Effects of smoking on agricultural productivity

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Abstract:

We examine the effects of smoking on productivity among agricultural workers in riverine islands (locally known as *chars*) of northern Bangladesh, where prevalence of tobacco consumption is around 80% compared to 35.3% nationally. There is a high correlation between physically-demanding occupations and smoking, wherein farmers and day laborers are among those most likely to smoke. This means the opportunity cost of smoking is potentially very high for people employed in the labor-intensive agriculture sector. We use primary data from the Bangladesh *Chars* Tobacco Assessment Project 2018 survey for our empirical analyses. The effects of smoking on agricultural productivity is modelled using a standard Cobb-Douglas production function, with an additional parameter to capture the effect of the primary farmer's smoking status on productivity. We estimate the effects using a two-stage non-linear least squares (NL2S) model through its impact on effective family labor. Our results show that smoking by the primary farmer reduces productivity of effective family labor input by 60-62%. Public policy objectives to improve labor productivity in the riverine islands of Bangladesh should actively target smoking behavior of agricultural households.

Keywords:
smoking, agricultural productivity, effective labor, Bangladesh

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Conflict of Interest:
The authors declare that they have no conflict of interest.

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1. Introduction

Smoking is one of the leading causes of premature deaths, claiming the lives of more than 7 million people across the globe each year. The annual global economic cost of smoking, including forgone productivity from death or disability, is approximately US$1.4 trillion. This economic burden falls disproportionately upon low- and middle-income countries (LMICs) where 80% of the world's smokers reside (WHO, 2016). Bangladesh, a LMIC located in South East Asia, has very high tobacco consumption rates which imposes a major public health burden on its economy. The prevalence of smoking among men in Bangladesh is 37% (Nargis et al., 2015), while the global average is 31.1% (Ng et al., 2014), putting Bangladesh among the top ten countries of the world with high incidence of smoking (WHO, 2009).

Similar to world trends, the prevalence of smoking in Bangladesh is higher among poorer people, most of whom are situated in the rural areas of the country (Nargis et al., 2015). Furthermore, the poorest members of the population in Bangladesh are twice as likely to smoke as those in the wealthiest income group (Efroymson et al., 2001). This means the indigent are subject to a heavier disease burden, and economic inequality is likely to exacerbate further due to concentration of smoking related illnesses among the poor (Nargis et al, 2015; Sultana, Akter, Rahman and Alam, 2015). Yunus (2001) and Sultana et al. (2015), in their comprehensive studies on the prevalence of smoking in Bangladesh, found a high correlation between physically-demanding occupations and smoking, with farmers and day laborers among those most likely to smoke. Majority of agricultural workers in Bangladesh come from poor socio-economic backgrounds with low levels of education and lifetime earnings. This means the opportunity cost of smoking, both in terms of expenditure on tobacco and deteriorated health status, is potentially high for people employed in this labor-intensive sector.

The goal of our paper is to examine the effects of smoking on agricultural productivity, through its impact on labor input. The extant literature assessing productivity of smokers engaged in agricultural occupations is rare at best. This paper contributes to two strands of the development economics literature. First, it contributes to the literature on smoking and its relationship with agricultural labor productivity – a first in a developing country. Second, context it adds to a growing literature studying farm-level labor productivity in agriculture. This article intends on informing policymakers about the productivity implications of smoking in the agricultural sector. If smoking is a major drag on agricultural productivity, a major economic driver in Bangladesh, then perhaps allocating scarce public dollars on anti-smoking campaigns or smoking cessation programs among agricultural households might boost labor productivity and promote economic growth.

We focus specifically on the smoking behavior of the lead farmer, who is responsible for making decisions regarding allocation of resources in the household's agricultural land. This paper presents a model on how the lead farmer's smoking status affects the effectiveness of family labor input in agricultural production. We use primary data from the Bangladesh *Chars*

Tobacco Assessment Project (CTAP) 2018 (Fakir et al., 2018) survey for our empirical analyses. The study area encompasses, and is representative of, riverine islands (locally known as *chars*) of Gaibandha district of rural northern Bangladesh. The *chars* represent a unique geographical area where a combination of poor soil quality and high variability of weather results in uncertain agricultural output. However, due to a lack of diversified employment opportunities, the dependence on agriculture is relatively high. Approximately 56% of holdings in the region are agricultural farmlands, cultivating a variety of crops including local and high-yielding variety (HYV) paddy, corn, jute, sugarcane, wheat and vegetables. Furthermore, households in the *chars* of Gaibandha district are poor with exceptionally high prevalence of tobacco consumption (Fakir et al. 2018).

The conceptual framework of the decision to smoke can be adopted from Becker and Murphy's (1988) "Rational Addiction Theory." The theory states that smoking is the outcome of an individual's rational decision-making process that takes into consideration both the present and future costs and benefits of smoking (Becker et al., 1994; Chaloupka, 1991). The benefits of smoking are mostly subjective in nature, such as stimulation, stress relief, positive social effect and reduced hunger (Rohsenow et al., 2002; Feldner et al., 2007; Fidler and West, 2009; Robles et al., 2017). Heishman et al. (2010) conducted a meta-analysis of 41 lab studies and arrived at the conclusion that consumption of nicotine leads to significant performance enhancement in fine motor skills, alertness, attention, accuracy, response time and working memory. However, the costs of smoking in terms of negative health effects, such as the development of lung and heart diseases, are well-established facts (Doll, 1986; Mattsom et al., 1987). Thus, while the nicotine in tobacco products can have a stimulant effect (Reus et al., 1984; Crooks & Dwoskin, 1997) that may augment productivity, smoking is also associated with severe health hazards that can negatively affect productivity if health is compromised. Levine, Gustafson and Velenchik (1997) have found that smoking reduces stamina, even for young workers. Therefore, when looking into the role of smoking on productivity of agricultural workers, the effect may lean on either direction, depending on which effect, positive performance enhancement or negative health costs, is dominant.

A qualitative assessment of smoking behavior in the study area in Gaibandha district found that agricultural workers believe smoking increases their level of productivity. For instance, cultivation of jute requires working in the waters for long hours that reduces body temperature. The jute farmers believe that smoking during intervals increase body temperature which helps to maintain their productivity. Furthermore, the farmers expressed that smoking is a way to remove boredom from the repetitive and tedious work in the agricultural field. Although people in *char* areas are fairly aware of health injuries associated with tobacco consumption, they are not, in general, very concerned about it (Alam, Khair & Fakir, WP).

A growing body of literature shares the consensus that the negative health effects of smoking are a major economic burden in terms of loss of productivity and forgone earnings. Productivity is usually measured in the literature using number of hours worked, absenteeism (the number of work days missed due to illness) and presenteeism (the number of unproductive hours spent due to illness while at work). Baker et al. (2017) reported smoking to be associated with higher absenteeism in the US and China, and higher presenteeism and significant activity impairment in the US, European Union and China. In another study, the number of days of work missed by smokers was found to be consistently higher than days missed by non-smokers and former smokers, across different occupations in the US (Bunn III et al., 2006). Higher absenteeism among smokers was also noted by Halpern et al. (2001) and Tsai et al. (2005). Alavinia et al. (2009) assessed the impact of various lifestyle factors on absence from work among Dutch construction workers and found smoking to be an important and significant predictor of moderate and long duration sick leaves.

Not surprisingly, the negative association between smoking and productivity can consequently lead to lower wages among smokers. The literature shows that there are two main direct pathways through which smoking can affect earnings: (i) smoking deteriorates health outcomes which reduces productivity and translates into lower earnings in the long-run; and (ii) employers may discriminate against smokers, possibly anticipating their lower productivity, and higher health insurance claims (Levine et al, 1997; Chaloupka & Warner, 2000; Lye & Hirschberg, 2004; Anger & Kvansnicka, 2010; Cowan & Schwab, 2011; Lang & Nystedt, 2018). Overall, the literature on wage penalty of smoking found that smokers earn from 2% to 24% less than non-smokers (Levine et al., 1997; van Ours, 2004; Auld, 2005; Grafova & Stafford, 2009).

Another theoretical explanation for wage penalty of smoking is that smoking may be correlated with other personal characteristics and behavioral factors that affect income (Levine et al., 1997; Lokshin & Beegle, 2011). These characteristics could be higher time preference (Becker & Murphy, 1988) or lower educational attainment than non-smokers (Evans & Montgomery, 1994). Several studies have attempted to address the endogenous correlation of smoking status with other unobserved factors that could affect income. Auld (2005) in his study of Canadian adult male workers found that wage penalty of smoking increases from 8% to 24% when accounted for endogeneity. In a study of Albanian males, Lokshin & Beegle (2006) also found that when accounted for endogeneity using instrumental variables, wage penalty of smoking increases from 4.8% to 23.4%. Lye & Hirschberg (2004) and Yuda (2011), on the other hand, found that smoking has no effect on wages, even after addressing potential endogeneity. Levine et al., (1997), van Ours (2004) and Anger & Kvansnicka (2010) are among other studies in literature that have taken measures to address potential endogeneity bias of smoking status in wage equations.

Since farmers in our sample are self-employed individuals working on their own agricultural land, they may not adhere to a strict “nine-to-five” work routine. As such, measures of absenteeism and presenteeism are difficult to standardize across farmers. Instead we examine the effect of smoking on the monetary value of agricultural output. Inspired by the works of Strauss (1986) and Deolalikar (1988), we estimate a production function where smoking by the lead farmer affects family labor productivity through the effective family labor function.

2. Data Description

The *Chars* Tobacco Assessment Project (CTAP) 2018 survey collected primary data from 985 households in the *chars* (riverine islands) of Gaibandha district in northern Bangladesh, following a two-stage clustered random sampling approach. The sample was constructed to be representative of households at the *char* level in Gaibandha district, with each *char* treated as a cluster. In the first stage, 24 *chars* (out of a total of 107) were randomly selected, with 42 households randomly chosen from each *char* in the second stage, for a total of 1,008 households. However, by the time enumeration initiated, some of homesteads of selected households were lost due to riverbank erosion, a frequent phenomenon in the *chars*, causing 23 households to relocate to mainland or other riverine islands. Final enumeration thus yielded 985 households. The survey collected data on tobacco consumption of the male household head, his health status, socio-economic status of the household, and agricultural production of farm households, among other things. For more details on the sampling procedure, power calculations, and the dataset, see Fakir et al. (2018).

Our final sample consists of 401 households where the male head of the household works on his own agricultural land as the lead farmer. Out of the 985 households, 434 households produced agricultural output in the past 12 months in 710 farm plots. While there are typically 3 production cycles per year (i.e. 4 months per cycle) in Bangladesh, more than 75% of the agricultural households reported land inundation between one to three months a year, and 22% reported land inundation between four to six months a year. Production information was thus collected from the most recent two production cycles within the past year. However, input information was collected only from each household’s primary agricultural land in the last production cycle (lead farmer identified household’s primary agricultural land). This led us to retain 425 study plots, one per household. Among these, 24 households contained missing data reducing the final sample for analyses to 401 observations. Around 82% of the primary farmers in our sample are current smokers, 6% are former smokers and 12% have never smoked. We generated a binary variable from this information to indicate whether a person is a current smoker at the time of the interview. Our final sample thus consists of 328 lead farmers who smoke, hereafter referred to as smokers, and 73 lead farmers who do not, hereafter referred to as non-smokers.

Table 1 shows the descriptive statistics for relevant demographic and agricultural variables, separately for smokers and non-smokers. The first group of variables is about the lead farmer’s human capital and socio-economic characteristics. Overall, smokers and non-smokers have very similar age distributions, with the average age of lead farmers ranging from 43 to 44 years. Majority of the farmers in our sample are between 35 and 54 years. Educational attainment of smokers is relatively low compared to non-smokers, with 63% of smokers having no education compared to 55% of non-smokers. A larger proportion of non-smokers have completed primary education, and secondary education or higher compared to smokers.

[Insert Table 1 Here]

Table 1 also presents summary statistics on the body mass index (BMI) of smokers and non-smokers. There is plenty of evidence in the medical literature that shows smoking to be associated with abnormal BMI (Klesges & Klesges, 1993; Jitnarin et al., 2008; Sneve & Jorde, 2008; Gasperin et al., 2014). Sneve & Jorde (2008) in a longitudinal study of Norway found there to be a U-shaped relationship between intensity of smoking (measured by number of cigarettes smoked per day) and BMI. In consensus with the findings of these studies, our sample shows that a lower proportion of smokers have normal BMI (18.5 to 24.9 kg/m^2) compared to non-smokers, and the difference is statistically significant at the 10% level.

Summary statistics for distribution of household's level of wealth by smoking status of the head are also presented in Table 1. Wealth index was constructed using principal component analysis following Moser & Felton (2007). Calculations for the wealth index took into account household's ownership of a number of assets, including transportation vehicles, mobile phones, basic furniture, and various productive assets such as agricultural machinery, livestock and small tea shop. We also took into account the farmer's housing condition, measured in terms of the number of rooms, construction materials, connection to solar-generated power etc., in our calculations. The summary statistics show that a greater proportion of non-smokers belong in the upper income classes compared to smokers. Around 56% of non-smokers belong in the 4th and 5th wealth quintiles, compared to 48% of smokers.

The second group of variables in Table 1 is related to agricultural production in the last cycle. From our sample of 401 agricultural plots, jute was grown in 13%, corn in 31% and rice in 50% of the plots. Chili, onion, nut and wheat are among the other crops grown in the remaining 6% plots. Majority of farms in our sample are small (<0.5 acres of agricultural land), with a greater proportion of non-smokers (59%) holding small agricultural lands compared to smokers (50%). The average farm land size is 0.7 acres for smokers and 0.6 acres for non-smokers.

We measure agricultural output by the monetary value of output (in BDT, Bangladeshi currency- *taka*) in the production cycle, which is the product of price of output (BDT/kg) and quantity of crops produced (kg). This serves as our dependent variable in the empirical model. On average, both total family labor and hired labor hours worked in the production cycle were higher in agricultural plots operated by smokers compared to that of non-smokers. The differences in average family labor hours and hired labor hours were statistically significant at 1% and 5% levels, respectively. On the other hand, farms operated by non-smokers spent, on average, more on mechanization than farms operated by smokers. Cost of direct inputs in seeds, fertilizers and pesticides were higher in agricultural plots owned by smokers compared to that owned by non-smokers. However, in per acre measures, smokers spent more only in the cost of pesticides than non-smokers. It should be noted that the per acre cost of all three inputs, seeds, fertilizers and pesticides, remain statistically insignificant between the two groups.

3. Empirical Framework

We employ a Cobb-Douglas production function as follows:

$$Y_j = \psi(F_j^*, H_j, K_j, Z_j, U_j, V_j, W_j) \qquad (1),$$

where Y_j is the total monetary value of output produced in the last production cycle, in BDT; F_j^* is effective family labor; H_j is the total number of hours worked by hired labor in the production cycle; K_j is total cost of capital machinery used in the production cycle; Z_j is size of the agricultural land, in decimals (1 acre = 100 decimals); U_j represents the total cost of seeds used in the cycle, in BDT; V_j is the total cost of fertilizers used in production, in BDT; and W_j is the total cost of pesticides used in production, in BDT. Effective family labor, F_j^*, is related to actual family labor in the following manner:

$$F_j^* = \left(L_{f,j}\right)^{1+\tau S_j} \qquad (2),$$

where, L_f represents total number of hours worked by family labor in the production cycle (primary farmer's labor hours are included in L_f); S_j is a binary indicator for the primary farmer's smoking status (current smoker = 1) and τ is the parameter of interest. A negative estimate for τ would suggest that smoking adversely affects the effective family labor productivity. The effective labor function is based on the theory that biological transformations related to smoking can affect labor effort per unit of time. This theory was also applied by Strauss (1986) and Deolalikar (1988) to show how actual family labor hours and the family's calorie intake enters the agricultural production function through a non-linear specification of the family's effective labor input. The farm's production function can be written as:

$$Y_j = A_j\left(L_{f,j}\right)^{\beta_1+\tau\beta_1 S_j} H_j^{\beta_2} K_j^{\beta_3} Z_j^{\beta_4} U_j^{\beta_5} V_j^{\beta_6} W_j^{\beta_7} \qquad (3).$$

Taking natural log on both sides transforms this equation as:

$$\ln Y_j = \ln A_j + \beta_1 \ln L_{f,j} + \tau\beta_1 S_j \ln L_{f,j} + \beta_2 \ln H_j + \beta_3 \ln K_j + \beta_4 \ln Z_j + \beta_5 \ln U_j + \beta_6 \ln V_j + \beta_7 \ln W_j + \mu_j + \varepsilon_j$$

(4),

where, μ_j captures individual level heterogeneity and ε_j is the i.i.d. error term. Given our econometric specification in (4) is non-linear in parameters, we estimate a non-linear least squares (NLLS) model following the econometric procedure outlined in Amemiya (1983).

From equation (4), one can write the effective family labor elasticity of value of output as $\frac{\partial lnY_j}{\partial lnL_f} = \beta_1(1 + \tau S_j)$. If the lead farmer is a non-smoker, effective family labor elasticity of value of output will be β_1. If the lead farmer is a smoker, we can formulate the following testable hypothesis:

Hypothesis 1: $H_o: \tau = 0$, smoking by the lead farmer has no effect on the agricultural productivity of effective family labor

Hypothesis 2: $H_o: \tau > 0$, smoking by the lead farmer increases agricultural productivity of effective family labor

Hypothesis 3: $H_o: -1 < \tau < 0$, smoking by the lead farmer reduces agricultural productivity of effective family labor by a proportion of τ

Hypothesis 4: $H_o: \tau < -1$, smoking by the lead farmer pushes the production function into the region of negative marginal product of effective family labor effort

Estimation with Instrumental Variable

Farmers who smoke may differ from non-smokers in some unobserved factors that can be negatively or positively associated with productivity. The extant literature suggests that the decision to smoke may be non-random and could be influenced by certain personality traits that could also be correlated with their level of productivity (for example, see, Fuchs, 1982; Lokshin & Beegle, 2006; Yuda, 2011; Lang and Nystedt, 2018). Smokers may have higher discount rates, making them less inclined to invest in health and human capital (Fersterer & Winter-Ebmer, 2000; Harrison et al., 2010; Harrison et al., 2015; Lang and Nystedt, 2018). This suggests that smokers are likely to have lower earnings and productivity. On the other hand, smokers may be more risk-loving (Barsky et al., 1995; Hersch & Pickton, 1995; Viscusi & Hersch, 2001; Harrison et al., 2018), which means they may engage in high-risk-high-return investments. Preferences in terms of risk and time could not be considered in our study because of data unavailability. Nevertheless, the consequences of not properly addressing the issue of unobserved heterogeneity can lead to biased and inconsistent estimate of τ. The literature further shows that not addressing endogeneity could potentially understate the effects of tobacco consumption on income (van Ours, 2004; Auld, 2005; Lokshin & Beegle, 2006). We attempt to correct for endogeneity bias using two-stage instrumental variable estimation procedure, a standard strategy in the literature (for example, see, van Ours, 2002; Heineck & Schwarze, 2003; Auld, 2005; Lokshin & Beegle, 2006). The other common estimation strategy used in literature to address endogeneity bias is the Heckman two-stage selection bias correction method (Lye & Hirschberg, 2004; Bondzie, 2016). However, Heckman two-stage estimation comes with very strict normality and homoscedasticity assumptions, the former of which will be difficult to satisfy given that our main independent variable, smoking status, is a dichotomous variable.

The instrumental variable we selected is average *char*-level exhaled carbon monoxide (CO) concentration of household heads. Non-invasive expired-air carbon monoxide measures have been established as a valid biochemical marker of smoking status (see, for example, Nakayama et al., 1998; Deveci et al., 2004), where a reading of more than 10 parts per million (ppm) is consistent with smoking (Muraven, 2010). Several studies in medical literature have verified a strong positive correlation between expired-air CO and self-reported smoking behavior, as well as between expired-air CO and another commonly used (invasive) biochemical marker, serum cotinine concentration (Nakayama et al., 1998; Deveci et al., 2004; Chatrchaiwiwatana & Ratanasiri, 2008; Vancelik et a., 2009; Babaoglu et al., 2016). The CTAP 2018 survey collected very precise short-term (past 12 hours) measurements of exhaled CO levels of all 985 household heads using a non-invasive Smokerlyzer tool (Deveci et al., 2004; Muraven, 2010). This was done by asking the respondents to exhale into the Smokerlyzer after holding their breath for 15 seconds. The CO measurements were taken daily between 4 and 6 PM, when most people usually retired from work for the day, to ensure consistency.

The average *char* CO level of household heads (includes both farm and non-farm households) acts as a proxy for peer smoking prevalence and intensity, with the assumption that higher average CO levels correspond with greater proportion of household heads being smokers in that *char*. Numerous studies have confirmed that peer smoking is a strong determinant of the decision to use smoking tobacco (Lewit & Coate, 1982; Becker & Murphy, 1988; U.S. Department of Health and Human Services, 1994; Tyas & Pederson, 1998; Lundborg, 2006; Clark & Loheac, 2007; Ali & Dwyer, 2009; McVicar, 2011; Olsen et al., 2012). Krauth (2004) found that even after accounting for potential selection and simultaneity bias of peer smoking, peer influence on smoking initiation is still significant. Similarly, Fletcher (2010) applied a combination of instrumental variables to establish a positive and significant association between peer smoking and individual-level smoking decision. Lundborg (2007), in their study of perceived addictiveness and mortality risk of smoking among teenagers in Sweden, used peer smoking as an instrumental variable to control for potential endogeneity bias arising from unobserved factors that affect both decision to smoke and perception of risk towards smoking.

While majority of research concerning the effects of peer influence on smoking behavior involve adolescents or young adults, the theoretical reasoning behind peer effects is more broadly applicable. According to Rice and Sutton (1998), peer effects play an important role in decision-making through the pay-off and social norms mechanisms. The pay-off mechanism refers to increasing the benefit to others of carrying out an action by doing that action oneself. The social norms mechanism suggests that deviating from perceived social norms can be socially penalizing. Together, these mechanisms can encourage an individual to consume tobacco if his environmental peer effects are sufficiently strong. Manski (1993) explain that the average behavior of a certain group can affect an individual's behavior in three ways: (i) *the endogenous effect*, where the behavior of the group affects the individual; (ii) *the exogenous or contextual effect*, where exogenous characteristics of the peer group affect the individual; and (iii) *the correlated effect*, where the individual is affected due to having similar characteristics/institutional environments as the group. Cutler & Glaeser (2010) also note that social interactions can influence smoking behavior among individuals if they perceive to gain greater pleasure from group participation, or believe smoking has net benefits due to information transmitted through social cues.

Therefore, there is sufficient theoretical and empirical evidence to suggest that peer influences have strong effects on individual behavior, thus making *char* average CO level, as a proxy for peer effect, a strong determinant of individual smoking status. It is unlikely that *char*-level smoking prevalence and intensity has a direct effect on household-level farm productivity, and is thus exogenous to the error term, making this variable a suitable instrument for our model.

Our dataset does not include information on smoking behavior, education or demographic characteristics of other family members who worked in the agricultural fields, besides the primary farmer. However, these unobserved factors can potentially make the family labor elasticity of value of output parameter (β_1) biased and inconsistent if they are correlated with both value of output (Y_j) and family labor ($L_{f,j}$). For instance, if there are smokers among family workers then it may potentially affect effectiveness of family labor input and subsequently agricultural output as well. Therefore, by not controlling for characteristics of other family laborers working in the field, we run into potential omitted variable bias. Similarly, since characteristics of hired laborers are also unobserved, the parameter estimate for hired labor elasticity of value of output (β_2) is also potentially biased. Correcting for potential bias in β_1 and β_2 is beyond the scope of this article.

Following the procedure outlined in Amemiya (1983), we estimated a first-stage OLS regression of smoking status (S_j) on a set of independent variables from our production function ((log of total family labor hours, log of total hired labor hours, log of total machinery costs, log of land size, log of costs of seeds, fertilizers and pesticides, and crop fixed effects) and our instrument Z_i- *char* average CO level. The predicted values from the first-stage regression were then used to estimate the production function. For robustness check, the first-stage regression was extended to incorporate additional instruments such as the lead farmer's age, education, body mass index and household wealth.

4. Results & Discussion

The parameter estimates and the associated standard errors for the NL2S regression models are presented in Table 2[5].

[Insert Table 2 Here]

Our first stage regressions estimates suggest that the instrument, char level average CO level, is positively correlated with smoking status. This positive association is statistically significant at the 1% level in all five specifications of the first stage regressions. Furthermore, the Montiel-Olea & Pflueger (2013) effective F-statistic is well above the critical value in all five

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[5] Comparable parameter estimates from NL regression model without IV is presented in in *Appendix A*.

specifications. Thus, we strongly reject the null hypothesis that the instrument is weak. Our Adjusted R-squared terms suggest that we are explaining about 55-56% of the variation. The input elasticities of output generally have the expected sign (positive) and are statistically significant at the conventional levels. The estimated machinery input elasticity of output is negative, small in magnitude, and statistically indistinguishable from zero. This finding likely reflects the fact that most of these farmers no do use much capital equipment as an input and that there is very little variation.

Our estimated coefficient on smoking status, τ, ranges between negative 0.62 to 0.60, depending on the specification. These estimates are highly statistically significant at the 1% level. Our results imply that smoking by the lead farmer reduces productivity of effective family labor input by 60-62%, *ceteris paribus*.[6] One might argue that our estimates are biased due to omitted variables that might be correlated with the smoking behavior of the lead farmer and value of agricultural output. But our findings are robust to the inclusion of different human and financial capital variables of the lead farmer such as age, educational attainment, BMI, and household wealth index. The effect of smoking on effective family labor productivity appears to be economically significant and thus warrants public policy attention.

It is important to note that we are estimating a loss in effective family labor input due to smoking. While it would have been more suitable to be able to decompose the productivity loss by absenteeism, presenteeism, and smoking breaks, we do not have the information necessary for generating such measures. Furthermore, the loss in effective family labor productivity can either be due to worsening health from smoking, or from behavioral traits associated with smoking, the two not being mutually exclusive. Decomposing the loss of effective family productivity into its various constituents remains an important avenue for future exploration that would not only help isolate the dominant pathway, but also aid in shaping efficient policy measures to combat losses in agricultural output.

Conclusion

Bangladesh has one of the highest incidences of smoking in the world. This research is the first to quantify the effect of smoking on agricultural labor productivity. Using a non-linear two stage regression framework we find that smoking by the household head reduces the effective family labor productivity of farmers in the riverine islands of rural northern Bangladesh by about 60 percent. This result is robust even after controlling for different human and financial capital variables. It appears that the adverse effect of smoking, in terms of lost productivity, is economically significant among households that lack diversified employment opportunities and

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[6] In column (1) of Table 2, we see the family labor elasticity of output is equal to 0.1780. From equation (4) in Section 3, we know $\frac{\partial lnY_j}{\partial lnL_f} = \beta_1(1 + \tau S_j)$. Therefore, smoking by lead farmer reduces family labor elasticity of output to $\frac{\partial lnY_j}{\partial lnL_f} = 0.1780\big(1 + (-0.6278 \times 1)\big) = 0.0663$. In other words, output becomes even less responsive to changes in family labor effort.

have a high dependence on agriculture. If the public policy objective is to improve labor productivity in the riverine islands of Bangladesh, one policy prescription might be to actively target smoking behavior of agricultural households.

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Tables

Table 1: Summary statistics of main variables

	Smokers			**Non-Smokers**		
Variables	Mean	St. Dev.	n	Mean	St. Dev.	n
(I) *Primary farmer's characteristics*						
Age (years)						
≤ 24 years	3.35	18.03	11	4.11	19.99	3
25-34 years	20.43	40.38	67	20.55	40.69	15
35-44 years	25.92	43.88	85	30.14	46.20	22
45-54 years	22.26	41.66	73	17.81	38.52	13
55-64 years	21.65	41.25	71	23.29	42.56	17
≥ 65 years	6.40	24.52	21	4.11	19.99	3
All age groups	44.46	13.05	328	43.25	12.47	73
Education (years)						
No education	63.11	48.32	207	54.80	50.11	40
Less than primary	13.11	33.80	43	12.33	33.10	9
Completed primary	17.38	37.95	57	24.66	43.40	18
Secondary and higher	6.40	24.52	21	8.22	27.66	6
Body Mass Index (kg/m^2)						
Underweight (BMI < 18.5)	21.95	41.46	72	13.70	34.62	10
Normal (BMI 18.5 - 24.9)*	72.26	44.84	237	82.19	38.52	60
Overweight/Obese (BMI ≥ 25)	5.79	23.40	19	4.11	19.99	3
Wealth Index						
Quintile 1	16.16	36.86	53	13.70	34.62	10
Quintile 2	17.38	37.95	57	12.33	33.10	9
Quintile 3	18.29	38.72	60	17.81	38.52	13
Quintile 4	22.26	41.66	73	30.14	46.20	22
Quintile 5	25.92	43.88	85	26.03	44.18	19
(II) *Agricultural production characteristics*						
Value of output (total value of production from last cycle in TK)**	30348.60	39841.08	328	20360.55	17615.68	73
Value of output (value of production from last cycle per acre (TK/acre))	51103.94	58808.65	328	42565.78	24826.96	73
Farm size						
Small farms (< 0.5 acres)	50.31	50.08	165	58.90	49.54	43
Medium farms (0.5 - 1.49 acres)	43.60	49.66	143	36.99	48.61	27
Large farms (≥ 1.5 acres)	6.10	23.97	20	4.11	19.99	3
Landsize (acres)	0.70	1.23	328	0.58	0.75	73
Agricultural production inputs						
Family labor (total hours worked in last cycle)***	106.11	228.60	328	35.73	26.00	73
Family labor (hours worked in last cycle per acre)***	247.07	495.54	328	95.73	72.13	73
Hired labor (total hours worked in last cycle)**	118.85	321.31	328	44.74	73.91	73

Hired labor (hours worked in last cycle per acre)**	180.77	383.52	328	84.97	122.43	73
Cost of machinery (total cost in last cycle in TK)	2954.45	5638.50	328	3008.90	6913.05	73
Cost of machinery (cost in last cycle per acre (TK/acre))	6076.20	14633.45	328	8020.22	22909.03	73
Cost of seeds (total cost in last cycle in TK)*	1956.20	4648.98	328	1014.19	1334.94	73
Cost of seeds (cost in last cycle per acre (TK/acre))	2044.27	1428.91	73	3314.56	6993.36	328
Cost of fertilizer (total cost in last cycle in TK)	2672.27	2707.52	328	2175.81	1766.41	73
Cost of fertilizer (cost in last cycle per acre (TK/acre))	5006.27	5755.98	328	5530.51	4611.79	73
Cost of pesticides (total cost in last cycle in TK)	483.48	955.89	328	266.97	394.50	73
Cost of pesticides (cost in last cycle per acre (TK/acre))	1510.49	10776.11	328	644.92	964.97	73
Number of observations		**328**			**73**	

significance levels for difference in means test: ***p<0.01, **p<0.05, *p<0.1

Table 2: Agricultural Production Function: Non-Linear Two-Stage (NL2S) Estimates

Variable	**(1)**	**(2)**	**(3)**	**(4)**	**(5)**
Smoker (=1)	-0.6278***	-0.6281***	-0.6277***	-0.6191***	-0.6048***
	(0.1404)	(0.1420)	(0.1427)	(0.1450)	(0.1513)
Log of family labor (hours)	0.1780**	0.1777**	0.1785**	0.1762**	0.1717**
	(0.0758)	(0.0758)	(0.0755)	(0.0755)	(0.0755)
Log of hired labor (hours)	0.0581***	0.0580***	0.0578***	0.0580***	0.0567***
	(0.0139)	(0.0139)	(0.0141)	(0.0141)	(0.0142)
Log of machinery costs (TK)	-0.0100	-0.0099	-0.0100	-0.0087	-0.0092
	(0.0302)	(0.0303)	(0.0303)	(0.0303)	(0.0303)
Log of land size (decimals)	0.5629***	0.5626***	0.5623***	0.5690***	0.5681***
	(0.0465)	(0.0472)	(0.0472)	(0.0477)	(0.0478)
Log of cost of seeds (TK)	0.0674**	0.0674**	0.0681**	0.0646**	0.0638**
	(0.0310)	(0.0311)	(0.0311)	(0.0310)	(0.0310)
Log of cost of fertilizer (TK)	0.0577**	0.0577**	0.0578**	0.0597**	0.0593**
	(0.0231)	(0.0231)	(0.0232)	(0.0233)	(0.0234)
Log of cost of pesticides (TK)	0.0221*	0.0222	0.0221	0.0207	0.0212
	(0.0134)	(0.0135)	(0.0135)	(0.0136)	(0.0136)
Crop codes:					
Jute	*Reference Category*				
Corn	0.2218**	0.2219**	0.2211**	0.2264**	0.2315**
	(0.0987)	(0.0989)	(0.0990)	(0.0990)	(0.0991)
Rice	-0.2051**	-0.2052**	-0.2062**	-0.1966**	-0.1912**
	(0.0915)	(0.0917)	(0.0917)	(0.0915)	(0.0916)
Other crops	0.0074	0.0074	0.0057	0.0043	0.0018
	(0.1394)	(0.1396)	(0.1398)	(0.1401)	(0.1402)
Age of farmer (years)		0.0001	0.0001	-0.0000	-0.0001
		(0.0022)	(0.0022)	(0.0022)	(0.0022)
Educational attainment of farmers (years)			0.0009	0.0017	0.0022
			(0.0083)	(0.0083)	(0.0084)
Body Mass Index				-0.0110	-0.0115
				(0.0112)	(0.0112)
Wealth Index					0.0092
					(0.0101)
Constant	6.3429***	6.3403***	6.3341***	6.5363***	6.5574***
	(0.2868)	(0.2967)	(0.2976)	(0.3464)	(0.3471)
n	401	401	401	401	401
Adjusted R-squared	0.5620	0.5609	0.5599	0.5590	0.5586
Effective F-statistic	41.632	41.725	41.632	42.902	42.983

Significance levels *p<0.1, **p<0.05, ***p<0.01

Appendix

Table A1: Agricultural Production Function: Non-Linear Least Squares (NLLS) Estimates

Variable	**(1)**	**(2)**	**(3)**	**(4)**	**(5)**
Smoker (=1)	0.9188	0.9095	0.9054	0.8318	0.7886
	(2.1779)	(2.1439)	(2.0875)	(1.8848)	(1.7248)
Log of family labor (hours)	0.0238	0.0240	0.02464	0.0260	0.0275
	(0.0386)	(0.0388)	(0.0389)	(0.0390)	(0.0390)
Log of hired labor (hours)	0.0561***	0.0561***	0.0551***	0.0552***	0.0539***
	(0.0139)	(0.0139)	(0.0141)	(0.0141)	(0.0142)
Log of machinery costs (TK)	0.0041	0.0040	0.0037	0.0041	0.0030
	(0.0297)	(0.0297)	(0.0298)	(0.0298)	(0.0298)
Log of land size (decimals)	0.5632***	0.5638***	0.5629***	0.5658***	0.5650***
	(0.0466)	(0.0473)	(0.0474)	(0.0478)	(0.0478)
Log of cost of seeds (TK)	0.0459	0.0459	0.0473	0.0460	0.0461
	(0.0296)	(0.0296)	(0.0298)	(0.0300)	(0.0300)
Log of cost of fertilizer (TK)	0.0536**	0.0536**	0.0532**	0.0541**	0.0540**
	(0.0231)	(0.0231)	(0.0232)	(0.0233)	(0.0233)
Log of cost of pesticides (TK)	0.0197	0.0196	0.0198	0.0192	0.0198
	(0.0134)	(0.0135)	(0.0135)	(0.0136)	(0.0136)
Crop codes:					
Jute	*Reference Category*				
Corn	0.2625***	0.2622***	0.2598***	0.2617***	0.2655***
	(0.0974)	(0.0977)	(0.0979)	(0.0981)	(0.0982)
Rice	-0.1428	-0.1426	-0.1456*	-0.1421	-0.1389
	(0.0876)	(0.0878)	(0.0881)	(0.0885)	(0.0886)
Other crops	0.0701	0.0699	0.0676	0.0660	0.0604
	(0.1372)	(0.1374)	(0.1376)	(0.1378)	(0.1379)
Age of farmer (years)		-0.0002	-0.0000	-0.0001	-0.0002
		(0.0022)	(0.0022)	(0.0022)	(0.0022)
Educational attainment of farmers (years)			0.0037	0.0040	0.0044
			(0.0083)	(0.0083)	(0.0083)
Body Mass Index				-0.0051	-0.0059
				(0.0109)	(0.0109)
Wealth Index					0.0098
					(0.0101)
Constant	6.5481***	6.5537***	6.5387***	6.6290***	6.6478***
	(0.2748)	(0.2841)	(0.2863)	(0.3458)	(0.3463)
n	401	401	401	401	401
Adjusted R-squared	0.5594	0.5583	0.5573	0.5565	0.5564

Significance levels *p<0.1, **p<0.05, ***p<0.01