(First Draft)

Is non-farm income relaxing farm investment liquidity constraints for marginal farms?: a double hurdle approach

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Abstract

The paper explores determinants of off/on-farm participation, and off-farm income and farm investment linkages. The data for this study are derived from 734 participant and non-participants sample households from eight villages, drawn from the three agro-climatic zones of the Geba catchment, in northern Ethiopia. To analyze the survey results and test the theory that off-farm income relaxes the liquidity constraints a double-hurdle model and Tobit models are employed. These models take into account the sample selection bias associated with access to off/on-farm activities. The robustness of the models has been validated by the various tests undertaken. Accordingly, farm input demand (fertilizers) for farm households is estimated. The results of the econometric models finds no evidence (for fertilizer) to support the hypothesis that income from non-farm activities contributes towards increasing farm investment for the sampled households. This is mainly the low level of income coming from the off/non-farm sector and thereby low savings rates left-over from the basic food and related expenses of the rural households. In addition to the endogenous variable, exogenous variables such as the human, land size and animal asset ownership, natural, physical and locational capitals were found to be significant and important factors affecting the decision to participate in off-activities and farm input use intensity, although some variables conditioning the two dependent variables (off-farm and participation, fertilizer) differently.

Key words: off-farm-farm investment linkage, double-hudle

1. Introduction

Following the pioneering work by Anderson and Leiserson (1980), the importance of non/off-farm activities to the livelihood of the rural households in developing countries, has remained the center of attention by both academics and policy research. The

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importances of non-farm income, in terms of income contribution have been evidenced by various field surveys (Reardon, 1997). The rise of rural non-farm activities or rural households enters into non-farm income generating activities for various reasons.

The work of Klein (1992) and Weller (1997) identify five main dynamics (obviously not mutually exclusive) of determinants of rural non-farm employment (RNFE). Three of them are related to agriculture where as two of them are not. First, activities arising from "production-linkages" that comes in the form of input processors (agro processing) or service providers (transport, input suppliers). Second, activities arising from rural consumer demand for nonfarm products, from rural or urban consumers. Third, activities arising from the abundant supply of labor from peasant families (seeking survival employment), including domestic services, farm wage labor and other activities to complement meager farm incomes. Alternatively, nonfarm income can serve as either to address the primary means of improving agricultural productivity by providing cash and relaxing liquidity, and thus raising household incomes (Lamb, 1995; Byerlee, 1988). In view of the stagnant agricultural productivity and rising poverty, this is the dominant feature in Africa in general and the research areas condition in particular (World Bank, 2004). Fourth, the demand by the urban population of nonfarm goods and services produced in rural areas.

Two observations are noteworthy in this regard. First, the close relationship between nonfarm and farm activities (Reardon, 1997; Holden et al., 2004; Evans and Ngau, 1991). Second, the important role that nonfarm income can play in poverty reduction (Reardon et al., 2000; Reardon and Taylor, 1996) and financing farm investment (fertilizers, improved seeds). Although the above studies and many more have examined the interactions between farm and nonfarm income, most of the results of the reviews remained inconclusive.

Most of the studies as reviewed by Reardon et al. (1994) tend to focus on quantifying the share of non-farm in total income; identifying the factors that affect households to diversify outside of agriculture; and examining equity and food security implications of nonfarm incomes. Studies which tried to study the interaction mainly focused on partial effect of non-farm income on farm investment without controlling consumption expenditure or consumption without controlling farm investment.

It is against the above background that this study raises the following research questions. First, how is nonfarm income being used by rural households: consumption or investment expenditure? As noted by Alene et al. (2008), Savadogo et al. (1994), and many others that nonfarm income contributes to higher productivity and thereby can drive a "virtuous circle" of self-reinforcing growth in the non-farm income is invested in farm technology and other farm improvements. On the other hand, if nonfarm income is used to finance consumption expenditure, non-productive household assets its contribution to broad-based growth and poverty reduction will be limited. However, if it is invested on expansion of other off-farm generating schemes the results can not determined a prior, as it will be dictated by the marginal productivity difference between the two sectors (farm versus nonfarm). Do the two expenditures (consumption and investment) explained by the same explanatory variables? Since the nature of the two expenditures do vary, while farm investment is part of the capital formation, consumption is on the other hand is can signal resource poorness of the farm households.

2. Theoretical framework

The literature identifies two major types of farm/nonfarm linkages: production and expenditure. Production linkages can be further divided into backward and forward linkages, some times called up- and down-stream linkages. Backward linkage is created when the non-farm sector supply inputs that can be used for agricultural production and forward linkage is created when the farm sector becomes the supplier of inputs to the non-farm sector. The expenditure linkages, which is the focus of this study, refer to a situation whereby the income generated from one type of activity, farm or non-farm, are likely to spend on products of other activities. That is farm income used to finance non-farm activities or vise versa.

The decision of the household to use farm/non-farm income to finance either of these activities is part of the over all resource allocation towards lifetime utility maximization. An important economic question concerns, whether the rising income from agricultural production drives the growth of rural non-farm activities, or whether the increasing income from such activities induces agricultural growth through increased application of improved agricultural inputs. According to the agricultural household model the farm household maximizes lifetime income derived from farm and non-farm sources given the resource constraints; and the resource allocation decision is made simultaneously (Nakajima, 1986; Phimister and Roberts, 2002). Following Singh et al (1986) let the household consume three commodities: leisure, X_L; a good that is purchased on the market, X_M; and own good produced by the household, X_O, as expressed by equation 1.

(1)

Subject to the following constraints

(2)

(3)

= (4)

(5)

(6)

The three activities in the time constraint (2) which shows that time is limited and is allocated between leisure ( ), farm work ( ) and off-farm work ( ). Consumption is constrained by budget (3). The household budget is derived from non-farm wages ( ), return to farm labor ( ) and non-labor income ( ), such as transfer income that comes in the form of public food aid and family transferred income. The return to farm labor is a function of farm profit and time (4). Farm profit is derived from the quantity of products produced times a vector of the prices received , less variable costs of production, , where is the input price vector and is the quantity of inputs used. The technology constraint (5) represents what can be produced on the farm. Total farm output is a function of the time allocated to farm work , the quantity of inputs used

, the human capital and finally which is a vector of exogenous factors that determine the production function, such as land size and quality. Finally the non-farm wage is also affected by human capital and local labor market conditions, .

Given the conceptual framework the main objective of the study is to examine how non-farm income or participation in non-farm activities is affecting households' expenditure: both consumption and productive investment. If there is a positive relationship between farm investment and non-farm income the non-farm income is playing as a catalyst role towards higher agricultural productivity and ameliorating the rural households' credit constraints. If there no positive relationship between non-farm income and farm investment, the non-farm income is used to finance daily consumption of households.

The existing literature on household level non-farm and farm linkages is limited and inconclusive. Using small farmers from Kenya, Collier and Lal (1986) find that, crop output is positively correlated with non-crop income and liquid assets. Savadogo et al. (1994) concludes that non-farm earnings do positively influence animal traction adoption. Similarly Clay et al. (1998) find a positive influence of non-cropping income on land conservation investments, but insignificant effects on use of fertilizers. In contrast to the above findings, Holden et al. (2004) show that in Ethiopia access to rural non-farm activities leads to increased soil erosion and land degradation suggesting a drop in agricultural total factor productivity. Using an Israeli panel data set a strong negative association between off-farm labor supply and farm capital stock was also reported by Ahituv and Kimhi (2002). The same is also true for non-farm income and household consumption expenditure linkages. For instance Reardon et al (1992) found a positive relationship between non-farm income and household calorie in take in Burkina Faso. The same result was also documented by Ruben and Van den Berg (2001)for Honduras, and Ersado (2003) between consumption expenditure and non-farm income for Zimbabwe. Contrasting results were by Pfeiffer et al. (2009) for Mexico and Huang et al. (2009) for China.

We are not aware of studies that have analyzed non-farm income impact on household expenditure from a broader perspective, taking into account how non-farm income affects productive investment and consumption expenditure of the household. We test whether non-farm income is linked with farming through investment; playing the complementary role and relaxing liquidity constraint or providing resource for immediate consumption, i.e. supplementary role.

3. The Empirical Model

3.1 Model specification

In this study the empirical model of non-farm income expenditure decisions consists of two-stage decisions: (1) whether or not to allocate family labor into non-farm activities or not (non-farm participation), (2) if the decision is to participate, the next step is to decide the how much for what: intensity and direction of expenditure. Since the study is based on a household level survey data over a single period, a typical nature of such data is some households are non-participant in non-farm activities. The disadvantage of such data is the survey may end up with too many zeros for many non-farm activities and modern inputs application variables. These zero response could arise from individuals' behavioral responses or the design of the survey. The zero response can be explained in two ways. First, the individual did not get the access to and/or want to participate in non-farm activities; or did not participate during the year, for some reason. The zero values in the former case are related to the households' participation decision and labor market characteristics, and are called household and locational characteristics induced zeros, while the latter case are termed as random zeros as they occurance is random (Wodajo 2008).

The traditional approach to deal with data that have too many zeros, yielding a censored dependent variable, has been to use the standard Tobit model, originally developed by Tobin (1958). Excluding non-participant (with zero non-farm expenditure) from the sample leads to a sample selection bias and biased regression parameters (Aramyan et al., 2007; Matshe and Young, 2004; Martinez-Espineira, 2006). Farmers may not participate in the non-farm activity because of insufficient labor supply or the non-farm activity wage offer might be less than the household's reservation wage. Therefore, it is important to include zero (i.e., non-participation) in the estimation procedure (Matshe and Young, 2003). The Tobit model is used to analyze, under the assumption that the two decisions (non-farm activities participation and non-farm income expenditures) are affected by the same set of explanatory variables. (A further restriction of the Tobit is that all zero observations on non-farm income expenditures are interpreted as corner solutions, i.e., the household is assumed to be a participant in the non-farm generating activities who chooses not to spend in improved agricultural inputs or consumption goods (Martinez-Espineira, 2006; Yen and Huang, 1996; Matshe and Young; 2003; Aramyan et al., 2007).

Heckman (1979) proposes a model that addresses the problem associated with the zero observations generated by non-participant decisions, arguing that an estimation on a selected subsample (i.e., censored estimation) results in a smple selection bias. Accordingly, a two-step estimation procedure (known as heckit) was proposed to overcome the stated problem. The heckman two-step estimates model differs from the Tobit model in two ways. First, it relaxes the one Tobit's one step assumption and recognizes the process to be a two–stage decision, and second, it permits the use of different set of explanatory variables in the two stage estimation. Cragg (1971) developed an alternative approach, double hurdle model to address the restrictive assumption inherent in the Tobit model.

The Heckman two-step and the double-hurdle models are similar in identifying the rules governing the discrete (zero or positive) outcomes. Both models assume that these outcomes are determined by the participation and intensity of use decision (Wodajo, 2008). They also permit the possibility of estimating the first and second-stage equations using different explanatory variables. Modeling the participation decision and intensity of expenditure as two separate decisions: (i) whether or not to participate in the non-farm activities; and (ii) the amount of resource allocated to farm investment and household consumption. However, the heckman two-step , as opposed to double-hurdle, assumes that there will be no zero observations in the second stage once the first-stage participation is passed, which is not compatible with the nature of our data set.

Hence, this study employs the double-hurdle model, with the assumption that the off/non-farm participation and intensity in the two lines of expenditures are two distinct decisions and zero observations in the second stage, even after the first hurdle (participation) is passed. The double-hurdle model, has been extensively applied in the demand analysis of consumer and durable commodities (Burton, et al., 1996; Newman et al., 2001; Yen and Huang, 1996). The double-hurdle model has a participation (Pi) equation:

(7)

Where is a latent variable that takes the value of 1 if the household participate in the non/off-farm activities and zero otherwise, Z is a vector of household and village level characteristics, α is avector of parameters. The level of adoption (for improved seed and fertilizers) and consumption expenditures has the following equations:

(8)

Where Yi is the observed value of the level of household expenditure, X is a vector of the households' and village level characteristics and β is a vector of parameters.
From equation (8) it can be observed the amount of expenditure can be zero either when there is censoring at zero (P^*_i 0) or if there is faulty reporting, or due to some random circumstance. Rewriting equation (8) more elaborately can help show explicitly the processes involved in observing zero values (Jones, 1992):

=0 (9)

Hence, to get the estimate of our interest (non/off-farm linkage with the household expenditure) a positive expenditure is observed if only a household participates in non/off farm activities and uses some part of the income into the two expenditures: productive investments and consumption expenditures. Non-zero values can also be observed if a non-participant reports positive expenditure (third condition). on the other hand, a zero expenditure is observed if a household is participant but did not spend in any money (condition two), or does not participate and does not report any positive spending (last condition). The error terms, Ui and Vi are distributed as follows: (10)

The double-hurdle model with independent error terms can be estimated by the following log-likelihood function (Moffatt, 2005):

(11)

The first term corresponds to the contribution of all the observations with an observed zero. It indicates that zero observations are coming not only from the participation decisions model but also from the outcome model (expenditure) decisions. This constrats with Heckman's (1979) model[2] (with independent error terms assumption) that assumes all the zeros are generated only by non-participation decision.

Comparing the first term of equation (10') to that of equation (10) reveals that the additional term — depicts the contribution of the double-hurdle model. This term capitures the possibility of observing zero values in the second stage decisions (Wodajo, 2008). The second term in equation (10) accounts for the contribution of all observations with non-zero household expenditures. The probability in the second term is the product of the conditional probability distribution and density function coming from the censoring rule and observing non-zero values, respectively (Fabiosa, 2006). For the case at hand, the former denotes the probability of passing the off-farm participation hurdle, and the latter indicates the density of observing non-zero outcomes of off-farm income on improved agricultural inputs and consumption expenditures.

3.2 Identification strategy

To control for the endogeneity of off-farm income two instruments: Woreda wide ratio of non-agricultural employment to economically active population (offfarmratio) and a dummy variable MigrantMember equal 1 if a household had any migrant member, at some time in their life, and zero otherwise; were used. Our first instrument by capturing employment in non-agricultural activities at the Woreda level in 2009, tries to indicate the potential and labor market availability and generally the availability of employment opportunities and a predictor of off-farm participation (Pfeiffer et al., 2009). Since the variable is measured in 2007, it is predetermined and not likely to have a direct impact on agricultural decisions in 2009. The second instrument is expected to be correlated with remittance and other off-farm incomes, but not directly with agricultural decisions in 2009.

4. Data sources and methodologies

The estimation of the farm household expenditure model use a cross-sectional dataset of 734 households drawn from four districts from Tigray region, the northern part of Ethiopia. The survey was conducted between May to June 2009. Since land holding size, livestock assets, education accessibility vary across agro-ecology and distance from the main market, sample households were randomly drawn from the three agro-climatic zones: highland, mid-highland and lowlands. The sampled households consists of participating in off/non-farm activities and non-participating households. Data collected was entered and analyzed using STATA version 11. Descriptive statistics, Tobit and Double-Hurdle models are used to analyze the data.

5. Descriptive statistics

Comparison of participants versus non-participants households in terms of the basic household and farm characteristics (indicated in Table 1.) the non-participant households,

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[2] — —— (11')

they show clear positive difference, except for level of household head schooling, over participants.

On average the share of land under modern fertilizers and improved seeds for non-participant households is 49.8% compared to 36.0% for participants respectively. Similarly, in terms land size holdings (both lagged and current), livestock asset, access to irrigation, percentage share of fertile land, and total value of farm inputs purchased the non-participant households show dominance over the participants. Finally, non-participant households do have more labor supply (family size), experience (age of the household head), and high participation rate in the extension program. The only exception is that participant households are more male headed and better average education level of the household head.

6. Results and Discussions

Before we proceed to interpretations of model results, a test for the Tobit model against the double-hurdle comes first. Accordingly, whether a Tobit or double-hurdle model is more appropriate can be determined by separately estimating the Tobit and the double hurdle models (the truncated regression model and the probit model) separately and then conducting a likelihood ratio test that compares the Tobit with the sum of the likelihood functions of the probit and truncated regression models[3] (Bekele and Mekonnen, 2010). Based on the likelihood values of the two models estimated, the LR test results suggest the rejection of the Tobit model. The test statistics Γ =290 exceeds the crtical value of the distribution (Teklewold, et al., 2006). This is also confimed by the result of the Akaike's information criteria, which is included as an alternative model selection criteria. Finally, most of the variables we used as controls generally behaved as expected, with a few exceptions, in the double-hurdle models, as compared with the Tobit mode, hence we concentrate our analysis on the results of the double-hurdle models.

The results from the double-hurdle and Tobit models are presented in Table 2. present the Tobit model double-hurdle and the alternative Tobit model estimates for intensity of fertilizer application. It is also reported the results of variables to explain separately the decision to participate in the off-farm activities.

[3] The likelihood ratio test statistics Γ can be computed (Greene, 2000) as:

, where is the likelihood for the Tobit model; is the likelihood for the probit model; is the likelihood for the truncated model; and k is the number of independent variables in the equations. If the test hypothesis is written as:

$H_{o:}$ $\lambda = \beta/\sigma$ and H_1: $\lambda \neq \beta/\sigma$, then H_0 will be rejected on a pre-specified significance level, provided $\Gamma >$, confirming the superiority of the double-hurdle specification over the Tobit model. In such a case, the decision to participate in the off-farm activities and the decision to fertilizer use and about how much percentage of the land to be covered by modern fertilizer will appear to be governed by different processes.

The per capita land holding variable was found to be negative and significant in both models as expected. The lower the landholding, other things remaining constant the more likely the household to resort to other income sources and vice versa. Likewise, the lower the land holding size the more likely to intensify the farming and fertilizer intensity. These results seem to affirm the important role of resource endowment in observed adoption behavior (Adesina and Zinnah,1993). Certainly, farmers with large farms are more likely to have more opportunities to learn about new farming practices. They are also likely to have more incentives to adopt new technologies and are more able to bear risks associated with the adoption of improved technologies (Adesina and Zinnah,1993; Tiwari et al., 2008; Zepeda, 1990).

The negative sign of current livestock asset holding variable (lntlucurrent) in the participation model (off-farm) is expected, but the insignificant in the second model is unexpected. This can be understood in terms of the substitutability nature of manure with fertilizer and larger livestock ownership may indicate better access to manure and less financially constrained; and less demand for artificial fertilizer.

The coefficient for age, inconsistent with the human capital and consistent with the adoption theories is negative in both models. According to the adoption theory, younger farmers have a longer planning horizon and are most of the time less risk averse than older, established farmers. If a household head is over 44 years old, it decreases (3 points) participation in the off-farm sector and intensity by 0.3 points. This is consistent with the results of previous technology adoption studies (D'Souza et al, 1993; Zepeda, 1990; Gebremedhin, et al., 2009) but inconsistent with previous studies (Adesina and Baidu-Forson, 1995; Teklewold et al., 2006).

Household head education is insignificant in the first model and significant and negative in the second stage, but very weak 0.2 points). This suggests that Suggesting that the average educational attainment in the research site is very low which is below first grade level, education as a variable could not have the power to explain the off-farm participation nor fertilizer application intensity This result corroborates Chianu and Tsujii, 2004; Alene and Manyong, 2007; Alene et al., 2000.

The coefficient for adult labor force supply condition (adultlabforce) variable is is positive and significant in the first model, and though not significant showed negative sign in the second stage. While the additional adult labor increases the probability of participation the participation in the first stage is not contributing to input use intensity. This is in contrast to the findings of De Janvry and Dadoulet (2001) who found a positive relationship between participation in rural non-farm and on-farm income for China. However, supports, Holden et al., (2004) findings for Ethiopia, who showed access to rural non-farm activities leading to increased soil erosion and land degradation and thereby a drop in agricultural total factor productivity. As expected, distance to the main market negatively and significantly influenced fertilizer input application intensity. This is basically the high cost of input as well as output which is discouraging farmers from applying modern agricultural inputs.

The positive and significant coefficient of participation in the first model and negative and significant is unexpected. This seems the extension program encouraging households in off-farm activities, instead of improving the agricultural productivity. However, the results should be seen in the light of what the extension program are doing: to provide diversified service to farmers including non-farm income generating (petty trade) extension services. And the results are consistent with other related works (Chaplin et al., 2004).

7. Conclusions

As rural households become increasingly involved in non/off-farm activities, their on-farm production changes. The ways in which off-farm participation affect agricultural production have not been a major area of inquiry in the development literature. In theory, the effects of nonfarm activities on agricultural production within households can be positive, negative, or nil; thus they must be ascertained empirically. Using household survey data from rural northern Ethiopia, we find that off-farm income did not have any effect on agricultural, especially fertilizer input utilization.

Table 1. Descriptive statistics of the dependent and explanatory variables

Variable	Description	Participants (obs=390) Mean	Non-parti (obs=344) Mean	t- value
Dependent Variables				
Off_farm	1 if the household participate in any of the non-farm income generating activities (wage business transfer and migrant member)	1	0	-
Prportfert	Proportion of farm land covered by fertilizer	0.3600	0.4978	3.6228***
household characteristics				
Householdheadage	Age of the household head (continuous)	43.2	49.9	3.8907***
malehhh	=1 if Sex of the head of the household is male and 0 otherwise	0.886	0.716	4.2444***
Adultlabforce	Working age group members of the household (> 14 years and <60 years)	2.8289	2.7147	0.8715
Dependent	Number of members of the household below and above the working agegroup	2.5263	2.6701	-1.0167
Headschooling	Educational level of the head of the household	0.9145	0.6582	-1.7802**
Farm characteristics				
LandPercapita	Lag land per capita, in Tsemad	3.5351	4.6265	1.8835**
AccessIrigation	=1 if the household has Access to irrigation and 0 otherwise	0.2030	0.3291	2.2721**
Lnlagged TLU	*Lag Livestock resource holding of the household in tropical livestock unit*	3.6560	4.6074	1.9047**
participation	1=if the household participate in the agricultural extension system	0.4473	0.5068	-1.3063*
Prosoiltype	Proportion of fertile land	0.1883	0.2627	2.2352***
tnonfarmincome	Total non-farm income earned by the household in the previous year	2653	500	-8.7117***
Social Capital				
Edirmembership	= 1If the hh is a member of edir 2 otherwise	0.2198	0.3164	1.7535**
Distance to market				
DistanceMekelle	Tabia distance to Mekelle market in Kms	71.0519	63.2151	-2.3601***
DistanceWoreda	Tabia distance to Woreda market in kms	11.6893	17.2658	4.8002***

Table 2. Participation and intensity estimation of double-hurdle and Tobit models: fertilizer

	Probit, D		Truncated regression, Y (Y>0)		Tobit	
	β	SE	β	SE	β	SE
LandPercapita	.2651***	.0840	-.0600***	.0210	.1809***	.0411
lntnonfarmincome			.0027	.0045	-.0076	.0072
lntlucurrent	.2212***	.0820	-.0096	.0206	.1426***	.0335
AccessIrigation	.7942***	.1618	-.0569*	.0306	.1917***	.0492
malehhh	.5213***	.1458	-.0515	.0386	.2108***	.0543
Householdheadage	-.0052	.0046	-.0028*	.0011	.0067	.0042
Headschooling	.0815*	.0487	-.0163	.0103	-.0067	.0160
Adultlabforce	.1692***	.0595	-.0231*	.0136	.0277	.0256
Dependent	.0946	.0804	-.0518**	.0207	-.0141	.0345
participation	.0420	.1209	.0104	.0272	.0426	.0405
DistanceMekelle	.0177***	.0031	-.0012**	.0005	-.0013	.0012
DistanceWoreda	.0675***	.0083	.0002	.0016	.0193***	.0025
Lnlagged TLU	.1345*	.0699				
Woredaunemply	-1.4956***	.2036				
lambda					-.6868**	.3058
_cons	2.0829***	.7629	1.0881***	.1042	-.5388***	.1442
Wald χ^2(LR χ^2)	115		198		175	
Prob> χ^2	0.0000***		0.0000***		0.0000***	
LOG-L	-317		-353		-530	
AIC(-LOG-L+K)/N	0.4482		0.4945		1.210	
χ^2 –Test Double Hurdle versus Tobit: Γ=290> χ^2(10)=23.21						
Obs.	734		734		447	

Note: *, **, *** refers statistically significant at 10%, 5% and 1% respectively

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