2003; Bird & Vaillancourt 2008). Methodologically, by assessing the effects of PE on household resilience, we contribute to research on economic flexibility in the production economics literature (e.g., Renner et al. 2014; Takeshima et al. 2020a).

This paper is structured as follows. Section 2 discusses our conceptual and theoretical framework. Section 3 discusses the data used for the analyses, and section 4 discusses the empirical methodologies employed. Section 5 presents descriptive statistics. Section 6 presents and discusses empirical results, while section 7 concludes.

2. CONCEPTUAL DISCUSSION

Evidence for the role that PE play in welfare improvement has been growing. However, understanding has evolved in somewhat mixed ways on certain aspects, while remaining scarce on other aspects of how such investments operate to improve the well-being of households.

Theoretically, PE can help to provide public goods and overcome market failures, both of which are essential for economic growth and welfare improvement, particularly in developing countries. Evidence, however, on how PE affects welfare remains inconclusive. While some studies find PE to be associated with more positive economic growth (Ram 1986; Sattar 1993), others have found the opposite (Landau 1986; Levine & Renelt 1992; Schaltegger & Torgler 2006). Some studies also show that the effects of PE depend on current expenditure levels. For example, expenditures that appear productive could become unproductive when used in excess (Devarajan et al. 1996).

Subnational public expenditures

Variations in levels of PE across subnational regions, which this study exploits, can potentially have important effects on variations in welfare outcomes. Past studies in developed economies have used subnational PE levels as the source of variation in identifying the effects of PE (Schaltegger & Torgler 2006), but applications of this method in studies in developing countries have been relatively scarce (Almanzar & Tolero 2017).

There are also differences in PE packages across different administrative levels. For example, in Nigeria, LGA-level PE tend to be limited to fewer items or projects than PE at state-level (Olomola et al. 2014). In theory, LGA-level PE can be more effective (positive) in bringing about household welfare improvements than state-level PE if expenditures at LGA level are more tailored towards local needs. However, economies-of-scale matter, such as those needed for the economical and efficient procurement of goods. As they are relatively small in scale, LGA-level PE may be less effective than those at state level. Also, decentralization can sometimes lead to

greater elite capture, or, alternatively, because of fear of such elite capture, the central government may not transfer sufficient funds to local governments, thus limiting the ability of LGAs to achieve economies-of-scale (Perez-Sebastian & Raveh 2016) and resulting in reduce investment (Faguet 2004). Decentralization through increased PE by lower administrative units has also had mixed effects on corruption (Lederman et al. 2006), with more negative effects where political competition is inadequate (Albornoz & Cabrales 2013).

Social sector public expenditures – health, education, social welfare

The heterogeneous effects of PE disaggregated by sector of expenditure have been increasingly studied. Social sector PE, including health, education, and social welfare, as well as PE for agriculture, have been studied considerably, including in the context of welfare improvements in developing countries. However, evidence on the effects of these types of PE on economic growth and welfare improvements has been mixed.

The potentially positive effects of education expenditure on these welfare outcomes have been indicated by observed positive associations between human capital investment and economic growth (Barro 1991; Mankiw et al. 1992; Easterly & Rebelo 1993). Other studies have found that PE on social welfare, education, and health significantly reduce income inequality (e.g., Martinez-Vazquez et al. 2012).

However, other studies show the opposite relationship between health (Kwon & Kim 2014) and education (Landau 1986) PE and changes in wellbeing at household level. Some studies show a negative relationship between measures of human capital and economic growth (Islam 1995; Caselli et al. 1996), or only weak effects of social sector PE (education, health) on mitigating within-country inequality and reducing poverty (Anderson et al. 2017, 2018; Bergh et al. 2020). The causes of such limited effects most often cited have been that social sector PE tends to be captured by the high- or middle-income class in urban areas rather than the lower-income class (Alesina 1998; Castro-Leal et al. 1999; Davoodi et al. 2010; Anderson et al. 2017). Other explanations include that the effects of educational PE on education outcomes, particularly in Africa south of the Sahara, are influenced by political, rather than economic, factors (Stasavage 2005) Also, increased public expenditures can lead to rent-seeking activities that cause general misallocation of production factors in the market (Reinikka & Svensson 2004). Such regressive effects have also been reported for health and education PE by subnational governments in Rwanda and Tanzania (Almanzar & Torero 2017).

In addition to regressive targeting, it has been shown that some social sector PE can have negative effects on human capital investment. In some contexts, social sector PE can crowd out, rather than crowd in, private investment, including in nonfarm sectors (e.g., Bahal et al. 2018). Arjona et al. (2003) argue that social protection could also have negative effects on growth by discouraging labor market participation, which has additional adverse impacts on nutrition investments within households, such as those that result in more diverse diets. The evidence is also scarce regarding the direct effects of health and education PE on certain welfare outcomes.

Public expenditures for agriculture

As a potential alternative mechanism to social sector PE for making progress on several development goals, PE for agriculture has received growing attention in the literature. An advantage of PE for agriculture is that it tends to allocate resources towards poorer households in the society, who are more likely to derive a major source of their livelihoods from agriculture. In this way, PE in agriculture is distinct from PE in social sectors, for which such self-targeting mechanisms are not embedded.

The effects of agricultural growth on overall economic growth are widely documented, including the effects of yield-enhancing technologies (McArthur & McCord 2017; Gollin et al. 2018), the effects of labor-saving crop varieties and production technologies on structural transformation (Bustos et al. 2016), and the economywide effects of aid to agriculture (McArthur & Sachs 2019). The effects on economic growth emerge through both backward and forward linkages with agricultural production activities, including household-level and small-to-medium-scale enterprises for agricultural input sales, mechanization of custom-hiring service provision, food processing, transportation, and retailing – activities in which higher agricultural productivity can induce private capital investments for nonfarm household enterprises or labor productivity increases in nonfarm sectors (Haggblade et al. 1989). The relationship of agricultural growth on changes in poverty levels shows similar patterns (e.g., Christiaensen et al. 2011).

In the absence of agricultural growth, evidence is persistently seen of continuing low food productivity inducing households to continue allocating a substantial share of their resources to subsistence food production (e.g., Lee 2018), because their own farming continues to be the provider of many of the basic needs for the household (Loizou et al. 2019). Moreover, despite growing market integration, local food prices still depend considerably on local agricultural production factors (e.g., Baffes et al. 2019). This is due to market imperfections and the resilience of traditional negative attitudes toward exchange and positive attitudes towards self-sufficiency in rural agricultural settings in developing countries (Carlson 2018).

This research literature suggests that if increased PE for agriculture contributes to improved household-level agricultural outcomes, it can also contribute to improvements in broader nonagricultural outcomes for households. Some studies have directly shown that PE on agricultural research and extension has some of the largest effects on poverty reduction (e.g., Fan et al. 2000; Fan & Zhang 2008). A growing body of literature similarly shows generally positive agriculture–nutrition linkages (Ruel et al. 2018; Fan et al. 2019; Bellows et al. 2020), including demonstrating the positive effects of PE for agriculture, such as spending on input subsidies, on nutritional outcomes (e.g., Harou 2018).

A greater share of total PE allocated to agriculture should enable increases in investments in public-goods and in high-return but often risky projects, like agricultural research (World Bank 2007, p.166) and agricultural extension (Fan & Zhang 2008; Benin et al. 2011) for which private investment tends to be limited and which require long-term commitment.¹ The public sector often plays an important role in technology generation in agriculture, compared to the private sector overall and compared to its role in supporting innovation in non-agricultural industries (Spielman & von Grebmar 2006; Evenson & Westphal 1995). Moreover, effective large-scale projects to expand agricultural production, potentially supported through greater PE for agriculture, can lead to greater local or national tax revenues (Deininger & Byerlee 2012), due to the increased land values they foster and, consequently, higher land tax revenues. Similarly, increased imports of inputs, such as fertilizer, other agro-chemicals, and machinery and parts, may contribute to increased tariff revenues for governments, which, in turn, further increases the fiscal space for PE in the agricultural sector.

However, the literature is also split with regard to whether agriculture has positive effects on growth in the nonfarm sectors of the economy. When the agricultural sector acts more as a competitor to nonfarm activities, higher agricultural productivity, which raises the cost of competing production factors, such as labor and capital, can negatively affect nonfarm sectors (e.g., Matsuyama 1992; Foster & Rosenzweig 2004). In such cases, even if PE for agriculture has positive effects on agricultural outcomes, its effects on overall incomes may be offset by the

¹While the study described in this paper investigates only the short-term effects of PE and, thus, may not capture the direct effects on longer-term projects, like agricultural R&D, greater PE in a particular year may still reflect the size of longer-term public investments.

potentially negative effects on nonfarm outcomes. Related, budgetary trade-offs, when an increase in the agricultural budget directly reduces the budget for other sectors, generally appear to be common in the budget process in developing countries (Mogues & Benin 2012). The positive effects of PE for agriculture may also be limited if it is mostly used to provide private goods and, thus, simply crowds out the private sector. Recent studies on input subsidies in Africa have shown evidence of such crowding-out (e.g., Jayne & Rashid 2013; Takeshima & Nkonya 2014), although there is 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 PE for agriculture may not necessarily contribute to improved agricultural outcomes (Spielman et al. 2010; Mogues 2011).

The potential role of agricultural PE on improving household economic resilience to shocks is another important aspect to consider, although direct evidence of such effects remains scarce. Farm households in developing countries increasingly are diversifying into nonfarm activities while also continuing their farming (Frelat et al. 2016). Flexibility between these livelihood activities has become an important dimension of the resilience of the rural households. For example, flexibility between farm production and nonfarm jobs has emerged as an important coping mechanism against recent COVID-19 induced shocks, as disruptions in food or labor markets, among others, have forced rural households to temporarily shift back to more food production, requiring significant readjustments in household resource allocations between farm and nonfarm activities (IFPRI 2020). PE for agriculture can potentially affect the economic flexibility of rural households, if, for example, it leads to the provisions of a more diverse set of technologies, knowledge, and resources for both their farm and non-farm economic activities.

Overall, the expected effects of sub-national PE, PE in the social sectors, and agricultural PE on household-level welfare outcomes are ambiguous. This motivates our empirical analyses.

3. DATA

This study uses household survey data, state and LGA-level public expenditure data, and weather data from Nigeria. Data was collected from the same sample households across three or four waves of the Living Standards Measurement Study–Integrated Surveys on Agriculture (LSMS-ISA) household panel survey by the National Bureau of Statistics of Nigeria (NBS) and the World Bank. Wave 1 was collected in 2010/, wave 2 in 2012/13, wave 3 in 2015/16, and wave 4 in 2018/19. Data from 5,000 nationally representative households was collected in the first three waves and from 1,507 of the original 5,000 households in the fourth wave (NBS and World Bank 2016, 2019). The sample of 5,000 households in wave 1 was constructed from 10 households randomly selected in each of 500 randomly selected enumeration areas across the country. These households were reinterviewed in waves 2 and 3. The 1,507 households in wave 4 were the survey sample households in 159 enumeration areas selected from the original 500 enumeration areas (NBS and World Bank 2019). Approximately two-thirds of the sample households in each wave were rural and agricultural households.

State and LGA-level expenditure data for all of Nigeria's 37 states and 774 LGAs were obtained from annual statistical bulletins and reports from the Central Bank of Nigeria and from annual surveys conducted jointly by the Federal Ministry of Finance, the Central Bank of Nigeria, NBS, and the Nigerian Communications Commission for the period 2008 to 2015 (Nigeria, Federal Ministry of Finance 2015 and previous years). These data include information on PE by type (recurrent and capital) and function (economic affairs, as well as general public services, defense, public order and safety, environmental protection, etc.). For both recurrent and capital

expenditures, PE for agriculture is classified as a s component of PE for economic affairs. While the exact classifications of PE vary considerably between years, agriculture, health, education, and social welfare (social security and social protection) were categorized consistently for all years of the study period, allowing us to include them in our panel-data analyses.² The expenditure data set also includes data on type of revenues, including tax revenues, other internally generated revenues, and other sources of revenue for each LGA and state.

We used annual rainfall and average annual temperature data for our analyses. These are gridded estimates produced by the Climatic Research Unit (CRU 2020) and the US National Oceanic and Atmospheric Administration's Physical Sciences Laboratory (NOAA/OAR/ESRL PSL 2020), respectively. The data used covers the period from 1980 through 2015. Point data were extracted from these gridded rainfall and temperature surfaces for the geographical coordinates of the centerpoints of the enumeration areas reported in LSMS-ISA.

4. EMPIRICAL APPROACH

Two sets of analyses were conducted in the study. The first set examines the effects of PE on several broad household development outcomes – consumption, poverty, private investment, and household dietary diversity. The second set examines the effects of PE on the economic flexibility of farm households. The first set of analyses focus on relatively short-term impacts, and thus use only the first three waves of LSMS-ISA data that correspond closely to the years of our PE data (2008-2015). The second set deals with a more medium-term phenomenon, and therefore uses data from all four-waves of LSMS-ISA data, but restricted to data from sub-sample of panel households that appear in all four waves.

Effects on consumption, poverty, private investment, and household dietary diversity

The first set of analyses are conducted in the standard panel data setting analytical framework,

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

where y_{ijt} is the outcomes of interests for household i that is located in an administrative unit j (LGA or state) at the time of survey wave t ($t = 1, 2, 3$). ES_{jt}^K is the share of PE (share of total PE) by LGA or state j for sector K ($K =$ agriculture, health, education, social welfare), and E_{jt} is the size of total PE per capita for LGA or state j (PE size). Z_{it} is a set of time-variant exogenous variables. θ_i is a set of unobserved, time-invariant household fixed-effects, which may be correlated with Z_{it} . θ_i may also be correlated with ES_{jt}^K or E_{jt} , if θ_i is correlated at LGA or state levels (e.g., farmers in certain LGAs may follow the same particular norms). Using a fixed-effects model to control for θ_i therefore mitigate biases in estimated parameters β_{Share}^K and β_{Size} , which measure the effects of PE related variables. Symbols α and γ are other estimated parameters, while ε_{it} is an idiosyncratic time-variant error.

² The Government of Nigeria (2015) does not provide detailed definitions of the PE categories, but it is expected that they largely follow the Government Finance Statistics Manual (IMF 2001), as is used by other countries. According to the IMF (2001), the type of PE classified under the agriculture, forestry, and fisheries expenditures typically include (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 agricultural industries; construction or operation of flood-control, irrigation, and drainage systems, or grants, loans, or subsidies for such work; operation or support of programs or 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.

By construction, β_{Share}^K measures the effects of changing the share of total PE (ES_{jt}^K), holding fixed PE size (E_{jt}) by the relevant subnational government j . Similarly, β_{Size} measures the effects of changing PE size by the relevant subnational government j , holding fixed ES_{jt}^K . Note that E_{jt} also includes PE on the remaining sectors other than agriculture, health, education, and social welfare. Therefore, both β_{Share}^K and β_{Size} measure the effects of changes in PE on sector K , but with different implications on PE size. We set up our empirical framework this way to distinguish between increasing PE in each sector K with or without changes in PE size, the latter of which may have different implications due to, for example, Ricardian equivalence.

In our primary model, we use aggregated measures for PE. That is, PE is measured by averaging over the PE by LGA (or state), averaging over the LGA (state) of household i as well as all contiguous LGAs (states), averaging over multiple years, and combining recurrent and capital PE. This is because our primary interests are on the aggregate effects of PE, and relatively less so on identifying detailed mechanisms of disaggregated effects, as these are beyond the scope of this paper. We, however, supplement the primary model by also showing results in which each of the spatio-temporal or categorical dimensions are disaggregated to further identify key patterns.

In addition, in our primary model, ES_{jt}^K and E_{jt} are based on PE figures from the survey year, as well as two years before the year of each survey wave t when outcomes y_{ijt} are measured. For example, for survey wave 1 (2010/11), ES_{jt}^K and E_{jt} are based on PE figures from 2008, 2009, and 2010. Similarly, for survey waves 2 and 3, PE figures from 2010 through 2012, and 2013 through 2015, respectively, are used. This is based on the assumption that the effects of PE are likely to materialize with some time-lags, while those effects may also dissipate over time so that PE from more than 2-years before may have limited effects at household level. In the results section, we show that PE from these three year periods have consistent effects and that the results are generally robust.

Outcome variables

Our key output variables of interest, y_{ijt} , include consumption, the incidence of poverty, investments in physical capital assets for households' nonfarm enterprises, and household dietary diversity scores. Our supplementary analyses also assess effects on several agricultural outcomes, including overall production and profitability (proxied by agricultural production revenue, agricultural production costs), receipts of public service and goods (proxied by receipts of extension services and receipts of subsidized fertilizer), private investments, such as the value of agricultural equipment, and employment (farm labor use).

The value of consumption per capita is calculated by aggregating for a household the value of food consumption (home consumption converted into expenditure values using market prices, as well as expenditures on food eaten outside the household); expenditures on nondurable consumption goods; education costs for household members; health expenditures, net purchase of livestock; net purchase of household assets; housing expenses, including water, electricity, fuel, land and mobile phones, refuse disposal, and rent payments; net cash lending; net purchase of agricultural equipment; net of other unearned income; and remittances received. Consumption and expenditure figures for each of these components are reported by LSMS-ISA sample households over different recall periods. For this reason, we converted each component of household consumption and expenditure to its 12-month equivalent.

Poverty status is indicated by using the per capita household consumption described above and applying the standard poverty lines of USD1.00, 1.90, 3.20, and 5.50 per person per day (international dollars, adjusted for purchasing power parity [PPP]). The USD3.20 poverty line has

been suggested as a benchmark for lower-middle-income countries, including Nigeria (Jolliffe & Prydz 2016), but, given the significant in-country heterogeneity in development levels across Nigeria, we also assessed poverty prevalence as defined by the other three poverty lines. From the data, we converted household-level consumption values to PPP international dollars using the regional price indexes provided with the LSMS-ISA data and exchange rates between the Nigerian naira and PPP international dollars (World Bank 2020) in the respective years.

Productive assets and physical capital goods used in nonfarm household enterprises are also considered important indicators of households' economic potential, resilience against risk (Zimmermann & Carter 2003), and the ability of a household to avoid poverty traps (McKenzie & Woodruff 2006; de Mel et al. 2008). The sum of the imputed market values of all capital assets owned and used for the household's nonfarm enterprises was used as the measure of these assets.³

For dietary diversity, the household dietary diversity score (HDDS) has long been used in household level analyses as a key indicator of household dietary quality. Separate HDDSs for the post-planting and post-harvesting periods, respectively, were calculated based on the seven-day recall data in LSMS-ISA. Following the classification methods described in the HDDS guidelines of the Food and Agriculture Organization of the United Nations (FAO 2011), we constructed the HDDS measures using 12 food groups.

Agricultural revenue is computed by summing the real value of all crop production and livestock products (live animals, meat, and byproducts). The value of subsistence production that is consumed by the producing household was imputed using local prices of each crop and livestock product. Agricultural production costs are computed by aggregating the value of purchased inputs used for crop and livestock production. Costs of own inputs, such as family labor and own land are not explicitly included in these cost calculations. Rather, they are controlled for by the use of exogenous endowment variables that are likely to affect their opportunity costs, including household demographic variables and area of farmland owned, which either was allocated by the community chief or obtained through outright purchase. Following Takeshima & Nkonya (2014), fertilizer received from the government, from a political leader, or any other fertilizer obtained for free was considered subsidized, while fertilizer obtained from other sources was considered unsubsidized. All other agricultural outcome variables were defined in a self-explanatory manner in the LSMS-ISA dataset.

Control variables

Control variables, Z_{it} , include (a) household demographics; (b) wealth endowments; (c) market conditions proxied by agricultural inputs; (d) weather conditions; (e) access to various community-level organizations or institutions; and (f) community-level shocks. We argue that in countries like Nigeria, where PE is small compared to the size of the economy, many of these variables are still largely exogenous to PE.⁴ This is because many of the socioeconomic characteristics of the households captured by these control variables will primarily be affected instead by private or communal resources and wealth in the informal sector.

Household demographic composition by age and sex, including dependency ratios, and overall household-level productivity and consumption needs have important implications for household welfare. Following earlier studies (e.g., Jacoby 1993), the number of household members by sex for different age-brackets (above 60 years of age, 20 to 60, 15 to 19, 10 to 14, 5 to 9, and 0 to 4)

³ While uncommon, this measure may include the value of certain capital assets that can be used for both nonfarm and farm activities, such as tractors, which can be used for land preparation and for transporting farm and nonfarm goods.

⁴ In Nigeria, in the 2000s and early 2010s for years for which data are available, tax revenues were only about 2 or 3 percent of GDP. These revenue levels are considerably smaller than the world standard of around 15 percent (World Bank 2020).

are included. Not only does the demographic composition of households change over time as members grow older, it may change irregularly due to premature deaths of members, which is not uncommon in countries like Nigeria. These changes can also cause irregular changes to the age and sex of the household head. To proxy human capital levels, we include the average level of completed education among working-age (15 to 60 years) members of the household, as that is unlikely to be affected in the short-term by PE levels for education.

Wealth endowments are proxied by the value of non-productive household assets, which is expected to be relatively unaffected directly by PE. This includes the value of livestock holdings, which we assume will be less affected directly by PE and more by long-term dynamic processes of asset accumulation.

Market conditions are proxied by prices for agricultural inputs, given that the agricultural sector is still one of the primary sources of livelihood in countries like Nigeria. These include agricultural wages and the private market prices of chemical fertilizer. We also include farmland endowments, as these are relatively exogenous at the household level, including in the models the area of farmland purchased outright in the past or distributed by community leaders and the number of plots the household farms.

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

Access to various community-level organizations or institutions is proxied by the count of different types of such organizations within the community in which household i resides at the time of survey wave t . Community-level shocks are dummy variables indicating their incidence in the community. Specific lists of organizations and institutions and types of shocks are described in section 5. These are taken from the community survey modules of LSMS-ISA.

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

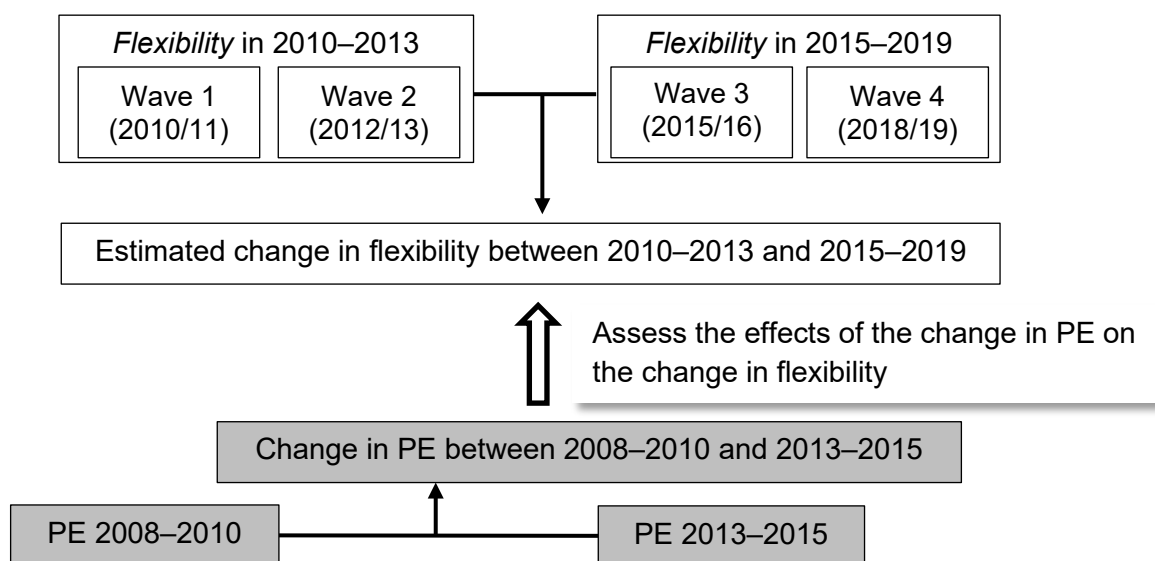
Effects on flexibility in shifting between farm and nonfarm income-earning activities

The second set of analyses to estimate the effects of PE for agriculture on household economic flexibility, proceed in ways that slightly differ from the above specifications (Figure 1). The analyses involve the estimation of the input distance function (IDF) that measures the joint productivity and efficiency of farm and nonfarm activities engaged in by the household (Coelli and Perelman 1996; Coelli and Fleming 2004; Irz and Thirtle 2004; Nguyen 2017), and the deriving measures of household-level flexibility and changes in this measure over time (Renner et al. 2014) (Appendix A describes in detail the econometric specifications used to obtain the estimates).

In essence, using four waves of panel data, we estimate indicators of flexibility for two subperiods, the first period consisting of panel survey waves 1 and 2, and the second period consisting of waves 3 and 4. This gives us the change in economic flexibility between these two subperiods. We then attempt to explain variations in the changes in flexibility by changes in PE for agriculture between the two subperiods, specifically the changes in average PE for agriculture between 2008–2010 and 2013–2015. We follow this approach because the estimation of flexibility itself requires at least two waves of panel data and the effects of PE for agriculture on flexibility can

be identified only between the two subperiods, but not between waves 1 and 2 or between waves 3 and 4.

Figure 1. Illustration of estimation methods – effects of changes in public expenditures on household flexibility in shifting between farm and nonfarm income-earning activities



Source: Authors.

Note: PE = public expenditures for different sectors, including agriculture, health, education, and social welfare.

5. DESCRIPTIVE STATISTICS

Table 1 provides descriptive statistics of annual total PE by value by LGAs and by states as well as percentage shares of total PE allocated to agriculture, health, education, and social welfare, respectively, for the LGAs and states in which are found LSMS-ISA sample households. To facilitate interpretation and to account for regional differences in prices, total PE figures are expressed on a per capita basis as the equivalent quantity of staple food (an average of rice and gari) in kg evaluated at their local prices. For example, the average recurrent expenditures by the LGA in which the sample households resided in the years of the LSMS-ISA panel survey rounds was equivalent in value to 56.65 kg of staple food per capita per year. Mean values are also often considerably higher than median values, suggesting skewed distributions.

PE by the state government per capita is shown to generally be larger than the LGA-level PE, for total, as well as for recurrent PE and capital PE. Shares of total PE are generally higher for education at around 16 percent of LGA PE and 9 percent of state PE at the medians, followed by health, at around 6 percent for both LGA and state PE. Shares of total PE for social welfare are generally lower, and those for agriculture are often the lowest at 2 percent of LGA PE and 3 percent of state PE. However, as indicated by the standard deviations, there is considerable variations in both total PE and shares of total PE by sector across the LGAs and states – and, thus, across households, depending on where they reside. This provides sources of variations in PE related variables with which to assess their effects on household-level outcomes.

Table 1. Descriptive statistics of public expenditure variables among all households, average over the three years leading up to each wave of Nigeria LSMS-ISA survey

Public Expenditure Variables	Recurrent expenditure			Capital expenditure			Total expenditure		
	Mean	Median	Std. dev.	Mean	Median	Std. dev.	Mean	Median	Std. dev.
Local Government Areas (LGA)									
Total (value per capita)	56.65	46.36	48.83	27.30	18.77	35.81	83.95	69.67	67.64
Agriculture (% share)	3.05	1.96	3.42	2.97	1.11	5.97	3.07	1.85	4.12
Health (% share)	9.42	7.47	7.11	4.41	2.86	4.88	7.57	6.27	5.35
Education (% share)	21.10	19.80	16.63	5.69	3.46	7.03	17.07	16.01	11.77
Social welfare (% share)	5.06	3.29	5.59	0.00	0.00	0.00	3.44	2.20	3.81
States									
Total (value per capita)	71.99	64.58	42.92	57.22	44.92	46.84	129.21	112.59	75.76
Agriculture (% share)	3.37	2.40	3.20	5.27	3.21	7.43	3.97	3.26	3.50
Health (% share)	6.82	6.17	4.85	5.86	4.37	5.35	6.15	5.71	3.56
Education (% share)	9.95	9.34	6.45	8.70	7.51	6.92	9.13	8.66	5.16
Social welfare (% share)	6.84	5.34	5.65	2.72	0.00	7.63	3.99	2.90	3.63
Sample size (all waves combined)	14,502			14,502			14,502		

Source: Authors, based on Nigeria, Federal Ministry of Finance (2015) and LSMS-ISA (NBS and World Bank 2016, 2019) data.

Note: "Value" is equivalent to the value in kilograms of staple food evaluated at local market prices.

Recurrent and capital expenditures may not add up to total expenditures due to rounding of decimals, and the total expenditures include a very small share of other categories that are neither recurrent nor capital.

Table 2 provides descriptive statistics for revenues by LGAs and by states – specifically, tax-revenue, internally generated revenue (IGR), and all revenues that include transfers from the central government. The size of local tax revenues and IGR are very small relative to the size of total revenues for both LGAs and states, although the relative sizes of tax revenues and IGR are substantially larger for states than LGAs. The PE by LGAs and states reported in Table 1 also are often much larger than tax revenues or IGR, indicating significant net transfers of resources from the central government. Therefore, variations in shares of total PE across LGAs and states (and thus households) in Table 1 also approximate a significant part of variations in net transfers received from central government by residents in these LGAs and states.

Table 2. Descriptive statistics of government revenue values per household, by type of revenue

	Tax revenues			Internally generated revenues			All revenues		
	Mean	Median	Std. dev.	Mean	Median	Std. dev.	Mean	Median	Std. dev.
LGA	0.21	0.00	1.36	1.37	0.51	3.43	75.20	69.91	38.86
State	9.45	5.81	16.01	20.33	11.99	25.91	126.18	115.22	77.17

Source: Authors, based on Nigeria, Federal Ministry of Finance (2015) and LSMS-ISA (NBS and World Bank 2016, 2019) data.

Note: Figures are expressed as annual value per household as measured by the equivalent to the value of local staple food in kg, and calculated as averages over 3 years leading up to each wave of Nigeria LSMS-ISA survey.

Table 3 provides descriptive statistics for all waves combined of the outcome variables examined. Not surprisingly, most households are consumption-poor, with per capita consumption values worth approximately 350 kilograms of staple foods annually, or about 1 kilogram per day. Consequently, about 14, 35, 60, and 82 percent of households fall below the poverty lines of USD 1.0, 1.9, 3.2, and 5.5 PPP international dollars per day, respectively. We see that some households have significant nonfarm enterprise capital assets. Lastly, the average HDDS (one-week recall) is around 8 in both the post-planting period and the post-harvesting period, still well below 12, which would indicate a sufficiently diverse diet.

Table 3. Descriptive statistics of key outcome variables of interest

Variables	Mean	Median	Std. dev.
Per capita consumption (value, annual equivalent)	484.907	348.933	1,019.621
Poverty prevalence at different poverty lines			
1.00 international dollars, PPP adjusted, per day (yes = 1)	0.139	0.000	0.346
1.90 international dollars, PPP adjusted, per day (yes = 1)	0.349	0.000	0.477
3.20 international dollars, PPP adjusted, per day (yes = 1)	0.599	1.000	0.490
5.50 international dollars, PPP adjusted, per day (yes = 1)	0.818	1.000	0.386
Nonfarm enterprise capital (value)	971.595	0.000	9,620.313
Household dietary diversity score (post-planting period)	7.775	8.000	2.117
Household dietary diversity score (post-harvesting period)	8.162	8.000	1.946
Agricultural outcomes (among agricultural households)			
Agricultural production revenue (value)	1,529.69	845.39	3,196.47
Costs of purchased agricultural inputs (value)	845.39	323.01	2,879.10
Received extension (yes = 1)	0.065	0.000	0.246
Received subsidized fertilizer (yes = 1)	0.022	0.000	0.147
Agricultural capital value (value)	76.540	9.056	2,793.89
Agricultural family labor use (person-days)	463.48	331.50	500.97

Source: Authors, based on LSMS-ISA data (NBS and World Bank 2016, 2019).

Note: "Value" is equivalent to the value in kilograms of staple food evaluated at local market prices. PPP = purchasing power parity.

Table 3 also provides descriptive statistics for the agricultural outcome variables with all waves combined. The agricultural households in our primary sample of interest are typically smallholders with approximate average production revenues of 1,500 kg staple food equivalent (and a median of 845 kg staple food equivalent), although the production values and cost figures are quite heterogeneous, suggested by the relatively high standard deviation.⁵ The estimated costs of purchased inputs are approximately 845 and 323 kg staple food equivalent on average and at the median, respectively. Production values were primarily derived from crop production. Production from livestock and other agricultural by-products was more limited. Seven and 2 percent of these farm households received extension services and received subsidized fertilizer, respectively.

Table 4 provides descriptive statistics for all control variables among all households in the samples. Most households are headed by adult males. Working-age household members have on average 5.6 years of education. These households are also generally asset-poor (with average and median asset values of 310 and 70 kg staple food equivalent per capita, respectively) and are located close to an hour away from a district administrative center by common means of transportation. Most households are, however, in communities with some community groups and institutional infrastructure of various types that provide public services in health, education, and other social services. However, the standard deviations for the variables suggest considerable heterogeneity in these household characteristics.

Table 4. Other control variables, all waves combined (all households, including nonagricultural households)

Variables	Mean	Median	Std. dev.
Rainfall anomaly of survey year (z-score with reference period of 1980–2010)	1.04	1.02	1.52
Temperature anomaly of survey year (z-score with reference period of 1980–2010)	0.98	1.02	0.98
Age of household head (years)	51.16	50.00	15.53
Distance to nearest administrative center (minutes)	63.94	47.90	54.82
Agricultural wages (value per day)	6.94	6.18	2.46

⁵ 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 between 5 and 10 percent of the sample) and found the results to be largely robust.

Variables	Mean	Median	Std. dev.
Average education of working-age members (years)	5.62	6.00	4.54
Female headed households (sample share)	0.17	0.00	0.37
Household members, by sex and age, number			
Male, over 60 years old	0.20	0.00	0.40
Female, over 60 years old	0.16	0.00	0.38
Male, 20–60 years old	1.01	1.00	0.89
Female, 20–60 years old	1.24	1.00	0.91
Male, 15–19 years old	0.24	0.00	0.52
Female, 15–19 years old	0.20	0.00	0.47
Male, 10–14 years old	0.32	0.00	0.60
Female, 10–14 years old	0.27	0.00	0.54
Male, 5–9 years old	0.53	0.00	0.81
Female, 5–9 years old	0.49	0.00	0.77
Male, 0–4 years old	0.38	0.00	0.68
Female, 0–4 years old	0.35	0.00	0.65
Price of fertilizer (value per kg)	1.94	1.90	0.45
Value of livestock (value, 1,000)	1.58	0.00	10.78
Value of household assets per capita (value, 1,000)	0.31	0.07	3.58
Distance to nearest major market (minutes)	66.91	60.70	43.64
Farm size (outright purchased or community distributed) (ha)	0.40	0.00	2.18
Number of plots (outright purchased or community distributed)	1.22	1.00	1.30
Tractor owners in local government area (sample share)	0.01	0.00	0.04
Community-level <u>negative</u> shocks in previous year (yes = 1)			
Drought	0.04	0.00	0.20
Flood	0.16	0.00	0.36
Crop disease / pests	0.06	0.00	0.24
Livestock disease	0.03	0.00	0.18
Human epidemic disease	0.03	0.00	0.18
Sharp change in prices	0.17	0.00	0.37
Massive job layoffs	0.03	0.00	0.16
Loss of key social service(s)	0.03	0.00	0.16
Power outage(s)	0.07	0.00	0.25
Other negative shocks	0.10	0.00	0.31
Community-level <u>positive</u> shocks in previous year (yes = 1)			
Development project	0.10	0.00	0.30
New employment opportunity	0.02	0.00	0.15
New health facility	0.06	0.00	0.23
New road	0.08	0.00	0.28
New school	0.07	0.00	0.25
Improved transportation services	0.06	0.00	0.24
On-grid electricity	0.03	0.00	0.18
Off-grid electricity	0.01	0.00	0.09
Other positive shocks	0.10	0.00	0.30
Organizations in the community (yes = 1)			
Village development committee	0.60	1.00	0.49
Agricultural coop	0.23	0.00	0.42
Savings and credit coop	0.18	0.00	0.39
Business association	0.24	0.00	0.43
Women's group	0.59	1.00	0.49
Youth group	0.71	1.00	0.46
Political group	0.74	1.00	0.44
Cultural group	0.37	0.00	0.48
Health committee	0.22	0.00	0.41
School committee	0.36	0.00	0.48

Variables	Mean	Median	Std. dev.
Parent-teacher association	0.66	1.00	0.47
Nongovernmental organization	0.05	0.00	0.21
Community police/watch group	0.52	1.00	0.50
Disabled association	0.07	0.00	0.25
Other	0.02	0.00	0.14
Infrastructure in the community (yes = 1)			
Nursery school	0.62	1.00	0.48
Primary school	0.84	1.00	0.36
Secondary school	0.60	1.00	0.48
Health center	0.62	1.00	0.48
Public hospital	0.24	0.00	0.42
Private hospital	0.29	0.00	0.45
Private clinic	0.33	0.00	0.46
Private doctor/specialist	0.20	0.00	0.39
Midwife	0.34	0.00	0.46
Dentist	0.09	0.00	0.28
Pharmacy	0.26	0.00	0.43
Cell phone distributor	0.24	0.00	0.42
Post office	0.18	0.00	0.37
Bus/minibus stop	0.47	0.00	0.49
Internet café	0.21	0.00	0.40
Bank (formal sector)	0.18	0.00	0.38
Microfinance institution	0.17	0.00	0.37
Police station	0.38	0.00	0.48
Market	0.64	1.00	0.47
Mosque or church	0.91	1.00	0.28
Community center	0.39	0.00	0.48
Fire station	0.08	0.00	0.27

Source: Authors, based on LSMS-ISA data (NBS and World Bank 2016, 2019).

“Value” is equivalent to the value in kilograms of staple food evaluated at local market prices.

6. RESULTS

Effects on welfare outcomes

Tables 5 and 6 summarize the effects of the shares of total PE and PE size on household-level outcomes among all households and among rural agricultural households, respectively. The “PE shares” columns show the effects of a 1 *percentage point* increase in the share of total PE allocated to the sector on outcome variables conditional on total PE size, while the rightmost “size” column shows the effects of a 1 *percent* increase in total PE on outcomes, conditional on PE shares. For example, increasing the share of total PE for agriculture, health, and social welfare by 1 percentage point was found to increase household-level per capita consumption by 4.26, 9.03 and 13.77 percent, respectively, while increasing the overall PE size (holding shares of total PE constant) by 1 percent further increased per capita consumption by 1.40 percent.

Generally, the results suggest that a higher share of total PE for agriculture has statistically significant positive effects on a broad range of outcomes at the household level, including consumption, poverty reduction, business capital investments, and household dietary diversity across seasons. This holds among all households as well as specifically for rural agricultural households.

Table 5. Effects of public expenditure share and size on household-level outcomes, full household sample

Outcome variables	PE shares for each sector (effects of 1 percentage point increase)				PE size (effects of 1 % increase)
	Agriculture	Health	Education	Social welfare	
Consumption per capita (% change)	4.263*** (1.437)	9.029*** (1.803)	0.752 (0.489)	13.770*** (1.239)	1.397*** (0.068)
Above poverty line of 1.00 international PPP dollars per day per capita (percentage point change in population share)	0.684** (0.342)	1.286*** (0.285)	0.072 (0.121)	2.063*** (0.273)	0.213*** (0.013)
Above poverty line of 1.90 international PPP dollars per day per capita	-0.037 (0.429)	1.314*** (0.323)	0.082 (0.165)	1.916*** (0.356)	0.173*** (0.017)
Above poverty line of 3.20 international PPP dollars per day per capita	0.250 (0.351)	0.916*** (0.311)	-0.247 (0.164)	1.291*** (0.324)	0.144*** (0.016)
Above poverty line of 5.50 international PPP dollars per day per capita	0.345* (0.207)	0.429** (0.210)	0.069 (0.124)	-0.012 (0.246)	0.065*** (0.012)
Nonfarm capital (% change)	4.248** (2.111)	5.843*** (1.732)	-0.044 (0.833)	7.989*** (1.657)	0.894*** (0.089)
Household dietary diversity score in post-planting season (change in score)	0.029* (0.017)	0.017* (0.010)	-0.014* (0.007)	0.000 (0.015)	-0.002*** (0.001)
Household dietary diversity score in post-harvesting season (change in score)	0.039*** (0.014)	-0.019** (0.009)	-0.004 (0.007)	-0.015 (0.012)	0.000 (0.001)

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

Note: Sample size = 14,502. Asterisks show statistical significance: *** 1%; ** 5%; * 10%.

Numbers in 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 wave, and within households across waves, using the vceimway command in STATA (Gu & Yoo 2019).

PE = public expenditures. "PE shares" indicates the effects of increasing the share of total PE while fixing the PE size. "PE size" refers to the effects of increasing the PE size while fixing the shares of total PE for agriculture, health, education, and social welfare.

Table 6. Effects of public expenditure share and size on household-level outcomes, rural household sample

Outcome variables	PE shares for each sector (effects of 1 percentage point increase)				PE size (effects of 1 % increase)
	Agriculture	Health	Education	Social welfare	
Consumption per capita (% change)	3.187** (1.319)	6.016*** (1.893)	1.408*** (0.536)	10.640*** (1.702)	1.224*** (0.091)
Above poverty line of 1.00 international PPP dollars per day per capita (percentage point change in population share)	0.856** (0.408)	0.608** (0.276)	0.071 (0.159)	1.317*** (0.442)	0.193*** (0.020)
Above poverty line of 1.90 international PPP dollars per day per capita	-0.056 (0.469)	0.557* (0.330)	0.148 (0.215)	0.831 (0.597)	0.132*** (0.024)
Above poverty line of 3.20 international PPP dollars per day per capita	-0.123 (0.420)	0.698* (0.356)	-0.209 (0.209)	0.360 (0.464)	0.099*** (0.022)
Above poverty line of 5.50 international PPP dollars per day per capita	-0.031 (0.228)	0.214 (0.225)	-0.093 (0.142)	-0.352 (0.305)	0.023 (0.016)
Nonfarm capital (% change)	1.213 (2.248)	4.617** (1.908)	1.568 (1.034)	6.716*** (2.164)	0.859*** (0.110)
Household dietary diversity score in post-planting season (change in score)	0.064*** (0.024)	0.041*** (0.012)	-0.015 (0.009)	-0.033 (0.022)	-0.001 (0.001)
Household dietary diversity score in post-harvesting season (change in score)	0.058*** (0.019)	-0.006 (0.011)	-0.016* (0.009)	-0.051*** (0.017)	0.000 (0.001)

Source: Authors' calculations.

Note: Sample size = 9,860. Asterisks show statistical significance: *** 1%; ** 5%; * 10%.

Numbers in 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 wave, and within households across waves, using the vceimway command in STATA (Gu & Yoo 2019).

PE = public expenditures. "PE shares" indicates the effects of increasing the share of total PE while fixing the PE size. "PE size" refers to the effects of increasing the PE size while fixing the shares of total PE for agriculture, health, education, and social welfare.

Higher shares of total PE for health, education and social welfare have somewhat mixed effects. They are more effective than share of total PE on agriculture for certain outcomes, but not so on other outcomes. Higher share of total PE on health and social welfare generally have significant and sizeable effects on consumption, poverty reduction (across a range of poverty lines), and business capital investment. However, their effects on dietary diversity are much weaker than share of total PE for agriculture. This underscores the importance of considering the overall food systems when designing agricultural policies and allocating public expenditures across sectors.

The effects of higher share of total PE on education are generally insignificant. This may be because in Nigeria, share of total PE on education was already relatively high compared to shares of total PE on agriculture, health, or social welfare (Table 1), so the marginal effects of additional share of total PE may be smaller. An alternate explanation is that the period covered by the panel data may be too short to capture the typically long-term effects of education investments.

Higher shares of total PE for health, education, and social welfare occasionally have negative effects on certain outcomes, such as on dietary diversity. The exact mechanisms of such effects must be investigated in future studies. They could be due to budgetary trade-offs with PE for other functions (aside from agriculture, health, education, and social welfare, which are already controlled for), such as infrastructure. For example, while the direct effects of a higher share of total PE for health on dietary diversity in the post-harvesting season may be positive, it may not be large enough to compensate for the potential negative effects of reduced shares of total PE for other functions. Such negative effects might also be due to the efficiency of PE with respect to particular outcomes.

Increasing PE *size* generally has positive effects on these outcomes, consistent with some of the literature discussed above – in developing countries, greater PE is generally associated with greater economic growth. The only outcome with a negative effect of increased PE size is dietary diversity in the post-planting season, but the magnitude is fairly small.

Importantly, the positive effects of increased PE are conditional on the shares of total PE. This means that, increasing the PE on each of agriculture, health, education and social welfare by simply increasing the overall PE size, while maintaining their shares of total PE, also has positive effects. These further underscore the general importance of increasing PE for these sectors to obtain improved household-level outcomes on consumption growth, poverty reduction, non-farm business capital investments, and dietary diversity.

These patterns generally hold among rural households as well (Table 6). The observed effects of PE therefore hold for broad segments of the population.

As was noted, the primary results in Table 5 (and Table 6) are based on PE in the year of the survey and two previous years. Further, these primary results also incorporate potential spillover from neighboring LGAs in that the PE for an LGA is measured as the average reported PE for the LGA of the household as well as that of all LGAs contiguous to the LGA in which the household resides. To check the robustness of our results, we adjust these aspects of the analysis to only consider PE figures computed as the average over the two years preceding the respective survey year (instead of three years, including the survey year) and when the expenditure figures from neighboring LGAs are excluded for our measure of PE in the LGA. The results after these adjustments are presented in Tables 12 and 13, respectively, in Appendix B. Comparing the results in Table 5 to those in Tables 12 and 13, while there are minor differences in statistical significance, the overall patterns of these results are consistent with those from our primary results presented in Table 5. The results are robust to which of these various data construction options is chosen.

Table 7. Effects of public expenditure share and size on household-level outcomes, disaggregated between LGA and state expenditures

Outcome variables	PE shares for each sector (effects of 1 percentage point increase)								PE size (effects of 1 % increase)	
	Agriculture		Health		Education		Social welfare		LGA	State
	LGA	State	LGA	State	LGA	State	LGA	State		
Consumption per capita	-0.627 (0.430)	3.218*** (0.552)	0.665* (0.402)	6.828*** (0.725)	-0.257 (0.263)	2.998*** (0.427)	-1.266 (0.819)	11.66*** (0.789)	0.008 (0.052)	1.080*** (0.059)
Above specific poverty line, international PPP dollars per capita per day										
1.00	-0.147 (0.136)	0.592*** (0.178)	0.160* (0.097)	0.765*** (0.180)	-0.089 (0.067)	0.665*** (0.115)	-0.439** (0.212)	1.771*** (0.163)	-0.002 (0.012)	0.159*** (0.013)
1.90	0.400** (163)	0.275 (0.229)	0.237* (0.129)	0.819*** (0.226)	-0.152 (0.095)	0.592*** (0.145)	-0.436 (0.284)	1.808*** (0.021)	-0.018 (0.017)	0.119*** (0.016)
3.20	-0.265 (0.173)	0.376* (0.205)	0.102 (0.126)	0.617*** (0.214)	-0.166* (0.091)	0.231* (0.136)	-0.304 (0.221)	1.352*** (0.216)	0.006 (0.016)	0.085*** (0.015)
5.50	0.066 (0.100)	0.159 (0.131)	-0.104 (0.081)	0.522*** (0.161)	0.008 (0.068)	0.100 (0.107)	-0.126 (0.151)	0.177 (0.168)	0.002 (0.012)	0.036*** (0.012)
Nonfarm capital	-0.157 (0.780)	1.746* (1.034)	-0.005 (0.601)	6.875*** (1.130)	-0.353 (0.419)	0.590 (0.681)	0.532 (1.091)	6.990*** (1.127)	0.080 (0.081)	0.582*** (0.081)
HDDS, post-planting season	0.011 (0.009)	0.023* (0.013)	0.008 (0.005)	0.001 (0.010)	0.004 (0.004)	-0.004 (0.007)	0.012 (0.011)	-0.025*** (0.009)	0.000 (0.001)	-0.003*** (0.001)
HDDS, post-harvest season	0.001 (0.006)	0.033*** (0.010)	-0.001 (0.005)	-0.013 (0.009)	-0.002 (0.004)	0.000 (0.006)	-0.010 (0.008)	-0.008 (0.008)	-0.001 (0.001)	0.000 (0.001)

Source: Authors' calculations.

Note: Sample size = 14,502. HDDS = Household Dietary Diversity Score. Asterisks show statistical significance: *** 1%; ** 5%; * 10%.

Table 8. Effects of public expenditure share and size on household-level outcomes, disaggregated between recurrent (R) and capital (C) expenditures

Outcome variables	PE shares for each sector (effects of 1 percentage point increase)								PE size (effects of 1 % increase)	
	Agriculture		Health		Education		Social welfare		R	C
	R	C	R	C	R	C	R	C		
Consumption per capita	8.375*** (1.157)	1.707*** (0.593)	7.050*** (1.513)	2.673*** (0.879)	0.099 (0.365)	0.971* (0.558)	7.456*** (0.816)	2.208*** (0.583)	1.467*** (0.101)	0.459*** (0.064)
Above specific poverty line, international PPP dollars per capita per day										
1.00	1.493*** (0.311)	0.285* (0.145)	0.938*** (0.244)	0.351* (0.196)	-0.116 (0.097)	0.091 (0.150)	1.229*** (0.190)	0.033 (0.144)	0.198*** (0.018)	0.087*** (0.014)
1.90	0.902** (0.374)	0.135 (0.193)	0.848*** (0.267)	0.342 (0.241)	-0.012 (0.126)	-0.024 (0.183)	0.949*** (0.251)	0.266 (0.198)	0.182*** (0.022)	0.053*** (0.017)
3.20	0.712** (0.331)	0.373** (0.165)	0.753*** (0.273)	0.075 (0.240)	-0.126 (0.120)	-0.158 (0.164)	0.494** (0.227)	0.149 (0.165)	0.161*** (0.022)	0.047*** (0.016)
5.50	0.316 (0.221)	0.124 (0.101)	0.294* (0.179)	0.057 (0.172)	-0.021 (0.090)	0.226* (0.114)	-0.153 (0.166)	0.077 (0.121)	0.081*** (0.016)	0.028** (0.012)
Nonfarm capital	5.514*** (1.814)	1.355* (0.853)	4.059*** (1.424)	2.958** (1.203)	-0.243 (0.630)	0.361 (0.846)	3.863*** (1.133)	1.139 (0.846)	1.005*** (0.121)	0.295*** (0.087)
HDDS, post-planting season	0.061*** (0.018)	-0.017* (0.009)	0.006 (0.009)	0.005 (0.011)	-0.007 (0.005)	0.001 (0.007)	-0.004 (0.009)	0.000 (0.001)	0.000 (0.001)	-0.001 (0.001)
HDDS, post-harvest season	0.043*** (0.015)	0.015** (0.007)	-0.012 (0.008)	-0.016* (0.010)	-0.001 (0.005)	-0.017** (0.007)	0.002 (0.008)	-0.024** (0.007)	-0.002** (0.001)	0.002*** (0.001)

Source: Authors' calculations.

Note: Sample size = 14,502. R = Recurrent Expenditure; C = Capital Expenditure. HDDS = Household Dietary Diversity Score. Asterisks show statistical significance: *** 1%; ** 5%; * 10%.

Tables 7 and 8 provide further insights to those in Table 5 by disaggregating the effects of PE on household-level outcomes between LGA PE and state PE and between recurrent PE and capital PE, respectively. These tables suggest the pathways of impact for PE on household outcomes are complex, since different development outcomes seem to respond differently to LGA PE and state PE and to recurrent PE and capital PE. Again, future studies will need to examine more closely the effectiveness of PE for agriculture by different levels of government, as well as by recurrent and capital PE types. However, an important point here is that, generally speaking, PE by

LGA and state, or by recurrent and capital PE rarely exhibit statistically significant opposite effects, and this is particularly so for the share of total PE for agriculture. These findings underscore the importance of aligning PE at LGA and state levels and aligning PE for recurrent and capital expenditures to have maximum beneficial effects at household level.

Effects on agricultural outcomes

Our general results suggest the positive effects of PE for agriculture on a broad range of household-level outcomes. Table 9 further shows that, for agricultural households, these effects are, in fact, partly realized through the improvements in household-level agricultural outcomes as intended. A one percentage point greater share of total PE allocated to agriculture leads to 2.56 percent increase in household agricultural revenue while leading to 4.75 percent lower agricultural production costs (and thus higher agricultural profit), 1.20 percentage point higher likelihood of receiving agricultural extension services, 3.37 percent greater value of agricultural capital, and 3.95 percent increase in labor use and employment in agricultural production. Similarly, a one percent increase in the total PE size, controlling for the share of total PE for agriculture and, thus, increasing PE for agriculture by one percent, leads to a 4 percentage point higher likelihood of receiving subsidized fertilizer.

Table 9. Effects of public expenditure share and size on household-level agricultural outcomes, agricultural households only

Outcome variables	PE shares for each sector (effects of one percentage point increase)				PE size (effects of 1 % increase)
	Agriculture	Health	Education	Social welfare	
Agricultural revenue (% change)	2.557* (1.342)	0.101 (0.726)	-1.028 (0.667)	-0.740 (1.314)	0.073 (0.074)
Agricultural cost (% change)	-4.751** (2.392)	3.849** (1.770)	-4.086*** (1.153)	5.992** (2.968)	0.371*** (0.135)
Receive subsidized fertilizer (yes = 1)	-0.143 (0.184)	-0.172* (0.103)	-0.434*** (0.122)	-0.253 (0.176)	0.040*** (0.013)
Received extension service (yes = 1)	1.203** (0.498)	-0.209 (0.202)	0.197 (0.165)	0.559 (0.347)	0.009 (0.016)
Agricultural capital investments (% change)	3.368*** (1.119)	1.343* (0.723)	0.031 (0.558)	-3.208** (1.280)	0.051 (0.061)
Labor use in agriculture (% change)	3.953*** (1.206)	0.234 (0.739)	-0.819 (0.630)	-1.858 (1.392)	0.467*** (0.094)

Source: Authors' calculations.

Note: Sample size = 10,091. Asterisks show statistical significance: *** 1%; ** 5%; * 10%.

Increasing shares of total PE for health, education, and social welfare do not exhibit similarly broadly positive effects on household agricultural outcomes as do increasing shares of total PE for agriculture. These results suggest that where shares of total PE for health, education, and social welfare exhibit positive effects on household-level outcomes, as shown in Tables 5 through 8, such effects are realized through other channels than agriculture-related outcomes.

Table 10 further breaks down the effects across PE by LGA and PE by state governments. Generally speaking, we find again that PE by LGA and state do not exhibit opposite effects in statistically significant manners for the effects on household-level outcomes of the shares of total PE for agriculture.

Table 10. Effects of public expenditure share and size on household-level agricultural outcomes, disaggregated between LGA and state expenditures, agricultural households only

Outcome variables	PE shares for each sector (effects of 1 percentage point increase)								PE size (effects of 1 % increase)	
	Agriculture		Health		Education		Social welfare		LGA	State
	LGA	State	LGA	State	LGA	State	LGA	State	LGA	State
Agricultural revenue	3.114*** (1.040)	1.305* (0.696)	0.819** (0.394)	-0.919 (1.008)	0.128 (0.385)	-2.293** (0.584)	-3.126** (1.009)	2.275** (0.091)	-0.013 (0.060)	0.086 (0.073)
Agricultural cost	-1.792 (1.571)	-4.277** (1.429)	0.205 (1.116)	6.710*** (1.676)	-2.027** (0.677)	-3.057** (1.019)	1.757 (2.085)	4.373** (1.789)	-0.003 (0.122)	0.461*** (0.123)
Received subsidized fertilizer	0.017 (0.117)	-0.107 (0.118)	-0.121* (0.062)	0.022 (0.131)	-0.180*** (0.065)	-0.285*** (0.074)	-0.315** (0.127)	0.146 (0.126)	-0.011 (0.012)	0.048*** (0.011)
Received extension service	0.476*** (0.222)	0.958*** (0.317)	0.033 (0.098)	-0.644*** (0.217)	0.199** (0.086)	0.112 (0.141)	0.815*** (0.248)	-0.163 (0.187)	-0.019 (0.014)	0.023 (0.015)
Agricultural capital investments	2.800*** (0.721)	0.541 (0.710)	0.509 (0.367)	0.577 (0.901)	-0.415 (0.322)	0.938* (0.492)	-2.576** (0.965)	-0.610 (0.967)	0.016 (0.057)	0.019 (0.059)
Labor use in agriculture	-0.513 (0.805)	3.311** (0.753)	-0.279 (0.339)	-1.035 (0.876)	-0.836** (0.365)	2.079*** (0.568)	-1.633* (0.975)	-0.900 (1.056)	-0.042 (0.065)	0.505*** (0.073)

Source: Authors' calculations.

Note: Sample size = 10,091. Asterisks show statistical significance: *** 1%; ** 5%; * 10%.

Our primary interest is in the effects of PE related variables on key household-level outcomes, so the effects of other control variables are of secondary importance. We therefore summarize the statistically significant signs for our control variables in Table 14 in Appendix B. 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 including them as control variables in our analyses is justified.

Effects on economic flexibility in shifting between farm and nonfarm income-earning activities

Table 11 summarizes the effects of the increased share of total PE for agriculture, health, education, and social welfare between waves 1–2 and waves 3–4, on the flexibility of households in shifting between farm and nonfarm activities. These are estimated by splitting household samples into two groups, i.e., one group in regions where the share of total PE relatively increased between waves 1-2 and waves 3-4, and the other group in regions where the share relatively decreased. Various thresholds of the changes the share of total PE are used and estimations are conducted on each set of two groups identified. The table shows how the estimated effects on flexibility indicators differ depending on the sectors of PE, and how these cross-sector differences hold relatively consistently regardless of threshold levels of changes in sectoral shares of total PE.

Table 11. Effects of public expenditure shares on flexibility of a household shifting between farm and nonfarm income-earning activities

Share of sample below threshold of change in share of total PE for the corresponding sector between waves 1-2 and 3-4	Effects of changes in share of total PE for each sector on changes in the flexibility index			
	Agriculture	Health	Education	Social welfare
20%	2.072* (1.143)	0.930 (3.313)	-0.361 (1.051)	-0.088 (0.930)
30%	1.326 (0.857)	1.510 (2.483)	-0.656 (1.076)	-0.289 (1.227)
40%	3.206** (1.430)	1.661 (1.685)	-1.648 (1.763)	-0.341 (1.268)
50%	1.482* (0.886)	1.760 (2.164)	-0.768 (1.398)	-0.824 (1.264)
60%	1.433* (0.877)	1.524 (2.050)	-0.450 (1.275)	-0.578 (1.644)
70%	2.455** (1.160)	1.107 (1.696)	-0.461 (1.098)	-0.117 (0.890)
80%	1.845* (1.038)	1.907 (1.450)	-1.306 (1.330)	-0.177 (0.923)

Source: Authors' calculations. Numbers in parentheses are standard errors. Asterisks indicate statistical significance: *** 1%; ** 5%; * 10%.

For example, the first row shows the case where the sample of households was split into 20 and 80 percent sub-samples based on the threshold changes in shares of total PE between the 2008–2010 and 2013–2015 periods. In this row, the 80 percent of households, which were located in LGAs in which the share of total PE for agriculture relatively increased (or decreased less), experienced a net increase of 2.07 in their average flexibility indicator (with statistical significance at 10 percent) compared to the 20 percent of samples households that were located in LGAs in which the share of total PE for agriculture saw a relative decrease during the same period. These results hold consistently for a range of thresholds (e.g., 40%, 50%, 60%, 70% and 80%) and are consistent with the hypothesis that increasing the share of total PE for agriculture helps households retain flexibility in shifting between farm and nonfarm activities.

The effects of the share of total PE for agriculture stand in contrast to the effects of shares of total PE for health, education, or social welfare. Changes in the shares of total PE for these sectors do not have significant effects on the flexibility of a household in shifting between farm and nonfarm activities.

As was described briefly above, greater flexibility to shift between nonfarm activities and farm activities can be particularly important during periods of social and economic shock, like the COVID-19 crisis. Because of disruptions in food markets and restrictions on worker mobility (especially in rural-to-urban migration) that can emerge as a result of government response measures against COVID-19 and similar shocks, some farm households might find themselves suddenly being forced to switch a significant share of their economic activities from nonfarm activities to farm activities, including increased subsistence production of certain food crops. Households with greater flexibility are more resilient against such types of shock, as they can switch between nonfarm activities and farm activities without facing a significant increase in production costs. Our findings suggest that a greater share of total PE for agriculture has helped farm households in Nigeria increase this flexibility and be more prepared for shocks, like COVID-19, while the level of shares of total PE for health, education, and social welfare did not affect this particular indicator of flexibility.

7. CONCLUSIONS

Public expenditures (PE) are an important instrument for achieving key public sector functions that contribute to development and welfare improvements through the provisions of necessary public goods and the mitigation of market failures, which are not readily provided by the private sector investments alone. Because of potentially heterogeneous pathways of development and welfare improvements, adjusting the shares of total PE across sectors and functions has long been recognized as critical for maximizing the effects of PE. Key social sector PE, such as for health, education, and social welfare, and PE for agriculture have been increasingly recognized as potentially important categories of PE for income growth, poverty reduction, private investment, nutritional outcomes, and resilience. However, direct evidence in developing countries, like Nigeria, has been relatively limited.

Furthermore, the importance of assessing the impacts of subnational PE on these household-level outcomes has also been recognized, as appropriately decentralized PE systems can potentially achieve greater effectiveness by enabling public support that is tailored more to local needs. In addition, variations in PE across subnational administrative units provide useful variations that can be exploited to assess the effects of PE on household-level outcomes.

This study contributes to filling this knowledge gap by estimating the effects at household level of the relative shares of subnational total PE allocated for agriculture, health, education, and social welfare, as well as PE size. We found that greater shares of total PE for agriculture, health, and

social welfare, conditional on PE size, generally had positive effects on consumption, poverty reduction, and non-farm business capital investments. The effects of a greater share of total PE for education were weaker, potentially because the share of total PE for education has already been relatively high in Nigeria. The positive effects of PE for agriculture were found to materialize through improved surplus generation in the agricultural sector, benefits which are captured by labor, while the impacts of health and social welfare PE materialize through other channels outside of the agricultural sector. Increasing the size of PE overall, controlling for shares of total PE for agriculture and other sectors, also had generally positive effects on these household-level outcomes, suggesting that increasing PE on these sectors by increasing overall PE size also contributes to economic development and welfare improvements in countries like Nigeria.

The results also underscore that increasing PE for agriculture is likely to be particularly important for improved outcomes for households. A greater share of total PE for agriculture also appeared to positively affect a broader range of outcomes than shares of total PE for health and social welfare. These included certain nutritional outcomes, like household dietary diversity, across seasons and certain dimensions of resilience, like economic flexibility between undertaking farm and non-farm activities, a feature of household economic resilience which may be particularly important in today's rapidly changing socioeconomic environment due to shocks such as COVID-19. Such multi-dimensional benefits of greater PE for agriculture are particularly worth attention in countries like Nigeria, which have historically allocated a lower share of total PE to agriculture compared to comparable countries in Africa and elsewhere.

REFERENCES

- Albornoz F & A Cabrales. 2013. Decentralization, Political Competition and Corruption. *Journal of Development Economics* 105:103-111.
- Alesina A. 1998. *The political economy of macroeconomic stabilisations and income inequality: myths and reality*. In V Tanzi & K Chu (eds), *Income Distribution and High-Quality Growth*. MIT Press, London.
- Almanzar M & M Torero. 2017. Distributional Effects of Growth and Public Expenditures in Africa: Estimates for Tanzania and Rwanda. *World Development* 95:177-195.
- Anderson E, MAJ d'Orey, M Duvendack & L Esposito. 2017. Does Government Spending Affect Income Inequality? A Meta-regression Analysis. *Journal of Economic Surveys* 31 (4): 961-987.
- . 2018. Does Government Spending Affect Income Poverty? A Meta-regression Analysis. *World Development* 103:60-71.
- Arjona R, M Ladaique & M Pearson. 2003. Growth, inequality and social protection. *Canadian Public Policy/Analyse de Politiques* 29, S119-S139.
- Arndt C, K Pauw & J Thurlow. 2016. The Economy-wide Impacts and Risks of Malawi's Farm Input Subsidy Program. *American Journal of Agricultural Economics* 98(3):962-980.
- Baffes J, V Kshirsagar & D Mitchell. 2019. What Drives Local Food Prices? Evidence from the Tanzanian Maize Market. *World Bank Economic Review* 33(1):160-184.
- Bahal G, M Raissi & V Tulin. 2018. Crowding-Out or Crowding-In? Public and Private Investment in India. *World Development* 109:323-333.
- Barrett CB & MA Conostas. 2014. "Toward a Theory of Resilience for International Development Applications." *Proceedings of the National Academy of Sciences* 111(40):14625-14630.
- Barro RJ. 1991. Economic growth in a cross section of countries. *Quarterly Journal of Economics* 106(2):407-443.
- Basu S. 2008. *Returns to Scale Measurement*. In *The New Palgrave Dictionary of Economics*, 2nd ed., edited by SN Durlauf & LE Blume. New York: Palgrave Macmillan.
- Bellows AL, CR Canavan, MM Blakstad, D Mosha, RA Noor, P Webb, J Kinabo, H Masanja, & WW Fawzi. (2020). The Relationship between Dietary Diversity among Women of Reproductive Age and Agricultural Diversity in Rural Tanzania. *Food and Nutrition Bulletin* 41(1):50-60.
- 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.
- Bergh A, I Mirkina & T Nilsson. (2020). Can social spending cushion the inequality effect of globalization? *Economics & Politics* 32(1):104-142.
- Bird RM & F Vaillancourt. (Eds.). 2008. *Fiscal decentralization in developing countries*. Cambridge University Press.
- Bustos P, B Caprettini & J Ponticelli. 2016. Agricultural Productivity and Structural Transformation: Evidence from Brazil. *American Economic Review* 106(6):1320-1365.
- Carlson C. 2018. Rethinking the Agrarian Question: Agriculture and Underdevelopment in the Global South. *Journal of Agrarian Change* 18(4):703-721.
- Castro-Leal F, J Dayton, L Demery & K Mehra. (1999). Public spending on health care in Africa: Do the poor benefit? *World Bank Research Observer* 14(1):49-72.
- Christiaensen L, L Demery & J Kuhl. 2011. The (Evolving) Role of Agriculture in Poverty Reduction: An Empirical Perspective. *Journal of Development Economics* 96(2):239-254.
- Caselli F, E Esquire & F Lefort. 1996. Re-opening the convergence debate: A new look at cross-country growth empirics. *Journal of Economic Growth* 1(3):363-389.
- Coelli T & E Fleming. 2004. Diversification Economies and Specialisation Efficiencies in a Mixed Food and Coffee Smallholder Farming System in Papua New Guinea. *Agricultural Economics* 31(2-3):229-239.
- Coelli T & S Perelman. 1996. *Efficiency Measurement, Multioutput Technologies and Distance Functions: With Application to European Railways*. CREPP Working Paper 96/05. Liège, Belgium: Centre de Recherche en Economie Publique et Economie de la Population, Université de Liège.
- CRU (Climatic Research Unit), 2020. *Datasets*. University of East Anglia, Norwich, UK. www.cru.uea.ac.uk/data, Accessed date: 15 January 2020.
- Davoodi H, E Tiongson & S Asawanuchit. 2010. Benefit incidence of public education and health spending worldwide: Evidence from a new database. *Poverty and Public Policy* 2(2):5-52.

- de Mel S, D McKenzie & C Woodruff. 2008. Returns to Capital in Microenterprises: Evidence from a Field Experiment. *Quart. J. Econ.* 123(4):1329-1372.
- Deininger K & D Byerlee. 2012. The Rise of Large Farms in Land Abundant Countries: Do They Have a Future? *World Development* 40(4):701-714.
- Devarajan S, V Swaroop & HF Zou. 1996. The composition of public expenditure and economic growth. *Journal of Monetary Economics* 37(2):313-344.
- Easterly W & S Rebelo. 1993. Fiscal policy and economic growth: An empirical investment. *Journal of Monetary Economics* 32(3):417-458.
- 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, P Hazell & S Thorat. 2000. "Government Spending, Agricultural Growth and Poverty in Rural India." *American Journal of Agricultural Economics* 82(4):1038-1051.
- Fan S & X Zhang. 2008. Public Expenditure, Growth and Poverty Reduction in Rural Uganda. *African Development Review* 20(3):466-496.
- 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, S Yosef & R Pandya-Lorch. 2019. *Agriculture for Improved Nutrition: Seizing the Momentum*. Washington, DC: International Food Policy Research Institute.
- FAO (Food and Agriculture Organization of the United Nations). 2011. *Guidelines for Measuring Household and Individual Dietary Diversity*. Rome.
- Foster A & M Rosenzweig. 2004. Agricultural Productivity Growth, Rural Economic Diversity, and Economic Reform: India, 1970–2000. *Economic Development and Cultural Change* 52 (3):509-542.
- Frelat R et al. (2016). Drivers of household food availability in sub-Saharan Africa based on big data from small farms. *Proceedings of the National Academy of Sciences* 113(2):458-463.
- Gollin D, CW Hansen & A Wingender. 2018. *Two Blades of Grass: The Impact of the Green Revolution*. NBER Working Paper 24744. Cambridge, MA, US: National Bureau of Economic Research.
- 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.
- Gu A & HI Yoo. 2019. vcemway: A one-stop solution for robust inference with multiway clustering. *The Stata Journal* 19(4):900-912.
- Haggblade S, P Hazell & J Brown. 1989. Farm–Non-farm Linkages in Rural Sub-Saharan Africa. *World Development* 17(8):1173-1201.
- Haggblade S, P Hazell & T Reardon. 2010. The rural non-farm economy: Prospects for growth and poverty reduction. *World Development* 38(10):1429-1441.
- Harou AP. 2018. Unraveling the Effect of Targeted Input Subsidies on Dietary Diversity in Household Consumption and Child Nutrition: The Case of Malawi. *World Development* 106: 124-135.
- Hoddinott J & Y Yohannes. 2002. *Dietary diversity as a food security indicator*. FCND Discussion Paper 136. Washington, DC: International Food Policy Research Institute.
- International Monetary Fund (IMF). (2001). *Government Finance Statistics Manual*. Washington DC.
- IFPRI. (2020). *COVID-19 & Global Food Security*. Washington DC.
- Irz X & C Thirtle. 2004. Dual Technological Development in Botswana Agriculture: A Stochastic Input Distance Function Approach. *Journal of Agricultural Economics* 55(3):455-478.
- Islam N. 1995. Growth empirics: A panel data approach. *Quarterly Journal of Economics* 110(4):1127-1170.
- 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.
- Jolliffe D & EB Prydz. 2016. Estimating International Poverty Lines from Comparable National Thresholds. *Journal of Economic Inequality* 14(2):185-198.
- Kwon HJ & E Kim. 2014. Poverty reduction and good governance: examining the rationale of the millennium development goals. *Development and Change* 45:353-375.

- Landau D. 1986. Government and economic growth in the less developed countries: an empirical study for 1960-1980. *Economic Development and Cultural Change* 35(1):35-75.
- Lederman D, N Loayza & R Soares. 2006. *On the Political Nature of Corruption*. In *The Role of Parliament in Curbing Corruption*, edited by R Stapenhurst, N Johnston & R Pellizo. Washington, DC: World Bank.
- Lee IH. 2018. Industrial Output Fluctuations in Developing Countries: General Equilibrium Consequences of Agricultural Productivity Shocks. *European Economic Review* 102:240-279.
- Levine R & D Renelt. 1992. A sensitivity analysis of cross-country growth regressions. *American Economic Review* 82(4):942-963.
- Liverpool-Tasie LS. 2014. Do vouchers improve government fertilizer distribution? Evidence from Nigeria. *Agric. Econ* 45(4):393-407.
- Loizou E, C Karelakis, K Galanopoulos & K Mattas. 2019. The Role of Agriculture as a Development Tool for a Regional Economy. *Agricultural Systems* 173:482-490.
- Mankiw G, D Romer & D Weil. 1992. A contribution to the empirics of economic growth. *Quarterly Journal of Economics* 107(2):407-437.
- Martinez-Vazquez J & RM McNab. 2003. Fiscal decentralization and economic growth. *World development* 31(9):1597-1616.
- Martinez-Vasquez J, V Vulovic & B Moreno-Dodson. 2012. The impact of tax and expenditure policies on income distribution: evidence from a large panel of countries. *Review of Public Economics* 200(4):95-130.
- Matsuyama K. 1992. Agricultural Productivity, Comparative Advantage, and Economic Growth. *Journal of Economic Theory* 58(2):317-334.
- McArthur JW & GC McCord. 2017. Fertilizing Growth: Agricultural Inputs and Their Effects in Economic Development. *Journal of Development Economics* 127:133-152.
- McArthur JW & JD Sachs. 2019. Agriculture, Aid, and Economic Growth in Africa. *World Bank Economic Review* 33(1):1-20.
- McKenzie D & C Woodruff. 2006. Do Entry Costs Provide an Empirical Basis for Poverty Traps? Evidence from Mexican Microenterprises. *Economic Development and Cultural Change* 55:3-42.
- Mogues T. 2011. The bang for the birr: Public expenditures and rural welfare in Ethiopia. *Journal of Development Studies*, 47(5):735-752.
- Mogues T & S Benin. 2012. *Public expenditures for agricultural and rural development in Africa*. Routledge.
- Mogues T & T Olofinbiyi. 2020. Budgetary influence under information asymmetries: Evidence from Nigeria's subnational agricultural investments. *World Development* 129, 104902.
- 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.
- . 2019. *Basic Information Document: Nigeria General Household Survey–Panel 2018/19*. <https://microdata.worldbank.org/index.php/catalog/3557/download/47680>.
- 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.
- Nguyen HQ. 2017. Analyzing the Economies of Crop Diversification in Rural Vietnam Using an Input Distance Function. *Agricultural Systems* 153:148-156.
- Nigeria, Federal Ministry of Finance. 2015. *CBN/NBS/NCC 2015 Collaborative Survey and Staff Estimates* (various years). Abuja. Computer disk.
- 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.
- Ram R. 1986. Government size and economic growth: A new framework and some evidence from cross-section and time-series data. *American Economic Review* 76(1):191-203.
- Reinikka R & J Svensson. 2004. Local Capture: Evidence from a Central Government Transfer Programme in Uganda. *Quarterly Journal of Economics* 119(2):679-705.
- Renner S, T Glauben & H Hockmann. 2014. Measurement and Decomposition of Flexibility of Multi-output Firms. *European Review of Agricultural Economics* 41(5):745-773.

- Ruel MT, AR Quisumbing & M Balagamwala. 2018. Nutrition-Sensitive Agriculture: What Have We Learned So Far? *Global Food Security* 17:128-153.
- Sattar Z. 1993. Public expenditure and economic performance: A comparison of developed and low - income developing economies. *Journal of International Development* 5(1):27-49.
- Schaltegger CA & B Torgler. 2006. Growth effects of public expenditure on the state and local level: evidence from a sample of rich governments. *Applied Economics* 38(10):1181-1192.
- Spielman D & K von Grebmar. 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.
- Stasavage D. 2005. Democracy and Education Spending in Africa. *American Journal of Political Science* 49(2):343-358.
- 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. 2020a. Effects of agricultural mechanization on economies of scope in crop production in Nigeria. *Agricultural Systems* 177, 102691.
- Takeshima H, J Smart, HO Edeh, MA Oyeyemi, B Balana & KS Andam. 2020b. *Public Expenditures on Agriculture at Subnational-Levels and Household-Level Agricultural Outcomes in Nigeria*. IFPRI DP 01952.
- World Bank. 2007. *World Development Report 2008: Agriculture for Development*. Washington, DC: World Bank.
- World Bank. 2020. *World Development Indicators*. Washington, DC: World Bank.
- Zimmermann M & M Carter. 2003. Asset Smoothing, Consumption Smoothing and the Reproduction of Inequality under Risk and Subsistence Constraints. *Journal of Development Economics* 71:233-260.

APPENDICES

Appendix A: Econometric models for estimation of effects of public expenditure on households' flexibility in shifting between farm and nonfarm activities

The approach illustrated in Figure 1 is operationalized in the following way. First, we estimate the parametric approximation of the input distance function (IDF). IDF has been used in the production economics literature to extract key features of production technologies, such as economies of diversification (Coelli and Perelman 1996; Coelli and Fleming 2004; Irz and Thirtle 2004; Nguyen 2017) and flexibility (Renner et al. 2014). Specifically, we estimate:

$$\begin{aligned}
 -\ln x_{0,ijt} = & \alpha_0 + \sum_{m=1}^2 \alpha_m \ln y_{m,ijt} + \sum_{n=1}^N \alpha_n \ln x_{n,ijt}^* \\
 & + 0.5 \sum_{m=1}^2 \sum_{\ell=1}^2 \alpha_{\ell m} \ln y_{m,ijt} \ln y_{\ell,ijt} \\
 & + 0.5 \sum_{n=1}^N \sum_{p=1}^N \alpha_{np} \ln x_{n,ijt}^* \ln x_{p,ijt}^* \\
 & + \sum_{n=1}^N \sum_{m=1}^2 \alpha_{nj} \ln x_{n,ijt}^* \ln y_{m,ijt} + \alpha_0^E ES_{jT} \\
 & + \sum_{m=1}^2 \alpha_m^E (\ln y_{m,ijt} \cdot ES_{jT}) + \sum_{n=1}^N \alpha_n^E (\ln x_{n,ijt}^* \cdot ES_{jT}) \\
 & + 0.5 \sum_{m=1}^2 \sum_{\ell=1}^2 \alpha_{\ell m}^E (\ln y_{m,ijt} \ln y_{\ell,ijt} \cdot ES_{jT}) \\
 & + 0.5 \sum_{n=1}^N \sum_{p=1}^N \alpha_{np}^E (\ln x_{n,ijt}^* \ln x_{p,ijt}^* \cdot ES_{jT}) \\
 & + \sum_{n=1}^N \sum_{m=1}^2 \alpha_{nm}^E (\ln x_{n,ijt}^* \ln y_{m,ijt} \cdot ES_{jT}) \\
 & + \beta_{Size} E_{jt} + \beta_Z \cdot Z_{ijt} + \theta_i + \theta_i^{w1w2} + \theta_i^{w3w4} + v_{it} - u_{it},
 \end{aligned} \tag{2}$$

in which $x_{0,ijt}$ is the total amount of reference input (household labor in person-days) used for farm and nonfarm-activities of household i in LGA or state j in survey wave t during the previous 12 months; $x_{n,ijt}^* = x_{n,ijt} / x_{0,ijt}$ in which $x_{n,ijt}$ is the total value of other variable inputs of type n (including hired labor) used for farm and nonfarm activities; and $y_{m,ijt}$ is the agricultural revenue, as well as revenues from nonfarm activities ($m = 1$ and $m = 2$, respectively). Z_{ijt} is other time-variant household characteristics. ℓ and p are aliases for m and n , respectively.

ES_{jT} is the same share of total PE variables used in equation (1), except that the subscript is jT instead of jt , where T denote two aggregated periods consisting of first (waves 1 and 2) and second periods (waves 3 and 4). Specifically, as is shown in Figure 1, for waves 1 and 2, ES_{jT} is the average between 2008 and 2010 (the year of wave 1), while for waves 3 and 4, ES_{jT} is the average between 2013 and 2015 (the year of wave 3). In other words, in (2), we are interested in the effects of PE for agriculture, health, education, and social welfare between 2008 and 2010 (2013 and 2015) on the characteristics of households during waves 1 and 2 (waves 3 and 4). Such specifications assume that the effects of PE on characteristics such as flexibility arise more in the medium term. This is because production characteristics, such as flexibility, depend on economies of scale and economies of scope, which are more medium-term, rather than short-term, concepts (see for example, Basu 2008).

Equation (2) is an expanded version of a standard IDF, being expanded by the interaction terms with ES_{jt} , which capture heterogeneity in various parameters α 's as functions of ES_{jt} . Recent studies, such as Takeshima et al. (2020a), apply a similar expansion to an IDF. Notations α 's, β 's

are estimated parameters. As is defined in the literature on IDFs, the residual terms are defined as $v_{it} \sim i. i. d N(0, \sigma_v^2)$ and $u_{it} \sim i. i. d |N(0, \sigma_u^2)|$.

In Equation (2), the additional subperiod-specific unobserved household fixed effects θ_i^{w1w2} and θ_i^{w3w4} control for potential short-term changes in these household fixed effects between waves 1–2 (2010–2013) and waves 3–4 (2015–2019). θ_i^{w1w2} and θ_i^{w3w4} can also affect the changes in production behaviors of the household, aside from the change in flexibility, between these subperiods. By controlling for θ_i^{w1w2} and θ_i^{w3w4} , we can more accurately capture the changes in flexibility. These short-term fluctuations in household fixed effects might occur, for example, due to short-term changes in farming ability, which can be positive if households gain some new short-term skills or experience household-specific positive shocks, or can be negative if the household faces new challenges due to location-specific pest outbreaks, etc.. These short-term fluctuations might differ from longer-term effects θ_i . In practice, θ_i^{w1w2} and θ_i^{w3w4} are controlled for first by converting variables through within transformations in each subperiod, so that in (2),

$$\begin{aligned} y_{it} &= y_{it} - \bar{y}_{i,12}, & x_{it} &= x_{it} - \bar{x}_{i,12}, & z_{it} &= z_{it} - \bar{z}_{i,12}, & t &= 1,2 \\ y_{it} &= y_{it} - \bar{y}_{i,34}, & x_{it} &= x_{it} - \bar{x}_{i,34}, & z_{it} &= z_{it} - \bar{z}_{i,34}, & t &= 3,4 \end{aligned} \quad (3)$$

where $\bar{y}_{i,12}$, $\bar{x}_{i,12}$, $\bar{z}_{i,12}$ are averages within each household i over waves 1 and 2, and $\bar{y}_{i,34}$, $\bar{x}_{i,34}$, $\bar{z}_{i,34}$ are similar averages over waves 3 and 4. Second, we then estimate a standard panel fixed-effects model using these subperiod-within-transformed variables, by which we also control for θ_i .

Following Renner et al. (2014), using the estimated vectors and matrixes of parameters from (2), the flexibility index can be computed for household i and period T ,

$$\text{Flexibility}_{iT} = -\{(\mathbf{1}'_i \cdot \mathbf{D}_x)^{-1} \cdot \mathbf{y}' [\mathbf{D}_y \mathbf{D}'_y - \mathbf{D}_{yy} + \mathbf{D}_{yx} (\mathbf{D}_{xx} + \mathbf{D}_x \mathbf{D}'_x)^{-1} \mathbf{D}_{xy}] \mathbf{y} + 2(\mathbf{1}'_i \cdot \mathbf{D}_x)^{-1} (\mathbf{1} + \mathbf{y}' \mathbf{D}_y \cdot \mathbf{D}^{-1})\}. \quad (4)$$

Notations are as defined in Renner, Glauben, and Hockmann (2014). In our case of two outputs and two inputs, specifically, $\mathbf{1}_i$ is the (1×1) vector of one, and \mathbf{D}_x and \mathbf{D}_y are vectors of coefficients for $\ln x$ and $\ln y$ in (2). Similarly, \mathbf{D}_{yy} , \mathbf{D}_{xx} , \mathbf{D}_{xy} are matrixes of coefficients for $\ln y \cdot \ln y$, $\ln x \cdot \ln x$, and $\ln x \cdot \ln y$ in (2); \mathbf{y} is the vector of the values of outputs; and \mathbf{D} is the predicted value of distance from the technology frontier estimated in (2). Formula (4) computes the flexibility index for each observation i , for each of two subperiods (waves 1–2 and waves 3–4). The negative sign “–” is added in front so that a more positive value of *Flexibility* indicates greater flexibility.⁶

We then assess how the changes in this flexibility are affected by changes in the corresponding PE of the LGA and state in which the household resides. Specifically, we split the samples into two groups, one that experience relative increase in share of total PE between waves 1-2 and 3-4, and the other that experience relative decrease, based on various thresholds. We then compute the sample medians of estimated Flexibility_{iT} in each group, and whether the changes in Flexibility_{iT} between waves 1-2 and 3-4 are statistically significantly different between these two groups.

⁶ This is because *flexibility* in Renner, Glauben, and Hockmann (2014) is based on the *flatness* of the cost curve, while the term inside the brackets $\{\}$ in (2) measures the steepness of the curvature of the cost curve.

Appendix B: Detailed analytical results

Table 12. Effects of public expenditure shares and size on household-level outcomes, when the PE figures are averaged over the two years preceding the respective survey year (instead of three years including the survey year)

Outcome variables	PE shares for each sector (effects of one percentage point increase)				PE size (effects of 1 % increase)
	Agriculture	Health	Education	Social welfare	
Consumption per capita	5.674*** (1.055)	5.969*** (1.259)	2.034*** (0.366)	9.329*** (1.106)	1.423*** (0.060)
Above poverty line of 1.00 international PPP dollars per day per capita	0.773*** (0.270)	0.947*** (0.217)	0.396*** (0.090)	1.039*** (0.246)	0.216*** (0.011)
Above poverty line of 1.90 international PPP dollars per day per capita	1.088*** (0.321)	0.740*** (0.220)	0.316*** (0.119)	0.953*** (0.346)	0.177*** (0.014)
Above poverty line of 3.20 international PPP dollars per day per capita	0.803*** (0.226)	0.617*** (0.212)	-0.047 (0.114)	0.628*** (0.303)	0.144*** (0.014)
Above poverty line of 5.50 international PPP dollars per day per capita	0.600*** (0.188)	0.283* (0.145)	0.134 (0.082)	-0.036 (0.216)	0.066*** (0.010)
Nonfarm capital	4.268*** (1.363)	2.825** (1.107)	0.487 (0.573)	3.877*** (1.429)	0.914*** (0.075)
Household dietary diversity score in post-planting season	0.025** (0.012)	0.034*** (0.007)	-0.002 (0.005)	-0.009 (0.013)	-0.002*** (0.001)
Household dietary diversity score in post-harvesting season	0.011 (0.010)	0.009 (0.007)	0.001 (0.005)	-0.043*** (0.011)	0.000 (0.001)

Source: Authors.

Note: Sample size = 14,502. Asterisks show statistical significance: *** 1%; ** 5%; * 10%.

Table 13. Effects of public expenditure shares and size on household-level outcomes, when the expenditure figures from neighboring LGAs are excluded

Outcome variables	PE shares for each sector (effects of one percentage point increase)				PE size (effects of 1 % increase)
	Agriculture	Health	Education	Social welfare	
Consumption per capita	3.964*** (1.151)	10.640*** (1.124)	0.756* (0.438)	13.760*** (1.067)	1.383*** (0.061)
Above poverty line of 1.00 international PPP dollars per day per capita	0.601** (0.305)	1.550*** (0.219)	0.044 (0.110)	2.072*** (0.232)	0.211*** (0.012)
Above poverty line of 1.90 international PPP dollars per day per capita	-0.085 (0.384)	1.521*** (0.269)	0.061 (0.148)	1.913*** (0.302)	0.171*** (0.015)
Above poverty line of 3.20 international PPP dollars per day per capita	0.223 (0.325)	1.033*** (0.252)	-0.220 (0.143)	1.262*** (0.277)	0.143*** (0.014)
Above poverty line of 5.50 international PPP dollars per day per capita	0.307* (0.188)	0.478** (0.179)	0.076 (0.103)	-0.019 (0.210)	0.065*** (0.011)
Nonfarm capital	4.038** (1.771)	7.537*** (1.314)	-0.375 (0.693)	8.336*** (1.411)	0.889*** (0.076)
Household dietary diversity score in post-planting season	0.037* (0.020)	0.013 (0.011)	-0.011* (0.006)	-0.003 (0.013)	-0.002*** (0.001)
Household dietary diversity score in post-harvesting season	0.045*** (0.014)	-0.024** (0.010)	-0.004 (0.006)	-0.015 (0.011)	0.000 (0.001)

Source: Authors.

Note: Sample size = 14,502. Asterisks show statistical significance: *** 1%; ** 5%; * 10%.

Table 14. Signs of statistically significant coefficients for control variables in the primary analytical specifications for key household output variables of interest

Variables	Outcome variables in the equations								
	Above poverty line of:							Dietary diversity (post-planting season)	Dietary diversity (post-harvest season)
	Consumption	1.00 international PPP dollars	1.90 international PPP dollars	3.20 international PPP dollars	5.50 international PPP dollars	Nonfarm capital			
Rainfall anomaly			+			-		+	
Temperature anomaly	-	-	-	-	-	-			
Age	-	-							
Distance to administrative center				-					
Agricultural wages				+	+		+	+	
Education	+	+	+	+		+	+	+	
Gender of head	+	+						-	
Household members, by sex and age, number									
Male, over 60 years old	+	+		-	-				
Female, over 60 years old			-	-	-	+	+	+	
Male, 20–60 years old		-	-	-	-	+	+	-	
Female, 20–60 years old	-	-	-	-	-	+	+	+	
Male, 15–19 years old			-	-	-	-		-	
Female, 15–19 years old	-		-	-	-	+	+	+	
Male, 10–14 years old			-	-	-				
Female, 10–14 years old	-	-	-	-	-		+	+	
Male, 5–9 years old		-	-	-	-	+			
Female, 5–9 years old	-		-	-	-	+	+	+	
Male, 0–4 years old	-	-	-	-	-	+	+	+	
Female, 0–4 years old	-		-	-	-	+			
Price of fertilizer	-					-		+	
Value of livestock			+				+		
Household asset per capita	+	+	+	+	+	+	+	+	
Distance to nearest major market						-			
Farm size								+	
Number of plots	+		+	+	+		+		
Tractor owners in LGA	-	-	-	-	-		+		
Community-level shocks									
drought						+	-		
flood									
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	+	+	+				+	-
Number of institutions in community	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Wave dummy	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Wave × geopolitical zones	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Wave × tractor owner in LGA	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Intercept	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Sample size	14,502	14,502	14,502	14,502	14,502	14,502	14,502	14,502

Source: Authors.

ABOUT THE AUTHORS

Hiroyuki Takeshima is a Senior Research Fellow in the Development Strategy and Governance Division (DSGD) of the International Food Policy Research Institute (IFPRI), based in Washington, DC, USA. **Bedru Balana** is a Research Fellow in DSGD of IFPRI, based in Abuja. **Jenny Smart** is a Senior Program Manager in DSGD of IFPRI, based in Washington, DC. **Hyacinth Edeh** is Country Program Manager for the Nigeria Strategy Support Program (NSSP) of IFPRI, based in Abuja. **Motunrayo Ayowumi Oyeyemi** a Research Analyst with the NSSP of IFPRI, based in Abuja. **Kwaw S. Andam** is a Research Fellow in DSGD of IFPRI and Leader of NSSP of IFPRI, based in Abuja.

ACKNOWLEDGEMENTS

This paper was prepared under the Feed the Future Nigeria Agricultural Policy Project, funded by the United States Agency for International Development (USAID). We also are grateful to the CGIAR Research Program on Policies, Institutions, and Markets (PIM) for providing additional support for this research.

INTERNATIONAL FOOD POLICY RESEARCH INSTITUTE

1201 Eye St, NW | Washington, DC 20005 USA
T. +1-202-862-5600 | F. +1-202-862-5606
Email: ifpri@cgiar.org | www.ifpri.org | www.ifpri.info

IFPRI-ABUJA

c/o International Fertilizer Development Center
No.6 Ogbagi Street | Off Oro-Ago Crescent, Garki II
Abuja | Nigeria
ifpri-nigeria@cgiar.org | nssp.ifpri.org/

The Nigeria Strategy Support Program (NSSP) is managed by the International Food Policy Research Institute (IFPRI) and is financially made possible by the generous support of the American people through the United States Agency for International Development (USAID) in connection with the Feed the Future Nigeria Agricultural Policy Project. The research presented here was conducted as part of the CGIAR Research Program on Policies, Institutions, and Markets (PIM), which is led by IFPRI. This publication has been prepared as an output of NSSP. It has not been independently peer reviewed. Any opinions expressed here belong to the author(s) and do not necessarily reflect those of IFPRI, USAID, PIM, or CGIAR.

© 2021. Copyright remains with the author(s). This publication is licensed for use under a Creative Commons Attribution 4.0 International License (CC BY 4.0). To view this license, visit <https://creativecommons.org/licenses/by/4.0>.