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The impacts of rural nonfarm employment on agricultural input use and productivity in Bangladesh*

by

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Abstract

In the present era of the structural shift in the agricultural sector, evidence from the rural livelihood literature shows that rural farm households engage in nonfarm employment to supplement their household income in developing countries. Therefore, it raises the question of whether nonfarm employment complements or competes with agricultural production due to a possible shift in farm household labour to nonfarm employment. Using Bangladesh Integrated Household Survey (BIHS-2015) data, this study examines the impact of rural nonfarm employment on farm households' agricultural production. To overcome the endogeneity issues of nonfarm income and censored nature of agricultural input expenditures, IV Tobit model is used to identify the effects of nonfarm employment on the expenditures of major agricultural inputs. The results show that nonfarm income has a positive impact on the total crop expenditure as well as expenditures on major purchased agricultural inputs (equipment, seed, fertilizer, purchased labour). In addition, the treatment effect models confirm the findings obtained by IV Tobit model. The findings also show that an increase in nonfarm income is negatively associated with the use of male family labour in crop production. In order to analyse the impact of nonfarm employment on the technical efficiency of agricultural production, the stochastic frontier production model is used, and the findings indicate that technical inefficiency in agricultural production decreases when nonfarm income increases. Overall, the findings of this study suggest that nonfarm employment exerts an income effect on agricultural production by reducing the liquidity constraint and intensifying major purchased inputs. Thus, introducing policies that would increase rural nonfarm employment opportunities to rural households complements agricultural production and that could be a means to increase foodproduction, ultimately leading to food availability as well as food security.

Keywords: Rural nonfarm employment;agricultural production; technical efficiency; farm household; Bangladesh

JEL code: D13; J43; Q12;

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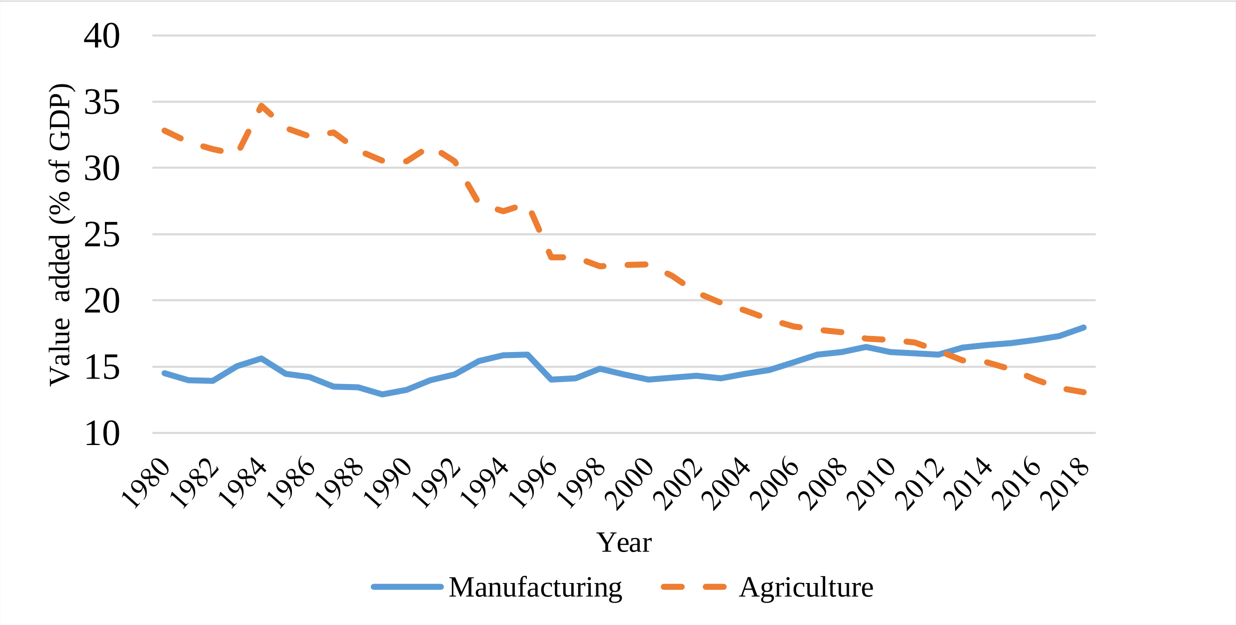
1. Introduction

Over the last few decades, many developing countries have experienced a significant structural changein the agriculture sector. It is a common phenomenon that farm households participate in nonfarm employment to supplement their household's income. The reasons for which a household participates in nonfarm employment can be divided into two factors, "Pull" and "Push" (Barrett et al., 2001). Pull factors include higher payoffs or lower risks than those related to farm activities (Ali and Peerlings, 2012; Reardon et al., 2006). On the other hand, push factors includes a drop in seasonal income from farming and a decline in the average size of land holdings (Reardon et al., 2006). However, the increasing rural nonfarm participation raises a concern regarding its impact on agricultural production due to labour movement from farm to nonfarm employment.

Figure 1 Contribution of manufacturing and agriculture sectors to GDP at constant price in Bangladesh, 1980-2018



Source: World development indicator, 2019

Bangladesh is a case in point where the structural change in the agricultural sector is more prominent. It is evident from Figure 1 that the relative share of the agriculture sector to GDP is declining compared to the manufacturing sector. Moreover, the cultivable land area is declining due to increased demand for land for non-agricultural activities such as urbanisation, infrastructural development, or homestead land demand (Shahabuddin, 2016). However, realising the increasing importance of nonfarm employment on reducing poverty or food insecurity rural households participatein different kinds of nonfarm employment. According to BBS (2018), the nonfarm employment participation rate in Bangladesh was 48 percent in 2000 which increased to 53 percent in 2010 and 59 percent in 2018. On the contrary, the participation in farm employment was 52 percent in 2000 which declined to 47 percent in 2010 and 41 percent in 2018. Additionally, the structural change was more prominent for rural youth labourers in Bangladesh. For instance, in 2000 about 59 percent of rural youth were employed in the agriculture sector which declined to 40 percent in 2013. Oppositely, rural youth employment in the manufacturing sector was 14 percent in 2000 which increased to 26 percent in 2013 (Bangladesh Labor Force Survey, 2015-16). However, the agriculture sector is still labour intensive and serves as the main source of food availability in Bangladesh.

The consequences of participation in nonfarm employment on agricultural production could be two-fold. On the one hand, the increased cash earnings from nonfarm employment of farm households could be used to purchaseagricultural inputs to intensify production.(e.g., Matshe and Young, 2004). Furthermore, agricultural production might face a shortage of labour due to increased competition for family labour between farm and nonfarm employment. However, the adoption of new technologies and mechanization of farms could be a solution to solve the labour shortage problem in the agriculture sector (Kilic et al., 2009; Ma et al., 2018). In this case, loss of labour in agriculture due to nonfarm employment could induce an input substitution effect in agricultural production. However, nonfarm earnings might also not be used in farm production since small and landless farmers primarily may prefer to use their earnings for consumption orinvestment in nonfarm activities. Hence, the direction of the impact of nonfarm employment on agricultural production needs to be investigated, especially in an agricultural dependent country like Bangladesh. To investigate the possible impact of nonfarm employment on agricultural production the present study focused on the research questions: Are there any benefits from increasing nonfarm employment on expenditures of agricultural production? Is there any impact of nonfarm employment on family labour use in agricultural production? And is there any gain in the technical efficiency of production through nonfarm employment participation?

The remainder of the study is organised as follows. Section 2 presents a brief literature review on rural nonfarm employment. Section 3 presents the details of data sources and a summary of household survey data. Section 4 presents the empirical specifications used in this study. Section 5 presents the empirical findings and the final section concludes.

2. Literature review

Nonfarm employment refers toemployment in all activities excluding agriculture/farm employment which may take place at home or outside the home (Haggblade S et al., 2007; Scharf and Rahut, 2014; Shi et al., 2007). A number of studieshave investigated the impacts of nonfarm employment on household consumption, poverty reduction, and food security in many developing countries(e.g., Babatunde and Qaim, 2010; Chang and Mishra, 2008; Mishra et al., 2015; Owusu et al., 2011; Ruben and Berg, 2001; Scharf and Rahut, 2014; Zhang et al., 2016). Most of these studies established a positive relationship between nonfarm employment and corresponding outcomes (e.g. household consumption, poverty reduction, or food security). Some other studies have investigated the effect of nonfarm employment in farm production,based ontwo aspects. The first aspect is related to the impacts of nonfarm employment on productivity and technical efficiency of farm production.The overall evidence found from these types of studies is mixed. For instance, Benjamin (2017) found a positive impact of nonfarm employment on farm productivity for smallholder farmers in Ghana.However, the results were different for Uganda where Amare and Shiferaw (2017) found a negative relationship between nonfarm employment and land productivity. In terms of technical efficiency, some studies argue that technical efficiency increases with increasinghouseholds' nonfarm income (e.g., Bojnec and Ferto, 2011; Chang and Wen, 2011; Shittu, 2014; Yang et al., 2016; Zhang et al., 2016) while, the Kilic et al. (2009) study in Albania did not find any positive linksbetween nonfarm income and farming efficiency.

The second aspect of the literature emphasised the linkage between nonfarm income and expenditure on agricultural inputs (Amare and Shiferaw, 2017; Chang and Mishra, 2012; Ma et al., 2018; Oseni and Winters, 2009; Pfeiffer et al., 2009; Phimister and Roberts, 2006). However, the literature provides mixed evidence regarding the relationship between nonfarm income and farm input intensification. For instance,Oseni and Winters (2009) found in Nigeria that the expenditure on purchased labour and chemical fertilizer increases with an increase in nonfarm income. Similar findings are also reported by Pfeiffer et al. (2009) for Mexico. On the contrary, Mathenge and Tschirley (2015) reported a reduction in fertilizer use with an increase in nonfarm income in highly productive areas of Kenya. Also, Kilic et al. (2009) found that rural households reduce expenditure on agricultural production and moving away from agricultural production with an increase in nonfarm income in Albania. However, Amare and Shiferaw (2017) did not find any significant effect of nonfarm income on the use of fertilizer or technologies in agricultural production in Uganda.

Although the literature provides some evidence of empirical investigation of the relationship between nonfarm employment and agricultural production, the research in this is area still inconclusive. Some studies have investigated the determinants and impacts of nonfarm employment on household consumption and food security (see for example Malek and Usami, 2009; Mishra et al., 2015; Pramanik et al., 2014; Rahman, 2013; Raihan and Haque, 2018). Although the majority of the Bangladeshi population (65 percent) lives in rural areas, there is no study regarding the impact of nonfarm employment on agricultural production in Bangladesh. While Bangladesh has been experiencing structural changes inthe agriculture sector for decades, it is the main source of the food supply. Furthermore, rural household welfare in Bangladesh is based on the production of different essential food crops. Since most of the agricultural production is still labour intensive in Bangladesh, labour movement from farm to nonfarm employment could reduce production due to the loss of farm labour. However, the agricultural production might also increase if the nonfarm earnings support the investment in productivity-enhancing inputs such as purchased fertilizers or technologies. Therefore, it is indeed necessary to investigate the impact of nonfarm employment on agricultural production in Bangladesh.

3. Data description of rural farm households

The *Bangladesh Integrated Household Survey* (BIHS) data 2015, collected by the International Food Policy Research Institute (IFPRI) has been used in this study. All data related to agricultural crop cultivationwas collected for the period of one year, December 2013 to November 2014. In this study, from the BIHS database, we have selected only those households which have at least one economically active member aged at least 15 years and who is engaged in any kind of employment or earning activities. Therefore, we have dropped those households from our total sample who are solely dependent on different nonearning occupations such as students, beggars, or in social safety-net programs. Since the focus of this study is on the linkage between nonfarm employment and agricultural production of rural households, only those households who have any kinds of agricultural income (crop, livestock and or fisheries) have been included for this study. This has resulted in the use of data from 4,110 households.

Summary statistics of different variables

The definition of those variables used in this study is presented in appendix Table A1. Summary statistics of the variables used in this study for households with nonfarm income as well as without nonfarm income are presented in Table 1. It can be seen from the top section of the table, about 4 percent of households with nonfarm income are female-headed, whereas about 25 percent of households without nonfarm income are female-headed. Among the household heads with nonfarm income, about 22 percent are illiterate (schooling1) while about 36 percent of household heads without nonfarm income are illiterate. About the same percentage of household heads with nonfarm income and without nonfarm income have completed elementary schools (schooling 5) as well as high schools (schooling 10). Among households with nonfarm income, about 14 percent of households receive some kind of agriculturaladvice from the agricultural extension officers, while only 8 percent of households without nonfarm income received agricultural advice. In terms of access to credit, about 84 percent of households with nonfarm income have access to credit, whereas about 73 percent of households without nonfarm income have access to that facility. In summary, compared to households without nonfarm income, the majority of household heads with nonfarm income are male-headed, are more educated, receive more agricultural advice and have greater access to credit facilities.

It can be seen from column (2) of the bottom half of Table 1, the average nonfarm income of nonfarm employed households is about BDT 94,800. Comparing column 2 with 6, it can be seen that, at sample means, the households with nonfarm income are spending more on total crop production (BDT 56,800), seed purchase (BDT 8,310), equipment (BDT 6,080), chemical fertilizer (BDT 9,100), and purchased labour (BDT 18,760) compared to households without nonfarm income spending on total crop production (BDT 38,470), seed purchase (BDT 5,760), equipment (BDT 4,010), chemical fertilizer (BDT 5,940), and purchased labour (BDT 12,740) respectively. In terms of family labour use, it can be seen that households with nonfarm income are using more male family labour hours, 4.58 ('00) for agricultural production per hectare compared to households without nonfarm income, 3.26 ('00). However, the use of the average number of female family labour for agricultural production, the age of the household head, area of own land, and travel time to a big city from the household are about the same in both households with and without nonfarm income. The average size of the household is larger in households with nonfarm income (5.41) compared to households without nonfarm income (4.72). The mean number of plots under production in households with nonfarm income (5.60) is greater than that in households without nonfarm income (4.09). It can also be seen from the bottom half of Table 1 that both agricultural wealth index and non-agricultural wealth index are higher in households with nonfarm income compared to households without nonfarm income. For households with nonfarm income, about 43 percent of total rural households have electricity connection, while about 32 percent of rural households have electricity connection for households without nonfarm income.

Table 1Summary statistics of main variables

	Households with nonfarm income (1,627 observations)				Households without nonfarm income (2,483 observations)			
Binary variables	As a percent of total households with nonfarm income				As a percent of total households without nonfarm income			
(1)	(2)				(3)			
Female headed household	4				25			
Schooling 1	22				36			
Schooling 5	13				12			
Schooling 10	5				4			
Agricultural advice received	14				8			
Access to credit	84				73			
Continuous variables	Mean	Std. Dev.	Min	Max	Mean	Std. Dev.	Min	Max
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Nonfarm income [a]	94.80	92.32	5.00	1415.40	-	-	-	-
Total crop expenditure [a]	56.80	43.38	3.80	811.76	38.47	49.39	0.00	899.69
Seed expenditure[a]	8.31	12.15	0.21	317.57	5.76	11.68	0.00	311.84
Equipment expenditure [a]	6.08	3.43	0.00	44.91	4.01	3.99	0.00	34.61
Chemical fertilizer expenditure [a]	9.10	10.41	0.00	270.55	5.94	7.21	0.00	108.47
Purchased labour expenditure [a]	18.76	22.49	0.00	592.80	12.74	19.13	0.00	395.20
Family labour _male [b]	4.58	5.63	0.00	68.71	3.26	6.10	0.00	123.50
Family labour _female [b]	0.05	0.05	0.00	0.69	0.03	0.06	0.00	1.24
Age of the household head	46.52	12.53	19.00	85.00	46.94	14.51	17.00	105.00
Household size	5.41	2.07	2.00	21.00	4.72	1.86	1.00	20.00
Own land	0.37	0.57	0.00	7.68	0.36	0.60	0.00	12.51
Number of plots	5.60	5.75	1.00	63.00	4.09	5.45	0.00	51.00
Agricultural asset index	0.27	0.90	-0.94	5.77	0.14	0.83	-0.56	6.56
Non-agricultural asset index	0.07	0.92	-1.33	8.10	-0.05	0.93	-1.23	16.14
Travel time to big city (hours)	3.93	2.22	0.00	12.82	3.92	2.14	0.00	13.00
Proportion of electricity network	43.49	21.50	0.00	94.74	32.30	19.75	0.00	94.74

[a] denotes that all expenditures are in (000'BDT) per hectareand nonfarm income is in (000'BDT) per year
[b] denotes that family supplied labours are in '00 labour hours per hectare per year

In summary, expenditures on total crop production as well as expenditure on major agricultural inputs are higher for households with nonfarm income compared to households without nonfarm income. In addition, the household size, total number of agricultural plots under production, wealth indices, and proportion of electricity network are higher in households with nonfarm income compared to households without nonfarm income.

4. Model specification

Modelling the impact of nonfarm income on expenditures of agricultural inputs

This study mainly focused on total crop expendituresas well as expenditures on major agricultural inputs to examine the impact of nonfarm employment on agricultural production. Based on past literature (Kilic et al., 2009; Oseni and Winters, 2009; Pfeiffer et al., 2009), it is assumed that the impact of nonfarm employment on agricultural input expenditures can be estimated using household and community characteristics. Following (Kilic et al., 2009; Oseni and Winters, 2009; Pfeiffer et al., 2009), we propose the following regression model to analyse the impact of nonfarm employment on the expenditure of agricultural input.

$$Y_i = \beta_0 + \beta_1 NFI_i + \boldsymbol{\theta}'\boldsymbol{X_i} + \varepsilon_i \qquad (1)$$

where Ydenotes the natural logarithm of the expenditure on agricultural input. We estimate model (1) at two levels, first at the aggregate level, total crop expenditure[4] as the dependent variable. Second, at disaggregate level, each of the major purchased input expenditure as dependent variable separately, namely, (1) equipment, (2) seed, (3) chemical fertilizer, and (4) purchased labour. The index i represents the household; NFI denotes the natural logarithm of yearly income received from nonfarm employment. The $\boldsymbol{X}$ is a vector of control variables which includes the age of household head, age squared, gender, education, household size, land area under operation, number of plots, agricultural advice received, asset indices, access to credit, and regional dummies. The inclusion of various independent variables in our empirical analysis is based on previous literature of agricultural input intensification and production (Amare and Shiferaw, 2017; Chang and Wen, 2011; Kilic et al., 2009; Ma et al., 2018; Mathenge and Tschirley, 2015; Oseni and Winters, 2009). The

[4]Total crop expenditure includes expenditures on major purchased inputs along with other purchased and non-purchased inputs for crop (both cereal and non-cereal) production

names of $\boldsymbol{X}$ variables and their descriptions are presented in the appendix Table A1. The coefficients β_1 and $\boldsymbol{\theta}$ denote the regression coefficients of the corresponding variables. The ε_i presents the stochastic error term. In this study, our main focus is on the sign and magnitude of β_1 as it measures the impact of nonfarm employment on expenditures on agricultural inputs. However, the major problem of estimating equation (1) using Ordinary Least Square (OLS) estimation is the possible endogeneity of our main interested variable, nonfarm income (Kilic et al., 2009; Oseni and Winters, 2009). There might have some unobservable characteristics which could influence the households' participation in nonfarm employment that have not been controlled in equation (1). For instance, the household head's entrepreneurship ability or economic motivation might affect the household's participation in nonfarm employment as well as nonfarm income. One way to deal with this endogeneity is to use the Instrumental Variable (IV) estimation approach in our study. Since all farm households may not have expenditure on crop production, even all farm households might not use all types of inputs in their production, our dependent variable becomes censored in nature. Therefore, we have used the IV Tobit model to estimate equation (1) with the maximum likelihood method. For a single endogenous situation, the IV Tobit model will follow the following two steps (Kilic et al., 2009; Oseni and Winters, 2009; Wooldridge, 2013):

$$Stage\ 1\colon\ NFI_i = \delta_0 + \delta_1 Z_{1i} + \delta_2 Z_{2i} + \boldsymbol{\gamma}'\boldsymbol{X_i} + \omega_i \tag{2}$$

$$Stage\ 2\colon\ Y_i = \beta_0 + \beta_1 \widehat{NFI_i} + \boldsymbol{\theta}'\boldsymbol{X_i} + v_i \tag{3}$$

In the reduced form of equation in the first stage (equation 2), NFI denotes the log of yearly nonfarm income; Z_1 denotes the travel time (hours) to cities with a population greater than

500,000; Z_2 denotes the proportion of household in the subdistrict with electricity connection at home. These two variables are used as exogenous instrumental variables. The $\boldsymbol{X}$ is a vector of other exogenous control variables as mentioned in equation (1). In the second stage, we replaced the nonfarm income variable NFI_i in equation (1) with the estimated value of nonfarm income ($\widehat{NFI_i}$) obtained from equation (2). Therefore, equation (3) will ultimately give us the two-stage estimation results.

Both of instrumental variables satisfy the relativity and excludability conditions for being an instrumental variable. In terms of the first instrument, it can be assumed that the shorter travel time to a big city for the household would increase various nonfarm work opportunities for the household members. Therefore, income from nonfarm employment might be increased which could be used to purchase different agricultural inputs. Further, it is evident that rural farmers mostly purchase their agricultural inputs from nearby markets or Upazila[5] markets. Therefore, it can be assumed that distance from a big city from the household does not have any direct impact on expenditures of agricultural inputs, which satisfy the excludability condition to be an instrumental variable. In addition, the proportion of households with electricity connections in Upazila is used as another instrument. It is assumed that participation in different rural nonfarm employment such as a small shop, mechanical workshop or laundry shop could be enhanced through having an electricity connection in the household. Additionally, this variable does not have any direct relationship with expenditure on agricultural inputs. The expenditure on agricultural inputs could only be influenced by the earnings from nonfarm employment of households with electricity connection. Since there are no statistical tests available to check the instrumental validity for the IV Tobit model estimated with the maximum likelihood method, we first tested the validity of our

[5]The administrative structure of Bangladesh consists of Divisions, Districts, Upazilas, and unions, in decreasing order of size.

instruments for 2SLS regression (Kilic et al., 2009). Since both the instruments have passed the validity in all our regressions, we use these instruments for IV Tobit estimations in equation (3) via equation (2). Additionally, we have checked the over-identification restrictions following Newey's minimum chi-squared estimator fitting the IV Tobit model. In our analysis, we will use the average marginal effects to interpret our results.

The average marginal effect *(AME)* corresponding to each specific variable in the instrumental variable (IV) Tobit model can be calculated as follows (Wooldridge, 2013).

For continuous variable:

$$AME_k = \frac{1}{n}\sum_{i=1}^{n} \Phi'(\boldsymbol{x}_i'\widehat{\boldsymbol{\beta}}/\hat{\sigma})\beta_k \tag{4}$$

For binary variables:

$$AME_k = \frac{1}{n}\sum_{i=1}^{n}[\Phi'\{(\boldsymbol{x}_i'\widehat{\boldsymbol{\beta}}|x_i = 1)/\hat{\sigma}\} - \{(\boldsymbol{x}_i'\widehat{\boldsymbol{\beta}}|x_i = 0)/\hat{\sigma}\}] \tag{5}$$

where, $\Phi(.)$ is a standard normal density function and $\boldsymbol{x}_i'\widehat{\boldsymbol{\beta}}$ is the estimated Y_i as in equation (3). Here subscript k represents the k-th variable for which the marginal effect is being calculated.

Modelling the impact of nonfarm income on the productivity and technical efficiency of production

We have modelled the impact of nonfarm income on the expenditure of agricultural inputs through equation (1) to (3) if nonfarm income could have a positive effect on the expenditure of agricultural inputs. If the expenditure of agricultural inputs increases with the increase in nonfarm income then another question will arise, is there any gain in the technical efficiency of production through participation in nonfarm employment? To address this issue, we used the stochastic frontier production (SFP) estimation in our study to investigate the impact of nonfarm income on productivity and *technical efficiency*. A farm household is said to be *technically efficient* if this household is producing maximum potential outputs with given inputs. Alternatively, it can be said that a farm household is *technically inefficient* if a higher level of output is technically attainable for the given inputsor that observed output can be attainable using fewer inputs (Kumbhakar et al., 2015. p.12). Therefore, the degree of a household's *technical efficiency* can be measured by SFP as the ratio of a household's observed outputs to the maximum potential outputs for a given level of inputs (Kilic et al., 2009; Kumbhakar et al., 2015). It is assumed that at maximum potential output level a household's degree of *technical inefficiency* equals to zero. Following past literature (Kilic et al., 2009; Kumbhakar et al., 2015; Pfeiffer et al., 2009; Shittu, 2014), we estimate the following SFP function which follows the log-linear Cobb-Douglas form.

$$\ln(Q_i) = \beta_0 + \sum_{j=1}^{k} \beta_j ln(X_{ji}) + v_i - u_i \qquad (6)$$

where Q denotes the value of total crop production of farm household *i* and X_{ji}denotesthe *j-th* agricultural inputs used by the *i-th* farm household; β_0 and β_j denote the intercept and parameter coefficient of *j*-th input respectively. Theagricultural inputs $(X_j, j = 1,2, \dots k)$ include expenditure on chemical fertilizer$(j = 1)$, pesticide$(j = 2)$, irrigation$(j = 3)$, equipment $(j = 4)$, *seed*$(j = 5)$, purchased labour$(j = 6)$, family supplied labour$(j = 7)$, and farm size*(j=8)*. The termv_i, is the idiosyncratic component which is assumed to be independently $N(0, \sigma_v^2)$distributed. The term u_i denotes the nonnegative random variable which accounts for the technical efficiency in the production process for the*i*-th household. Therefore $-u_i$can be interpretedas the technical inefficiency term. Moreover, technical efficiency (u_i) could also be shown as a function of someexplanatory variables related with the technical efficiency of production (Kilic et al., 2009; Zhang et al., 2016).

$$u_i = \Omega_1 + \Omega_2 NFI_i + \sum_{j=1}^{k} \Omega_j m_{ji} + \varphi_i \tag{7}$$

where *NFI* denotes the natural logarithm of nonfarm income.We use NFI as the technical efficiency-related variable assuming that NFI could influence the technical efficiency of production through influencing the expenditure of agricultural inputs.m_j $(j = 1,2, \dots .k)$ denotes the household head's age$(j = 1)$, education$(j = 2)$, female-headed household$(j = 3)$, household size$(j = 4)$, agricultural advice$(j = 5)$, number of plots$(j = 6)$, agricultural asset index$(j = 7)$, and non-agricultural asset index$(j = 8)$. Now we will have a single equation while substituting equation (7) into equation (6), which can be estimated applying the maximum likelihood method in SFP using the Cobb-Douglas functional form.

5. Empirical results

Impact of nonfarm income on the expenditures of agricultural inputs

To find the impacts of nonfarm income along with other control variables on major purchased agricultural input expenditure, the IV Tobit model has been estimated using equation (3) viaequation (2)in this study. The average marginal effects (*AME*) of each corresponding variable of the IV Tobit modelhave been calculated using equation (4) and (5) and are reported in columns 2-6 of Table 2. In general, we use a 5 percent level of significance for testing the significance of the model parameters. The bottom part of the table gives the results of the diagnostic test which shows that the model was endogenous, and the instruments are valid.

It can be seen from columns 2 of Table 2 that nonfarm income of farm households is statistically significant and positively associated with total crop expenditure in aggregate level. This means that a one percent increase in nonfarm income of a farm household leads to about 23 percent[6] increase in total crop expenditure. Likewise, it can also be seen from columns 3-6 that a one percent increase in nonfarm income leads to an increase in expenditure on major purchased inputs by 17.1 percent to 18.8 percent. Thus, these results support the hypothesis that cash earnings from nonfarm employment positively influence agricultural production through intensifying agricultural inputs.

The marginal effect for the variable 'age of the household head' is also statistically significant and positively associated with total crop expenditure (column 2) as well as with expenditures on major agricultural inputs (column 3-6). It suggests that while the head of the farm household ages, they are supposed to be involved in more intensive agricultural production through spending more on different agricultural inputs. However, the significant and negative coefficients of the age squared variable suggest the nonlinear relationship between the age of the household head and expenditure on agricultural inputs. This suggest that expenditure on agricultural inputs increases at a decreasing rate with an increase in the age of the household head.

In terms of educational levels, the marginal effects of the literacy variable (schooling1) are not statistically significant in any regressions (columns 2-6). Besides, the marginal effect of schooling5 variable, 0.396 in column 6, seems to be statistically significant and positively associated with expenditures on purchased labour input. This means that the household head

[6]Although the magnitude of the coefficient for nonfarm income seems to be high, the results are not surprising. This study has considered expenditures on all types of crop production including both cereal and non-cereals. Hence, total crop includes some high-value agricultural crops that might need more capital and that could be facilitated through nonfarm income.

who has completed education up to class 5 spends more on purchase labour input compared to those household heads who are illiterate or have education more than class 5. Although the schooling5 variable is also positively associated with equipment expenditure (column 3), the coefficient is only significant at the 10 percent level. However, it can also be seen that the marginal effect of the variable schooling10 is statistically significant and negatively associated with expenditures on agricultural inputs across all the regressions (columns 2-6). It implies that household head who has completed education up to high school level spends less on agricultural inputs compared to those household heads who are illiterate or have education more than high school level[7]. This finding is not surprising since a higher level of education might work as a pathway for labour movement from farm to nonfarm employment.

Based on the household head's gender differentials, it can be seen from Table 2 that, female-headed households (columns 2-6) spend less on agricultural inputs compared to the male-headed households. This result is not surprising since females are more likely to operate small scale farms compared to males and thus spend less on purchased agricultural inputs. The variable 'household size' is statistically significant and positively associated with total crop expenditure (column 2), equipment expenditure (column 3), and seed expenditure (column 4) while the magnitude of corresponding marginal effects is almost the same (0.07). Although the marginal effect of household size is positively related to chemical fertilizer expenditure (column 5), it is only significant at the 10 percent level. These findings suggest that households with more family members spends more on agricultural inputs. It indicates that the presence of more members in the household creates an opportunity for the excess household members to participate in the labour market and spend their cash earnings on agricultural inputs.

[7]Unfortunately, only 3 percent of the farm household heads have education more than high school level (class 10) in our sample. We have also tried to use another variable with schooling more than class 10, but the coefficient was not significant. Hence, this additional schooling variable has not been used in the final model.

Table 2: Estimated marginal effects of different factors on major agricultural input expenditures in farm households

Variables	Total crop expenditure	Equipment expenditure	Seed expenditure	Chemical fertilizer expenditure	Purchased labour expenditure
(1)	(2)	(3)	(4)	(5)	(6)
Log of nonfarm income	0.231***	0.179***	0.186***	0.188***	0.171***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.002)
Age of household head	0.202***	0.169***	0.166***	0.166***	0.164***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Age squared	-0.002***	-0.002***	-0.002***	-0.002***	-0.002***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Schooling_1	0.023	0.068	0.035	0.047	0.022
	(0.892)	(0.632)	(0.797)	(0.737)	(0.894)
Schooling_5	0.294	0.277*	0.225	0.249	0.396**
	(0.123)	(0.093)	(0.151)	(0.121)	(0.037)
Schooling_10	-1.003***	-0.941***	-0.787***	-1.038***	-0.658**
	(0.000)	(0.000)	(0.001)	(0.000)	(0.017)
Female headed household	-4.541***	-3.589***	-3.725***	-3.765***	-4.041***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Household size	0.074**	0.076**	0.069**	0.059*	0.009
	(0.036)	(0.015)	(0.018)	(0.050)	(0.816)
Area of own land	0.261***	0.156*	0.181**	0.155*	0.423***
	(0.009)	(0.069)	(0.027)	(0.070)	(0.000)
Total number of plots	0.223***	0.199***	0.182***	0.191***	0.225***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Agricultural advice	0.697***	0.571***	0.582***	0.581***	0.866***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Agricultural asset index	0.298***	0.090	0.260***	0.251***	0.328***
	(0.000)	(0.179)	(0.000)	(0.000)	(0.000)
Non-agricultural asset index	-0.281***	-0.224**	-0.246***	-0.231***	-0.106
	(0.008)	(0.012)	(0.006)	(0.006)	(0.269)
Access to credit	0.440**	0.387***	0.334**	0.380***	0.315*
	(0.011)	(0.008)	(0.018)	(0.009)	(0.066)
Observations					
Left censored observations	869	952	912	1065	869
Uncensored observations	3241	3158	3198	3045	3241
Endogeneity test					
Wald test of exogeneity (p-value)	0.000	0.005	0.000	0.003	0.000
Endogeneity test (p-value)	0.000	0.007	0.000	0.005	0.000
Validity of instruments					
Over-identification test (p-value)	0.459	0.825	0.244	0.682	0.693
Weak identification test (F-value)	107.297	107.297	107.297	107.297	107.297
Amemiya-Lee_Newey (p-value)	0.426	0.276	0.329	0.552	0.485

Note:Robust p values are in parentheses. *"***" denotes significant at 1 percent level, '**' denotes significant at 5 percent level, and '*' denotes significant at 10 percent level.* Regional dummies based on seven divisions are included in all the regression estimations.

It can also be seen that the marginal effects of the variable ‘area of own land’ are statistically significant and positively associated with the total crop expenditure (0.26, column 2) as well as with seed expenditure (0.18, column 4) and purchased labour expenditure (0.42, column 6). This means that expenditure on these inputs in agricultural production rises with an increase in the area of own land under production. Although the area of own land also positively associated with equipment expenditure (column 3) and chemical fertilizer expenditure (column 5), marginal effects are only significant while considering a 10 percent level.

Likewise, the statistically significant and positive relationship between the total number of plots and expenditures on agricultural inputs across all the regression (columns 2-6) indicates that expenditures on agricultural inputs increase with the increase in the number of agricultural plots. Moreover, the marginal effects for the variable ‘agricultural advice’ across all the regressions (columns 2-6) suggest that the households who receive any kind of agricultural advice spend more on agricultural inputs compared to those households who do not receive agricultural advice. The variable ‘agricultural asset index is statistically significant and positively associated with expenditures on agricultural inputsacross all the regressions (columns 2, 4-6) except equipment expenditure (column 3). This suggestthat an increase in agricultural assets leads to an increase in spending on these agricultural inputs. On the other hand, the non-agricultural asset index is statistically significant and negatively associated with the total crop expenditure as well as with expenditures on equipment, seed, and chemical fertilizer (columns 2-5). Finally, the statistically significant and positive marginal effects of access to credit variable indicate that those households who have access to credit spend more on agricultural inputs (columns 2-6) compared to those households who do not have that access. This finding indicates the need for an available financial facility for agricultural production. The findings obtained from the IV Tobit model estimation was robust based on the alternative estimations.[8]

Impact of nonfarm income on family labour use in agricultural production

To find the estimated effect of nonfarm income and other variables on the use of family labour in agricultural production, we have estimated the model specified in equation (3) via equation (2) applying the two stages least square (2SLS) procedure. Since the crop production is labour intensive and almost all household who have crop production use family labour, we have constrained our estimation on a sub-sample of 3,241 farm households participating in crop production during 2014. Column 2 and column 3 of Table 3 present the estimated coefficients for the impact of nonfarm income on the use of family supplied male and female labour respectively. The diagnostic tests at the bottom of Table 3 confirms the endogeneity of nonfarm income and the validity of the instruments. Furthermore, the value of the F statistic (F>10) shows that our instrumental variables are not weak.

It can be seen in column (2) of Table 3 that, the coefficient of nonfarm income is statistically significant and negatively associated with the use of male family labour in crop production. The magnitude of the coefficient implies that a one percent increase in nonfarm income leads to a 4.5 percent decrease in the use of male labour (hours/ha) in crop production. This finding confirms the direction of movement of the family supplied male labours towards nonfarm employment.

[8]We have also estimated three nonparametric treatment effect models namely nearest neighbour matching, propensity score matching, and inverse probability weighted regression adjustment approach (IPWRA). Results suggest that households with nonfarm income allocate more on crop expenditure compared to households who do not have nonfarm income.

Table 3 Estimated coefficients for the impact of nonfarm income on family labour use in agricultural production

Variables	Use of family labour	
	Male labour	Female labour
(1)	(2)	(3)
Log of nonfarm income	-0.045***	0.001
	(0.003)	(0.948)
Age of household head	0.049***	0.021**
	(0.000)	(0.011)
Age squared	-0.001***	-0.000***
	(0.000)	(0.009)
Schooling_1	0.095**	-0.079*
	(0.022)	(0.079)
Schooling_5	0.133**	0.008
	(0.013)	(0.895)
Schooling_10	-0.221**	0.028
	(0.013)	(0.780)
Female headed household	-1.308***	0.191**
	(0.000)	(0.017)
Household size	0.055***	-0.011
	(0.000)	(0.299)
Area of own land	-0.032	0.252***
	(0.388)	(0.000)
Total number of plots	0.092***	0.082***
	(0.000)	(0.000)
Agricultural advice	0.146***	0.162***
	(0.002)	(0.003)
Agricultural asset index	0.237***	0.168***
	(0.000)	(0.000)
Non-agricultural asset index	-0.202***	-0.019
	(0.000)	(0.515)
Access to credit	0.081*	0.073
	(0.086)	(0.142)
Constant	3.249***	2.906***
	(0.000)	(0.000)
Observations	3,241	3,241
R-squared	0.453	0.342
Endogeneity test		
Endogeneity test (p-value)	0.038	0.078
Validity of instruments		
Over-identification test (p value)	0.576	0.645
Weak identification test (F-value)	82.295	82.295

Note: Robust p values are in parentheses. *"***" denotes significant at 1 percent level, '**' denotes significant at 5 percent level, and '*' denotes significant at 10 percent level.* 2SLS estimation has been applied. Regional dummies based on seven divisions are included in all the regression estimations.

Since the expenditure on different purchased inputs increases with an increase in nonfarm income (see Table 2), it indicates that nonfarm income received by male family labour might reduce the liquidity constraint of crop production. Therefore, it indicates a substitution effect of family supplied male labour between farm and nonfarm employment as well as an income effect on agricultural production.

The age of the household head variable (column 2, Table 3) indicates that the use of family supplied male labour increases while the head of household head ages, however, this result follows a nonlinear relationship. It can also be seen that among different educational levels, the use of male family labour in crop production is higher while the head of the household is illiterate (schooling1) compared to households who are literate. Likewise, household heads who completed elementary education (schooling5) use more male family labour in crop production compared to the household heads who are illiterate or have education greater than elementary level. However, the statistically significant and negative coefficient of schooling10 variable (0.133) indicates thathousehold heads who completed high school level education use a lower amount of male family labour for crop production compared to households without education or education less than class 10 or have education greater than class 10. This result supports the view regarding the exit pathway of male family members from farm to nonfarm employment. In addition, the use of male family labour is found to be lower in the female-headed households compared to male headed-household. Among other control variables in column (2), it can be seen thathousehold size, the total number of plots, agricultural advice, asset indices, and access to credit variables are also significantly associated with the use of male family laboursin crop production with their expected sign.

Column (3) of Table 3 presents the results of the impacts of nonfarm income and other variables on the use of family supplied female labour in crop production. It can be seen that nonfarm income does not have any significant relationship with the use of family supplied female labour in crop production. However, the age of household head positively influences the use of female family members with a nonlinear relationship. In terms of educational levels, only schooling1 variable is statistically significant while considering a 10 percent level. This implies that household heads who have no education use lower amountof female family labours compared to the households who are educated. In addition, the use of female labour is higher in female-headed households than male-headed households. Among other control variables, area of own land, the total number of plots, and agricultural asset index are statistically significant and positively associated with the use of family supplied female labour in crop production.

Impact of nonfarm income on agricultural productivity and technical efficiency

From the results presented in Table 2, we have identified that expenditures on agricultural production increase with the increase in the household's nonfarm income. However, it is now necessary to see if the nonfarm income has any effect in reducing the technical inefficiency in production. The estimated coefficients of the stochastic frontier production (SFP) model specified in equation (6) and (7) are presented in Table 4. The upper panel (overall estimation) of Table 4 presents the elasticity of agricultural production concerning different inputs. It can be seen that all inputs are positively associated with agricultural production and statistically significant at one percent level of significance. However, average production elasticity is highest for seed expenditure (0.300) following farm size (0.277), family supplied labour (0.269), and equipment expenditure (0.195). The lower panel of Table 4 presents the coefficients related to technical efficiency variables. In an SFP model, the negative coefficients of efficiency variable correspond to a decrease in technical inefficiency and vice versa (Kilic et al., 2009; Kumbhakar et al., 2015; Pfeiffer et al., 2009; Shittu, 2014).It can be seen that nonfarm income is statistically significant and negatively associated (-0.045, column 2) with technical inefficiency. This finding confirms that technical inefficiency in agricultural production decreases by 4.5 percent with a one percent increase in nonfarm income.

Table 4 Estimated coefficients of stochastic frontier production model

	Overall estimation		
Variables	Coefficients	Standard errors	P-values
(1)	(2)	(3)	(4)
Seed expenditure	0.300***	0.018	0.000
Chemical fertilizer expenditure	0.088***	0.015	0.000
Equipment expenditure	0.195***	0.019	0.000
Purchased labour expenditure	0.041***	0.008	0.000
Family supplied labour hours	0.269***	0.028	0.000
Pesticide expenditure	0.017***	0.007	0.006
Irrigation expenditure	0.033***	0.004	0.000
Farm size in hectare	0.277***	0.065	0.000
Constant	4.134***	0.172	0.000
	Technical inefficiency estimation		
Variables			
Nonfarm income	-0.045**	0.020	0.025
Age of household head	0.008	0.007	0.305
Household heads education (years of schooling)	-0.049*	0.027	0.068
Female headed household	-0.011	0.215	0.960
Household size	0.121***	0.045	0.008
Agricultural advice received	-0.198	0.0242	0.414
Number of plots under production	-0.067***	0.024	0.005
Agricultural asset index	-0.112	0.175	0.521
Non-agricultural asset index	0.098	0.155	0.527
Constant	-0.527	0.607	0.385

Note: *"***" denotes significant at 1 percent level, '**' denotes significant at 5 percent level and '*' denotes significant at 10 percent level.* Dependent variable: log of the value of total production. All variables used in the overall model along with nonfarm income are measured natural logged form.

Although the household head's education is also negatively associated with the technical inefficiency of production, this variable is only significant at the 10 percent level. It can also be seen that an increase in the number of plots significantly decreases the technical inefficiency (-0.067) of production. However, the larger household size (0.121) is found to be associated with the increase in technical inefficiency of production. The most likely reason might be that additional labour in a larger sized household creates excess pressure on a limited amount of land for employment. Therefore, the probable way to increase technical efficiency of production might be to increase nonfarm income through participation in different rural nonfarm activities.

6. Conclusions

In the present era of the structural shift in the agricultural sector, evidence from the rural livelihood literature shows that rural farm households become increasingly involved in nonfarm employment in developing countries. Therefore, it raises the question of whether nonfarm employment complements or competes with agricultural production due to a possible shift in farm household labour to nonfarm employment. Although the literature provides some empirical evidence of the relationship between nonfarm employment and agricultural production, the research in this area is still inconclusive based on the mixed findings in different countries. However, no previous study has investigated the impact of nonfarm employment on agricultural production in Bangladesh. Since most of the Bangladeshi population (65 percent) lives in rural areas and the country has been experiencing structural changes in the agricultural sector for a decade, it is indeed necessary to investigate the impacts of nonfarm employment on agricultural production in Bangladesh.

Using Bangladesh Integrated Household Survey (BIHS-2015) data, we find that nonfarm employment has a significant and positive effect on the agricultural input expenditure. This finding indicates that nonfarm employment could provide the means to finance agricultural production and to undertake timely farm operations. The findings also suggest that there might have a substitution effect of male family labour between farm and nonfarm employment. Generally, a male family member is mainly responsible for earning in the household and therefore they participate in different types of nonfarm activities in rural areas. The findings also indicate that technical inefficiency in agricultural production decreases with an increasein nonfarm income of farm households. Overall, the findings of this study suggest that nonfarm employment exerts an income effect on agricultural production by reducing the liquidity constraint and intensifying major purchased inputs. Thus, introducing policies that would increase rural nonfarm employment opportunities to rural households complements agricultural production and that could be a means to increase food production, ultimately leading to food availability as well as food security.

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Appendix

Table A1 Definition of variables

Variables	**Definition**
Dependent variables	
Total crop expenditure	Total expenditure on crop production per hectare (000'BDT)[9]
Seed expenditure	Total expenditure on seed purchase per hectare (000'BDT)
Equipment expenditure	Total expenditure for different equipment rental (ploughing, transplanting, harvesting or threshing) for crop production per hectare (000'BDT)
Chemical fertilizer expenditure	Total expenditure on chemical fertilizer used per hectare (000' BDT)
Purchased labour	Total cost of purchased labour use per hectare (000' BDT)
Family supplied male labour	Total family supplied male labour use per hectare (00' hours)
Family supplied female labour	Total family supplied female labour use per hectare (00'hours)
Independent variables	
Nonfarm income	Total amount of household's yearly earnings from nonfarm employment sources (000'BDT)
Age of household head	Age of the household head (Rahut et al.) in years
Age squared	Squared of the age of the household head
Female headed household	1= if the household head is female; 0= Otherwise
Schooling 1	HH schooling. Literate dummy (1= no schooling; 0 Otherwise)
Schooling 5	HH schooling. 1= Elementary school (class 5) completed; 0= Otherwise
Schooling 10	HH schooling. 1=High school (class 10) completed; 0= Otherwise
Household size	Total number of members in the household
Own land	Total area of own land under the household's operation (ha)
Number of plot	Total number of plot under the household's operation
Agricultural advice	1= if the household received any kind of agricultural advice from the agricultural offices; 0= Otherwise
Agricultural asset index	The non-land agricultural asset index of the farm household, calculated using principal component analysis (PCA[10])
Non-agricultural asset index	The non-agricultural asset index of the farm household, calculated using PCA
Access to credit	1= if the household has access to credit facility; 0= Otherwise
Regional dummies	Dummies for seven divisional regions are used to capture the heterogeneity due to the difference in regional characteristics
Instrumental variables for nonfarm employment	
Travel time to big city	Travel time (hours) to cities with population greater than 500,000
Proportion of electricity network	Share of households with electricity at the sub-district level

[9]BDT refers to the Bangladeshi currency. USD 1= BDT 80 (app.)

[10] In PCA the factor sources act as weights assigned to each variable (normalised by its mean and standard deviation) in the linear combination of the variables that constitute the first principal component (Filmer and Pritchett, 2001; Oseni and Winters, 2009)