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On-Farm and Off-farm Works: Complement or Substitute?

Evidence from Rural Nigeria

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Abstract

Farming as a primary source of income has failed to guarantee sufficient livelihood for most farming households in developing countries, and agricultural development policies have largely produced little improvement, especially in Sub-Saharan Africa. Diversification into off-farm activities has become the norm. While the poverty and inequality effects of off-farm income have been analyzed in different developing countries, much less empirical studies have been conducted on the impact of off-farm income on agricultural production and efficiency. Using survey data from rural Nigeria, this article examines the effect of off-farm income on farm output, expenditure on purchased inputs and technical efficiency among farm households. The results indicate that off-farm income has a positive and significant effect on farm output and demand for purchased inputs. Though the result does not establish that off-farm income improves technical efficiency, there is a slight efficiency gains in households with off-farm income. The findings of this study challenge the notion that participation in off-farm activities may lead to a decline in own-farm agricultural production, due to competition for family labour between farm and off-farm works. Rather, they tend to suggest that there are indeed elements of complementarities and positive spill-over effects between the farm and off-farm sectors of rural the economy. Removing credit market imperfections and upgrading rural infrastructure could enhance the development of both sectors simultaneously.

Key words: Farm households, farm output, off-farm income, purchased inputs, technical efficiency.

1. Introduction

For a very long time, the perception of farm households in developing countries is that they rely almost exclusively on agriculture and undertake little or no activities off farm. This perception has led policy makers to concentrate on the farm sector at the expense of the off-farm sector. However, since the last three decades or so, there has been increasing evidence showing that small-holder farm households in developing countries rarely rely on agriculture alone, but often maintain a portfolio of income activities in which off-farm activities are an important component (Barrett et al., 2001). Haggblade et al. (2010) indicate that non-farm income accounts for between 35% and 50% of total income of rural households in developing countries. Davis et al. (2007) put the global figure at approximately 58%, with some countries having a share as high as 75% of total income on average. The share of off-farm income is expected to increase substantially in the coming years, especially in sub-Saharan Africa where increasing population growth and limited agricultural resources are threatening the growth of the agricultural sector (Haggblade et al. 2007). In terms of participation, the level is even higher. For instance, Jolliffe (2004) found that in rural Ghana in 2004, 74% of farm households were engaged in off-farm activities. Fernandez-Cornejo (2007) reported 65% and 75% participation rate among United States and Taiwan farm households respectively.

Development economics literature has identified two main factors that drive diversification into off-farm activities among farm households in developing countries. These factors are broadly classified into "pull factors" and "push factors". Reasons why a farm household can be pulled into the off-farm sector include higher returns to labour and or capital and the less risky nature of investment in the off-farm sector (Kilic et al., 2009). The push factors that may drive off-farm income diversification include: first, the need to increase family income when farm income alone cannot provide sufficient livelihood (Minot et al., 2006); second, the desire to manage agricultural production and market risks in the face of a missing insurance market (Reardon, 1997; Barrett et al., 2001); and third, the need to earn income to finance farm investment in the absence of a functioning credit market (Reardon, 1997; Ruben and van den Berg, 2001; Kilic et al., 2009; Oseni and Winter, 2009).

The agricultural investment effect of off-farm income diversification is particularly important for poor farm households. This is because lack of liquidity and poor access to credit are the most pressing constraints to improved agricultural productivity among farm households in developing countries (Deininger et al., 2007; Haggblade et al., 2007). Apart from providing flows of cash income that can be used to purchase farm inputs and hire labour for agricultural production, evidence of a steady off-farm income has been used as collateral for agricultural loans, given the inadequacy of land, in certain settings (Hert, 2009; Collier and Lal, 1986; Hoffman and Heidhues, 1993).

There is a relatively large body of literature in which the effect of off-farm income diversification on poverty and inequality in developing countries have been examined (e.g. Block and webb, 2001; de Janvry and Sadoulet, 2001; Lanjouw et al., 2001). In contrast, only few studies have been conducted on the agricultural production and efficiency effects of off-farm income diversification (Pfeiffer et al., 2009).The few available studies are either based on qualitative analyses or rely on a simple comparison of means with biased ordinary least squares approaches (Ellis and Freeman, 2004; Oseni and Winter, 2009). This apart, many of the available studies often present mixed results, and this calls for further empirical research, at least, to better understand the situation in specific settings and provide findings that are needed for an appropriate policy response.

The objective of this study is to examine the effect of off-farm income diversification on agricultural production in rural Nigeria. Both descriptive and empirical approaches were employed to analyze the effect of off-farm income on farm output, purchased input expenses and technical efficiency.[1] I use detailed cross-sectional survey data collected from 220 farm households in 40 villages of Kwara State, Nigeria.

In Nigeria, evidence on the importance of off-farm income diversification and its effect on agricultural production are scarce. Available studies such as Oseni and Winter (2009), though used a nationally representative data set, relied only on crop input expenses to draw conclusion on the agricultural production effect of off-farm income diversification. Besides, the study focused on rural non-farm income, which excludes agricultural wage income. However, agricultural wage income could be very important, particularly for the landless and migratory farmers who are more common in the north-central region of Nigeria. Apart from the study mentioned above, I am not aware of other recent and related studies that have analyzed the agricultural production effect of off-farm income from a broader perspective, also taking into account, apart from crop input expenses, the value of farm output and technical efficiency in rural Nigeria.

Theoretically, the effect of off-farm income on agricultural production within the same household could be positive, negative or nil, depending on the household's degree of integration with factor or product markets (Lopez-Feldman et al., 2007). For instance, it could be positive when off-farm incomes are spent on financing farm investment so that the positive investment effect outweighs the negative effect of removing family labour from agriculture (Pfeiffer et al., 2009). On the other hand, it could be negative, if the income earned off the farm is not spent on agricultural production, but rather, on increasing consumption, financing investment in non-agricultural activities, or migration out of agriculture entirely (Pfeiffer et al., 2009). The effect could also be nil when the

[1] Off-farm income and non-farm income are used interchangeably in several places in this paper. The difference between the two is that off-farm income is much broader than non-farm income and it is made up of agricultural wage income plus non-farm income. Some authors adopt non-farm income, which exclude income from agricultural employment on other people's farm. They prefer to include it as a component of farm income, but in this paper it is included as component of off-farm income.

positive effect through agricultural financing just equals the negative effect of family labour loss from agriculture.

Despite the complex nature of the off-farm – farm linkages that makes it very difficult to have an *a priori* expectation of the net effect of off-farm income on agricultural outcomes, it is hypothesized that off-farm income contributes positively to better agricultural production in terms of larger farm output, crop input expenses and technical efficiency. Changes in agricultural production and input use by farm households that receive off-farm income are likely to represent an important part of the overall effect of off-farm income diversification in economies where agriculture remains an important source of livelihood for many households. Understanding the linkages could have far-reaching policy implications for the development of the rural economy as a whole. A positive effect of off-farm income on agricultural production could imply that stimulating the rural off-farm sector will enhance growth of the farm sector also (Pfeiffer et al., 2009). On the other hand, if off-farm income impacts negatively on agricultural production, then what policy measures are needed to eliminate or reduce the negative impact?

The remaining parts of this paper are organized as follows. Section 2 discusses the data used. Section 3 presents the sample characteristics and section 4 explains the methodology adopted, including the empirical strategy and estimation procedures. Section 5 presents and discusses the results, while section 6 concludes with policy implications.

2. Data

The data used in this study are derived from a comprehensive farm household survey of 40 rural villages in Kwara State, north-central region of Nigeria, which was conducted in 2006. According to Oseni and Winter (2009), the northern region is mainly an agricultural economy and has higher poverty prevalence and more rural villages than the southern region. As a livelihood strategy, most rural farm households in northern Nigeria participate in off-farm activities as an alternative source of income. Kwara State was chosen for this study because of its high poverty incidence, its considerable socioeconomic heterogeneity and its location: it is among the six poorest in Nigeria in terms of prevalence of undernourishment and income poverty (NBS, 2006), it has a good mixture of the three major ethnic groups in Nigeria and it is the gateway between the northern and southern regions. Local farm produce is often sold to itinerant traders from the south and far north, while the presence of these traders also encourages other off-farm businesses. Kwara State has a total population of about 2.4 million people, 70% of which can be classified as smallholder farmers (NBS, 2006). The farming system is characterized by low quality land and predominantly cereal-based cropping patterns. Farm size is generally low so that most farm households are net buyers of food, at least seasonally (KWSG, 2006).

The sample consists of 220 farm households which were selected by using a multi-stage random sampling technique. Eight out of the 16 local government areas in Kwara State were randomly selected in the first stage.[2] Then, five villages were randomly chosen from each selected local government area, and finally, six households were sampled in each of the resulting 40 villages, using complete village household lists provided by the local authorities. Thus a total of 240 households were selected. Personal interviews were carried out with the household head, usually in the presence of other family members. A standardized questionnaire was used that covered information on household farm and off-farm activities and income, socioeconomic characteristics, and various institutional and contextual variables. Agricultural production activities are mainly food-crop-based with little livestock rearing. Farm income covers commodity sales and subsistence production, both valued at local market prices. Respondents were asked to specify in detail all inputs used, outputs obtained, and prices for the different crop and livestock activities over the 12-month period prior to the survey.

Since the primary interest is to examine the agricultural production effects of off-farm income, emphasis was more on the inputs used and farm output obtained from the household farm during the last 12 months before the survey. Off-farm income is defined here to include all cash money received from agricultural wage employment, non-agricultural wage employment, self-employment, remittances, and other income such as capital earnings and pensions. These were recorded separately for all household members, also covering a 12-month period, in order to avoid a seasonality bias. Total farm output is obtained by converting the total harvest of the individual crops to their grain equivalent (GE).[3] The total grain equivalent is thereafter converted to the market value in naira using the prevailing local market price. Value of purchased inputs such as hired labour, seeds and seedling, fertilizer, agrochemicals and machinery, were collected for the last farming season. These data were collected at individual crop/plot level and subsequently aggregated to obtain household level information.

3. Sample characteristics

Table 1 presents the definition and summary statistics of selected socioeconomic characteristics derived from the sampled households, which were later used as covariates in the econometric estimations. The annual total value of all farm output is approximately 110 thousand naira (735 US$) and 24 thousand naira worth of purchased input (165 US$)

[2] Local government area is the smallest administrative unit in Nigeria, usually made up of several wards. A ward consists of several villages that are often composed of people of related ethnicity and culture.

[3] Grain equivalent is the metric tons of grains necessary to produce a given amount of non-cereal commodity. It is obtained by multiplying the metric weight of the non-cereal commodity by a conversion factor that is specific for that commodity. For effective aggregation of non-cereal agricultural commodities, conversion to grain equivalent has been used extensively in research work to get a common denominator that is free of bias.

was used during the farming season. Though many farm households rarely put value on their family labour input, we find that 33 thousand naira (224 US$) worth of family labour input was used in farm work. This amount is higher than the total value of purchase input use for the same period. The estimated technical efficiency figure of 0.71 is consistent with efficiency estimates that have been reported by many authors for north central region of Nigeria (Liverpool-Taise et al., 2011).

The average household size of five adult equivalents (AE) is consistent with the national average reported by NBS (2006). About 10 per cent of the households are headed by women. The average age of the respondent farmers in the sample is 59 years and has approximately seven years of schooling. The average educational status of the household head is slightly higher than the national average, which can be explained by the fact that the density of elementary schools is relatively high in the rural areas of Kwara State (Babatunde and Qaim, 2009). We differentiated between the education of household (HH) heads and of other adult HH members. This is important in our context, as household members' education may contribute in different ways to the decision to enter off-farm activities. The average education of other adult household members is about 10 years of schooling. The mean farm size of 1.9 ha is comparable to the national average of 2 ha. The value of the household productive assets is approximately 74 thousand naira (US$617).

Table 1: Summary statistics and definition of variables used in the analysis

Variable	Definition and unit	Mean	SD
Dependent variables			
FARM_OUT	Average value of total farm output (naira)	110,323	50,532
PURCH_INP	Average value of purchased inputs use (naira)	24,755	23,168
FAM_LAB	Average value of family labour use (naira)	33,527	15,873
TECH_EFF	Average technical efficiency estimate	0.71	0.62
Independent variables and instruments			
HH_SIZE	Number of people in the household (adult equivalent)	5.08	1.31
GENDER	Gender of household head (male = 1, female = 0)	0.90	0.31
AGE_HHH	Age of household head (year)	59.1	6.80
EDU_HHH	Education of household head (year)	6.89	3.93
EDU_OTHER	Education of other adult household member (year)	10.2	5.21
FARM_SIZE	Land area cultivated by the household (ha)	1.90	0.58
HIRED_LAB	Average value of hired labour use (naira)	7,590	4,641
TOT_LAB	Average value of both hired and family labour use (naira)	41,118	16,896
FARM_EXP	Years of farming experience of household head (year)	35.3	10.8
ASSETS	Value of household productive assets (naira)	73,761	53,154
ELECT	Dummy for electricity in household (yes = 1, no = 0)	0.83	0.38
T_WATER	Dummy for tap water in household (yes = 1, no = 0)	0.65	0.48
D_MARKET	Distance to the nearest urban market place (km)	11.71	12.89
TOT_INC	Average total household income per year (naira)	140,845	94,997
FARM_INC	Average total household farm income per year (naira)	70,845.9	51,334.4
OFF-FARM_INC	Average total household off-farm income per year (naira)	69,999.1	77,575.2

Notes: Official exchange rate in 2012: 1 US dollar = 150 naira; SD is standard deviation. AE is adult equivalent. The number of observations is N = 220.

The infrastructure variables shown in Table 1 indicate that many of the farm households do not have access to electricity and pipe-borne water and the distance to the nearest urban market place is 11.7km on average. On average, a respondent farmer has about 35 years of experience in agricultural production. Total household income is approximately 140,845 naira (939 US$) per year from all income sources. This is higher than the national average of 126,895 naira (846 US$) in Nigeria.

4. Methodology

The main objective of this study is to assess the impact of off-farm income on farm household agricultural production outcomes, including farm output, purchase input expenses and technical efficiency. The analysis begins with analyzing the impact of off-farm income on the total value of farm output, and then followed by the impact on the total value of purchased input, which includes hired labour and other variable inputs. The last part of the analysis explores the impact of off-farm income on technical efficiency of the farmers.

Following Kilic et al. (2009), a farm production outcome model of a farm household was specified as follows:

$$Y = \beta_0 + \beta_1 O + \beta_2 X + \varepsilon \quad (1)$$

Where Y is the value of farm output or purchased input or technical efficiency; β_0 is the constant term, β_1 and β_2 are parameters to be estimated, O is household off-farm income, X is a set of household characteristics and ε is the error term. The coefficient β_1 is the main parameter of interest because it measures the impact of off-farm income on the production outcome. A positive and significant value of β_1 would suggest that off-farm income has a favourable effect on agricultural production and efficiency and vice-versa.

A key requirement for the estimation of equation (1) is that all the right-hand side variables are truly exogenous. However, in reality, there might potentially be a reverse causality problem leading to endogeneity of off-farm income: investment in farm production at the household level could depend on earnings from off-farm work, and access to off-farm economic activities might also depend on income from agriculture. The effect is that the estimate of coefficient β_1 will be biased and inconsistent when ordinary least square regression method is used (Kilic et al., 2009). In order to tackle this endogeneity bias, the study uses an instrumental variable (IV) approach. This is considered appropriate given that a cross-sectional dataset was used that could not allow controlling for unobserved household-level fixed effect.

Apart from endogeneity of off-farm income, an additional consideration in estimating the model is that which is related to the multi-stage random sample selection approach adopted in the survey. In this approach, household observations are clustered by villages thereby introducing a potential intra-cluster correlation of the error term that produces an inconsistent variance-covariance matrix. As a remedy for this problem, the study uses a cluster correction procedure, so that the t-values are derived from robust standard errors (Deaton, 1997). While the empirical strategy described above represents the main analytical technique used in the article, additional information on specific estimation issues, explanatory variables and instruments used for the individual model are described in a more detailed form in the following sessions.

5. Results

5.1 Preliminary descriptive result

To get a sense of the effect of off-farm income in a descriptive way, I present in Table 2 important farm and household variables, differentiating between households with and without access to off-farm income.

Table 2: Farm and household variables disaggregated by off-farm income status

Variable	Households with off-farm income (N = 193)	Households without off-farm income (N = 27)	T-test (mean difference)
FARM_OUT	110,908.6	106,144.1	1.72*
PURCH_INP	25,492	19,486	2.21**
FAM_LAB	28,850	34,150	1.51
TECH_EFF	0.73	0.71	-1.01
HIRED_LAB	41,700	36,800	1.67*
AGE_HHH	56.0	58.6	-1.09
GENDER	0.90	0.85	1.16
EDU_HHH	7.0	7.0	0.55
HH_SIZE	5.0	5.4	-0.71
FARM_SIZE	2.0	1.8	1.55
FARM_EXP	34.9	37.7	-1.11
TOT_LABOUR	71,550	70,950	2.17**
EDU_OTHER	10.3	9.5	1.71*
ELECT	0.84	0.74	1.07
T_WATER	0.66	0.59	1.44
D_MARKET	13.8	11.1	1.27

* Mean differences between households with and without off-farm income are statistically significant at 10% level.

** Mean differences between households with and without off-farm income are statistically significant at 5% level.

Table 2 indicates that, on average, households with off-farm income have larger values for most of the farm and households variables. When the differences are subjected to a t-test, it is interesting to note that expenditures on purchased inputs by households that have off-farm income are significantly higher, at 5% level, compared to those households that are without off-farm income. It is not surprising, therefore, that hired and total labour uses were also significantly higher among households with off-farm income. Likewise, farm output is higher among households that earn income from off-farm activities. So based on these descriptive results, it can already be suggested that access to off-farm income is associated with better agricultural production in terms of larger expenses on purchased inputs and farm output. The pathway by which off-farm income impacts on agricultural production is further examined through empirical analysis in the following sections.

5.2 Off-farm income and agricultural food production

To analyze the impact of off-farm income on agricultural production, equation (1) was estimated where the value of total farm output in naira is regressed against off-farm income and several other explanatory variables. As against the cash crop production

region of southwestern Nigeria, the dataset is from a region that is predominantly a staple crop production region, so that the value of farm output is non-zero for all households and this justifies the use of two-stage least squares (2SLS) regression technique. Being the dependent variable in this estimation, the value of total farm output is obtained by converting the total harvest of the individual crops to their grain equivalent (GE). The total grain equivalent is thereafter converted to the market value in naira. To maintain the degree of freedom, given the small sample size, six explanatory variables, including gender, age and education of household head, farm size, household size and off-farm income were used.

Four instruments were used to control for the endogeneity of off-farm income. These are education of other adult members in the household, access to electricity, access to water and distance to the nearest market place. Theoretically, education is believed to be important for off-farm income participation and also important is the education of adult members of the households. Statistically, education of adult members is relevant because it is correlated with off-farm income but very unlikely to affect agricultural production outcomes after controlling for households total income. As can be seen in Table 4, the average education of other adult members of the household with off-farm income is statistically higher than those of households without off-farm income.

Apart from education, access to infrastructure such as electricity and water, and market closeness are also believed to be important determinants of off-farm income earnings (Reardon, 1997; van den Berg and Kumbi, 2006). Households that have access to social infrastructure like electricity and water, and are close to the market are more likely to enter the off-farm sector because this infrastructure could facilitate starting of an own business and contribute to higher returns in those businesses by reducing the transaction costs (Babatunde and Qaim, 2009). The analysis of the data was carried out using the STATA statistical software package. Several functional forms of the 2SLS regression were tried, but the linear function shows the best statistical fit.

To start with, the results of the first-stage estimation of off-farm income equation were presented in Table 3 to demonstrate the relevance of the instruments. Indeed, the instruments are very relevant because of all the four instrumental variables used; only tapped water is not statistically significant, the rest are significant. As expected, education of other adult member of the household has a positive effect on off-farm income. This makes sense, since several family members often pursue off-farm income activities and educated people often have access to higher-paying off-farm jobs.

Table 3: First-stage regression results of off-farm income

	Off-farm income (naira)
Variables	
Constant	-64404.9
	(-1.44)
AGE_HHH	618.0
	(1.05)
GENDER	5485.0*
	(1.83)
EDU_HHH	3913.4***
	(3.37)
HH_SIZE	5679.3
	(1.34)
FARM_SIZE	15494.9
	(1.03)
Instruments	
EDU_OTHER	4540.5***
	(4.66)
ELECT	20877.4*
	(1.90)
T_WATER	15639.6
	(1.44)
D_MARKET	-544.2*
	(-1.89)
R^2	0.478
F-test	21.36

N = 220. Figures in bracket are *t*-values.
*, **, *** Coefficients are significant at the 10%, 5%, and 1% level, respectively.

These results agree with previous studies that have highlighted the important role of education for access to off-farm incomes (Lanjouw, 2001; Satriawan and Swinton, 2007). Access to electricity shows a positive and significant impact on off-farm income which is consistent with findings of Matshe and Young (2004) and Escobal (2001) in different contexts. Likewise, market distance plays a role, with larger distances having a negative effect on off-farm income. This result is as expected, because market closeness is a location advantage for any economic activity, thus contributing to increased off-farm income.

The second-stage results of the IV estimation of the value of farm output are shown in column (2) of Table 4. The results of the OLS estimation are also presented alongside in column (1). Because there might be some unobservable village factors that could be correlated with the off-farm income variable that are not properly captured by the instruments, I run another IV regression. In this regression, I include village-fixed

effects through 39 dummy variables, corresponding to the 40 villages in the sample. The results of the estimation are shown in column (3). The results remain largely the same and none of the village dummies is significant at the 10% level. I therefore conclude that village-fixed effects do not bias the results and so stick to the IV regression result in column (2).

The Durbin-Wu-Hausman test statistic confirms that off-farm income is indeed endogenous, so that the IV approach is appropriate. Test of validity of instruments was conducted using the Sagan chi-squared over-identification test estimator. The null hypothesis of over-identification test is that the instruments are jointly valid, and that the excluded instruments are correctly excluded from the estimated equation. Rejections of the null hypothesis will means that the instruments are not valid and vice-versa. As can be seen in Table 4, the Sagan test chi-square is insignificant, thus establishing the validity of the instruments. Column (2) indicates that off-farm income contributes positively and significantly to higher farm output of the households. This result which is consistent with the finding of Collier and Lal (1986) in rural Kenya, confirms the assertion that farm and off-farm work are complementary rather than substitutes. It also reinforces the descriptive results of Table 2 namely that household with off-farm income has a significantly higher farm output than households without off-farm income. Table 4 shows that an increase in annual off-farm income by 1000 naira will increase the value of farm output by 267 naira, on average.

The variable education of the household's head is positive and significantly related to farm output, implying that other things being equal, households with an educated head will produce more food than those without an educated head. On average, each additional year of schooling will increase the value of farm output by 1,575 naira. As expected, farm size contributes positively to farm output and every additional hectare of land cultivated leads to a rise in value of farm output by approximately 11,331 naira.

Table 4: Household agricultural production models

	(1) OLS Farm output	(2) 2SLS Farm output	(3) 2SLS Farm output
Constant	45865.2	71435.5*	71270.7*
	(1.22)	(1.87)	(1.90)
OFF-FARM_INC	0.01*	0.267**	0.202**
	(1.70)	(2.14)	(2.19)
AGE_HHH	436.9	124.7	120.3
	(0.79)	(0.23)	(0.30)
GENDER	7163.3*	1243.5	1228.1
	(1.89)	(0.10)	(0.21)
EDU_HHH	479.7	1574.6*	1620*
	(0.60)	(1.80)	(1.82)
HH_SIZE	-396.6	302.1*	300*
	(-0.15)	(1.77)	(1.78)
FARM_SIZE	16424.7***	11330.6**	11321.4**
	(2.68)	(2.11)	(2.01)
Village fixed effect	No	No	Yes
R^2	0.056		
Endogeneity test			
Durbin-Wu-Hausman χ^2		10.98***	10.29***
Test of validity of instruments			
Sagan test χ^2		4.21	4.01
F-test	2.08	2.80	2.67

N = 220. Figures in bracket are *t*-values.
*, **, *** Coefficients are significant at the 10%, 5%, and 1% level, respectively.

5.3 Off-farm income and purchased input demand

In this section, I analyze the effect of off-farm income on the demand for purchased input. In the regression, the dependent variable is the total value of purchased input in naira, including the value of hired labour, fertilizer, pesticides, seeds and machinery. As explanatory variables, I use the same households' characteristics as above. However, unlike before, I use IV Tobit for this estimation. This is because not all households spend on purchased inputs during the season, so that the values of purchased input are censored at zero. The same instruments were also used as above and I run the regression employing a cluster correction technique. As a complementary analysis, I also carry out a 2SLS estimation of family labour use. This is to be able to isolate the effect of substitutionability of family labour and hired labour. For instance, it is often assumed that households that use more family labour will use less hired labour, other things being equal. Besides, family labour is not imputed into the purchased input variable (Pfeiffer et al., 2009).

Table 5 shows the results of the estimation of purchased input and family labour use. In the purchased input equation, the estimates are marginal effects, while they are linear estimates in the family labour use equation. As before, the endogeneity of off-farm income is confirmed for both equations, and the test of validity of instruments failed to reject the null hypothesis of validity of the instruments. Column (1) shows that off-farm income significantly increases expenses on purchased inputs among farm households in the Kwara State. A 100 naira increase in off-farm income will increase expenditure on purchased input by 11 naira on average. By contrast, off-farm income significantly decreases family labour use (column 2). Indeed, an increase of 100 naira in off-farm income will reduce value of family labour input use by 10 naira. This result is in tandem with findings by Pfeiffer et al. (2009) for Mexico, Mathenge and Tschirley (2009) for Kenya, Maertens (2009) for Senegal and Lamb (2003) for India. When the results of column (1) and (2) are combined, they explain the substitution effect between the use of family labour and purchased input (which includes hired labour and machinery). The results also imply that off-farm income helps to loosen the liquidity constraints of households that prevent them from purchasing the optimal amount of inputs.

Table 5: Purchased inputs and family labour use model

	(1) IV Tobit Purchased input	(2) 2SLS Family labour
Constant	50363.6***	26268.7**
	(3.13)	(2.34)
OFF-FARM_INC	0.11**	-0.10**
	(2.11)	(-2.08)
AGE_HHH	-982.2	-168.5
	(-0.89)	(-1.07)
GENDER	7376.0	7999.6**
	(1.43)	(2.23)
EDU_HHH	481.3***	-185.6
	(4.34)	(-0.49)
HH_SIZE	1353.7	2482.3***
	(1.14)	(3.01)
FARM_SIZE	6261.1**	1143.3
	(2.18)	(1.57)
R^2	0.110	0.01
Endogeneity test		
Durbin-Wu-Hausman χ^2	25.67***	17.10***
Test of validity of instruments		
Amemiya-Lee-Newey min. stat. χ^2	1.217	
Sagan test χ^2		4.29

N = 220. Figures in bracket are *t*-values.
*, **, *** Coefficients are significant at the 10%, 5%, and 1% level, respectively

The other significant variables in the purchased input equation are education of the household head and farm size. Every additional year of schooling by household heads will increase expenditure on purchased inputs by 481 naira, on average. Likewise, an additional hectare of land cultivated will add 6,261 naira to expenses on purchased inputs. This makes sense considering that larger farms are those where larger purchased inputs are needed for effective coverage. The family labour equation results indicate that households headed by a male farmer use more family labour than those headed by a female farmer. This might be because male farmers are able to compel adult members of the household to help more often in farm work than their female counterparts. It might also be because men work more on the family farm than women in rural Nigeria. Household size is positively related to family labour use. This is expected as larger households are more likely to use family labour than smaller households, other things being equal.

5.4 Off-farm income and technical efficiency

To test the effect of off-farm income on farm technical efficiency, a stochastic frontier production function was estimated. Given the input use in agricultural production, the stochastic frontier production function approach enables one to compute each household's degree of technical efficiency, which equals to the ratio of actual output to its potential output. It also corresponds to a particular point on the household's production frontier at which technical inefficiency is zero (Kilic et al., 2009).

According to Pfeiffer et al. (2009), the production frontier represents the maximum output attainable from each input combination and farms operating on this frontier are technically efficient while those operating below the frontier are not. For the purpose of this study, I estimate a stochastic frontier production function, which is in Cobb-Douglas (log-log) form:

$$\ln(Y_i) = \beta_0 + \sum \beta_n \ln X_{ni} + \varepsilon_i \quad (2)$$

$$\ln(Y_i) = \beta_0 + \sum \beta_n \ln X_{ni} + (v_i - u_i) \quad (3)$$

Y is the value of farm output; β_0 is the constant term; X_n is a set of input quantities, β_n refers to unknown parameters to be estimated and ε_i is the error term. The error term ε_i is further defined as $(v_i - u_i)$, where v_i are random variables assumed to be normally distributed and it include measurement errors, exogenous and other random errors. The term u_i is nonnegative random variables that are assumed to account for technical inefficiency in production. In particular, u_i corresponds to shortfall in output from its maximum value given by the stochastic production frontier (Kilic et al., 2009). A similar model was used by Coelli et al. (1998) to investigate productivity and efficiency differences in agricultural production between households with and without off-farm income.

The stochastic frontier production function was estimated using the maximum likelihood method. This approach helps to estimate both the stochastic frontier production equation and the determinants of technical inefficiency simultaneously. In the estimation of the stochastic frontier production function, purchased input, farm size, total labour input and years of farming experience were included as explanatory variables. To avoid the multicollinearity problem, the value of hired labour was excluded from the value of purchased input, since it is also included in another explanatory variable, value of total labour use. In the inefficiency equation, I include off-farm income, household size, age, education and gender of household head. Since it is impossible to instrument for off-farm income while estimating this equation, I use predicted values from the first-stage regression of off-farm income in Table 3.

Table 6 presents the maximum likelihood result of the stochastic frontier estimation. The estimates represent direct elasticity of production. The upper part of the table indicates that purchased inputs, farm size and labour input, all have a positive and significant effect on the value of farm output. The elasticity of purchased input, farm size and labour input are 0.11, 0.18 and 0.01, respectively. This implies that 0.11%, 0.18% and 0.01% increase in agricultural production will result from a 1% increase in purchased input expenses, farm size and labour input respectively.

The bottom part of Table 6 presents the results of the determinants of technical inefficiency (i.e. distance from the production frontier) across farm households. A negative estimate on the variable corresponds with a positive effect on technical efficiency and vice-versa. The results show that off-farm income is positively related to technical efficiency, but the effect is not statistically significant. This indicates that, though off-farm income enables farmers to buy more purchased inputs and produce more output, it cannot be said to enhance farmers' efficiency. This might not be unconnected with the fact that farmers with off-farm income have less time to monitor and ensure an efficient utilization of the purchased inputs they deployed in agricultural production. Age of the household's head significantly increases technical efficiency. This is probably because older farmers are more experienced in managing farm work than younger farmers. Similarly, households with a more educated head tend to be more efficient in agricultural production.

Table 6: Double-log stochastic frontier estimation results of value of farm output

	Stochastic frontier MLE
Constant	5.02***
	(16.37)
PURCH_INP	0.112**
	(2.55)
FARM_SIZE	0.179***
	(3.91)
TOT_LABOUR	0.01**
	(2.35)
FARM_EXP	0.222
	(1.02)
Inefficiency variables	
Constant	7.51
	(1.34)
OFF-FARM_INC	-0.005
	(-0.98)
AGE_HHH	-0.071**
	(2.08)
GENDER	-0.623
	(-1.10)
EDU_HHH	-0.047***
	(4.21)
HH_SIZE	0.261
	(0.72)

Note: Dependent variable is the logarithm of value of total farm output and the explanatory variables are in logarithm form also.
N = 220. Figures in bracket are *t*-values.
*, **, *** Coefficients are significant at the 10%, 5%, and 1% level, respectively

6. Conclusions

To overcome their credit constraints, farm households in developing countries are increasingly seeking alternative sources of income by participating in off-farm activities. The income from these activities may then be used for investment in agricultural production. So far, the pathways by which off-farm income affect agricultural production has not been a major subject of empirical research in the development economic literature. In this article, I have analyzed the effect of off-farm income on agricultural production, using farm households survey data collected from 40 villages in Kwara State of Nigeria.

The results of the Instrumental Variable estimation suggest that off-farm income contributes to higher farm production and larger expenses on purchased inputs, while it

decreases the use of family labour. This implies that, unlike in countries such as Albania, where it appears that off-farm income is not invested in agriculture, in Kwara State of Nigeria, where liquidity constraints is a major problem, off-farm income is used to relax liquidity problems and expand agricultural production. Though our result does not establish that off-farm income improves technical efficiency, there is a slight efficiency gains in households with off-farm income.

Clearly, this finding is specific to the empirical example of Kwara State of Nigeria and should not be generalized to other regions of the World. Nonetheless, it tends to suggest that there are elements of complementarities and positive spill-over effects between the farm and off-farm sector of the rural economy. The result challenges the notion that participation in off-farm activities may lead to a decline in own-farm agricultural production due to competition for family labour between farm and off-farm works. Indeed, there is a decrease in family labour available for farm work, but this is over-compensated for through the purchased inputs demand that is made possible using the off-farm work earnings.

From a policy perspective, the findings suggest that, although most households participate in the farm sector, rural development policies aimed at poverty reduction should focus equally on both the farm and the off-farm sectors. Farming as a primary source of income has failed to guarantee sufficient livelihood for most farming households in developing countries and agricultural development policies have largely produced little improvement, especially in Sub-Saharan Africa. Off-farm activities have been meeting the gap by directly increasing households' income and providing cash that is invested in farm inputs to increase agricultural production. The concern therefore should be to implement policies that will impact positively on both sectors for overall improvement in rural life. Given the complementarities between off-farm and farm activities and the fact that both sectors actually face similar constraints, application of appropriate policy programmes that can serve both sectors is recommended. For instance, removing credit market imperfections and creation of accessible credit schemes can facilitate the establishment of off-farm businesses and promote agricultural development simultaneously. Likewise, provision of physical infrastructure can reduce transaction costs in both sectors and increase overall employment opportunities.

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