Farmers' health and agricultural productivity in rural Ethiopia

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This paper estimates a stochastic production using household survey data to analyze the relationship between farmers' health impediments and agricultural production efficiency in Ethiopia. The results show that healthy farmers produce more per unit of inputs, earn more income and supply more labor than farmers affected by sickness. The model results show that production inefficiency increases significantly with the number of days lost to sickness. This finding suggests that investing in the health sector in rural areas will not only improve farmers' agricultural performance but also increase their income. Policymakers should therefore devise strategies that will maximize the contribution of health investments to agricultural productivity and the overall rural economy.

Keywords: health; productivity; stochastic frontier; efficiency; Ethiopia

Cet article estime une frontière de production en utilisant des données d'une enquête des ménages de fermiers afin d'analyser la relation entre les problèmes de santé de ces derniers et l'efficacité en matière de production agricole en Ethiopie. Le résultat montre que les fermiers en bonne santé produisent plus par unité d'intrants agricoles, qu'ils gagnent plus de revenus et qu'ils fournissent plus de travail que les fermiers malades. Les résultats du modèle montrent que l'inefficacité en matière de production augmente de manière significative en raison du nombre de jours perdus pour cause de maladie. Cette conclusion suggère que l'investissement dans le secteur de la santé dans les zones rurales n'améliorera pas uniquement la performance agricole des fermiers mais aussi leurs revenus. Par conséquent, les décideurs devraient concevoir des stratégies qui maximisent la contribution des investissements dans le secteur de la santé en faveur de la productivité agricole et l'ensemble de l'économie rurale.

Mots-clés : *santé ; productivité ; frontière stochastique ; efficacité ; Ethiopie*

1. Introduction

The literature linking health to labor productivity is built on the household production theory developed by Becker (1965). In Becker's framework, households are treated as producers of 'commodities' rather than just consumers of goods and services. This framework was extended by Grossman (1972, 1999) to analyze the demand for health. In

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Grossman's model, health is viewed as a durable capital stock that yields an output of healthy time. Individuals are endowed with an initial amount of this stock that depreciates over time and can be increased by investment. By investing in health, a household expects to increase the stock of available healthy time, which will increase the amount of time available for earning income or for producing consumption goods (Cropper, 1977). Extending the traditional agricultural household models, Pitt and Rosenzweig (1986) developed a framework that makes it possible to evaluate the impact of a change in health on productivity, labor supply and overall farmers' income. This extension involves incorporating the health variable into the utility function and introducing an explicit production technology for health.

Health as a capital good can either improve or reduce a household's productive ability. A study of women farmers in mixed cropping systems found that the vast majority suffered from intense muscular fatigue, heat exhaustion and skin disorders, which forced them to take days off from attending to crops (Cole, 2006). Poor health will result in a loss of days worked or in reduced worker capacity which, when family and hired labor are not perfect substitutes or when there are liquidity constraints, is likely to reduce output (Antle & Pingali, 1994). For example, prolonged exposure to pesticides could cause cardiopulmonary problems, neurological and hematological symptoms, and adverse dermal effects which could significantly hamper farmers' work capacity in the field and reduce their management and supervision abilities (Spear, 1991).

As pointed by the World Bank (2007), illness and death from HIV/AIDS, malaria, tuberculosis and other diseases reduce agricultural productivity through the loss of labor, productive adults' knowledge, and assets to cope with illness. For Lipton and De Kadt (1988), the failure of agriculture and health departments to coordinate their policymaking undermines efforts to overcome ill-health among the rural poor and hampers agriculture's role in alleviating many of the world's most serious health problems.

This paper addresses some policy relevant questions, such as (i) What is the impact of illness on agricultural technical efficiency? (ii) How different are the effects of health improvements on inputs productivity, output and income? (iii) How does illness affect the distribution of labor supply within households? (iv) Is the impact of health impediments similar across different sources of income?

The paper offers a comprehensive descriptive analysis, and uses a parametric approach that consists in estimating jointly both efficiency as a function of farmers' characteristics and a stochastic production frontier as a function of agricultural inputs. Traditionally, first a stochastic frontier production function, from which the agricultural efficiency index is computed, and then the efficiency index are regressed on farmers' characteristics. As pointed by Liu and Myers (2009), such a procedure is biased for two reasons. First, there is a possible correlation between variables in the frontier function and the inefficiency term. Second, the inefficiency term from the first step is correlated with the exogenous factors.

The rest of the paper is organized as follows. The second section presents empirical findings from previous studies. The third section explains the agricultural household model framework. A descriptive analysis of the data is supplied in the fourth section. The empirical results are presented and discussed in the fifth section, and the last section draws conclusions and suggests policy implications.

2. Previous findings

The importance of the role of health in promoting economic development has been highlighted by Sachs (2001) in the Report of the Commission on Macroeconomics and Health. Indeed, improvements in health care increase the productivity of labor, especially if people switch from low to high productivity jobs as their health improves. In particular, there is strong evidence that growth in early industrialized countries was associated with significantly increased caloric intake and therefore greater height and a higher body mass index (Fogel, 1994; 2004). In addition, good health interacts positively with schooling: healthy children learn more in school and are more likely to stay in school (Bhargava et al., 2001; Miguel & Kremer, 2004). In addition, improved levels of human capital may increase the rate of return to further investments in human capital. This is particularly true of increases in life expectancy: people who expect to live longer earn the returns to education over a longer period. Jayachandran & Lleras-Muney (2009) report that decreases in maternal mortality have led Sri Lankan girls to stay in school longer: the reduced likelihood of dying in childbirth has increased the returns to schooling by increasing life expectancy for girls.

At the micro level, empirical evidence on the link between health and agricultural productivity is based on the implementation of the agricultural household models as extended by Pitt and Rosenzweig (1986). As pointed out by Hawkes and Ruel (2006), in agricultural communities poor health reduces income and productivity, further decreasing people's ability to address health problems and inhibiting economic development. Using cross-sectional data on hoe-cultivating farm household data from Sierra Leone, Strauss (1986) investigated the efficiency wage hypothesis, or the relationship between nutritional quality and agricultural productivity. He found that 'effective family labor', which is a function of actual labor and per capita daily calorie intake, is a significant input in the production process. His study shows a highly significant effect of calorie intake on labor productivity. However, working with panel data from rural South India, Deolalikar (1988) did not find similar results. Neither market wages nor farm output were observed to be responsive to changes in the daily energy intake of workers. However, both were highly elastic with respect to weight-for-height.

Combining production data from a farm-level survey and health data from the same population of farmers in two rice-producing regions of the Philippines, Antle and Pingali (1994) found that pesticide use has a negative effect on farmer health, while farmer health has a significant positive effect on productivity. In Ethiopia, Croppenstedt and Muller (2000) found evidence of a significant link between health and nutritional status and agricultural productivity. Their results show that the distance to the source of water as well as nutrition and morbidity status affect agricultural productivity, and elasticities of labor productivity with respect to nutritional status are very significant. The results also show a large scope for improving productivity through better nutrition.

Estimating the worker productivity benefits of health, Audibert and Etard (2003) used a quasi-experimental design along with a generalized linear model (GLM) for longitudinal data. Unlike Pitt and Rosenzweig (1986), Audibert and Etard (2003) assumed that the family members and the hired labor who are working in the fields are imperfect substitutes because of the cost of hired labor and the low agricultural yield. They observed an increase of 26% in the production per family labor person-day in the experimental group relative to the control group. Their results also suggest that agricultural households prefer to use the additional time available to them for leisure activities or for cultivating crops other than those currently under cultivation.

Analyzing the productivity and attendance at a tea estate in western Kenya, Fox et al. (2004) found that HIV-positive workers picked between 4.11 and 7.93 kg/day less in the last year and a half before they died. Compared to non-HIV-positive pickers, HIV-positive workers took between 9.2 and 11.0 more sick leave days, between 6.4 and 8.3 more annual leave days, and between 11.8 and 19.9 more casual leave days, and spent between 19.2 and 21.8 more days doing less strenuous tasks in the two years before they died. Tea pickers who died from AIDS-related causes earned 16.0% less in the penultimate year before death and 17.7% less in the year before death. In Cote d'Ivoire, studying farmers engaged in intensive vegetable production, Girardin et al. (2004) found that malaria sufferers produced about half the yields and earned half the incomes of healthy farmers.

Kim et al. (1997) analyzed the impact of onchocercal skin disease (OSD) on productivity at a coffee plantation in southwest Ethiopia. Their results revealed that permanent male employees, the core of the plantation labor force, suffered significant losses in economic productivity (in the form of lower daily wages earned) as a result of OSD. Depending on the severity of the disease, and controlling for factors such as age, daily wages were 10 to 15% lower among those with skin-related problems. Relatively older (35+), permanent male employees had the biggest OSD-related loss in economic productivity in terms of diminished earnings, and labor supply was adversely affected.

3. Modeling the impact of farmers' health on efficiency

To account for the sequential nature of agricultural households' decision-making process, Singh et al. (1986) propose a recursive analytical model with profit and utility maximizing components. More specifically, each farmer is assumed to maximize a utility function of the following form:

$$U = U(C_a, C_m, C_l), \qquad (1)$$

where the commodities comprise an agricultural staple (C_a), a market-purchased good (C_m), and leisure (C_l). Utility is maximized subject to a cash income constraint:

$$p_m C_m = p_a(Q_a - C_a) - w(L - L^f) - w_x X + E, \quad (2)$$

where p_m and p_a are respectively the prices of the market-purchased commodity and the staple; Q_a is the farmers' production of the staple; w is the market wage; L is total labor inputs; L^f is family labor input (so that the difference $L - L^f$, if positive, is hired labor or off-farm labor if negative); X is a variable input (for example, fertilizer); w_x is the variable input's market price; and E is any non-labor, non-farm income such as remittance.

Every farmer also faces a time constraint: he cannot allocate more time to leisure, on-farm production, or off-farm employment than the total available amount of time (T). Welch (1970) suggests that farmers' management ability should be reflected in both the technical efficiency of the production process and the allocative efficiency of input and output decisions. Accordingly, the total stock of farmers' time available for farm production (L^f) is divided between management M and field work F. Following Bliss and Stern (1978), and Antle and Pingali (1994), effective management input is given by

$$M^e(I, M) = m(I)M, \ \partial m/\partial I < 0, \quad (3)$$

where I is the index of health impairment. Similarly, effective family labor input is given by

$$F^e(I, F) = f(I)F, \ \partial f/\partial I < 0. \quad (4)$$

Theoretically, the decrease in production is due to reduced effective management input and effective family labor input. However, the comparative static effects of illness I on actual family labor inputs M^e and F^e and on other inputs are not straightforward (Antle & Pingali, 1994): i) the effect of lower overall productivity may be partially offset by the substitution of hired labor or other inputs for family labor input, ii) the allocation of family labor to management and field labor depends on the relative marginal productivities of management and field labor and the relative impacts of illness on the ability to perform field labor and management tasks.

Pitt and Rosenzweig (1986) conclude that production performance is independent from change in farmers' health only if inputs markets are perfect and there is no missing market for any of the consumed commodities or inputs in health production. As for farmers' income, no prediction is possible because the effect of health environment on the level of the farmers' work time depends on the properties of an unknown utility function and on the characteristics of the health production and efficiency labor functions.

Empirically, I assume a stochastic production frontier of the following form (Battese & Coelli, 1995; Kumbhakar & Lovell, 2000):

$$q_i = f(x_i, \beta)\varepsilon_i \exp(\upsilon_i), \tag{5}$$

where $i = 1,..., N$, denotes farmers, q_i is a $(n \times 1)$ vector of output for farmer *i*, x_i is a $(1 \times k)$ vector of associated inputs, β is a $(k \times 1)$ vector of unknown parameters to be estimated, and ε_i represents the *i*-th farmer's level of efficiency. In addition, the farmers' production activity is subject to a stochastic shock $\upsilon_i \sim N(0, \sigma_\upsilon^2)$.

In log form, equation (5) can be written as

$$\ln q_i = \beta_0 + \sum_{j=1}^{k-1} \beta_j \ln x_{ij} + \ln \varepsilon_i + \upsilon_i . \tag{6}$$

Let $u_i = -\ln \varepsilon_i$, it then follows that

$$\ln q_i = \beta_0 + \sum_{j=1}^{k-1} \beta_j \ln x_{ij} - u_i + \upsilon_i , \tag{7}$$

where $u_i \sim N^+(0, \sigma_\upsilon^2)$, and $\lambda = \sigma_u / \sigma_\upsilon$.

Since variables influencing agricultural efficiency (ε_i) may also directly affect agricultural production (q_i), I adopt the approach proposed by Wang and Schmidt (2002) and Liu and Myers (2009), where equation (7) is rewritten as follows:

$$lnq_i = \beta_0 + \sum_{j=1}^{n} \beta_i lnx_{ij} + v_i - u_i(z_i, \theta), \qquad u_i(z_i, \theta) \geq 0. \tag{8}$$

where z_i include health variables. Thus, to achieve both efficiency and consistency, the frontier function and the inefficiency segment are jointly estimated using a one-step maximum likelihood estimation (MLE) procedure.

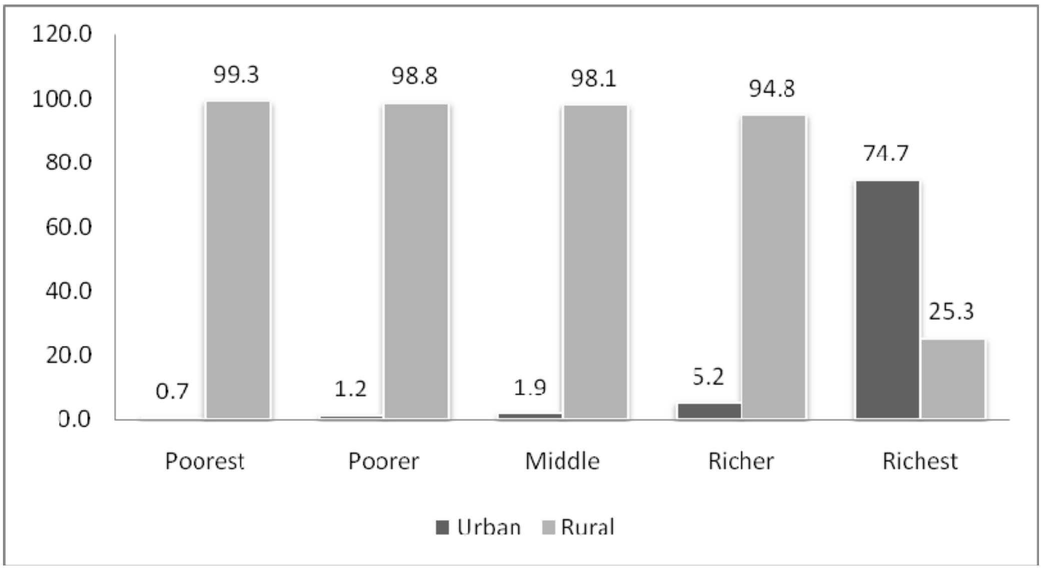
The marginal effect of z_i on production (q_i) and efficiency (u_i) is given by

$$\partial[E(q_i|x_i, z_i)] / \partial z_{ik} = \partial[E(-u_i|x_i, z_i)] / \partial z_{ik} . \tag{9}$$

Equation (9) represents the semi-elasticity of output (efficiency) with respect to exogenous factors, i.e. the percentage change in expected output (efficiency) when z_{ik} increases by one unit.

4. Descriptive analysis

I use an asset-based measure of poverty, the DHS[1] wealth index (see Rutstein & Kiersten, 2004, for details), to highlight the difference in living standards between rural and urban populations in Ethiopia. The DHS wealth index includes household assets such as type of flooring, ownership of refrigerator, water supply, type of vehicle, sanitation facilities, persons per sleeping room, electricity, ownership of agricultural land, telephone, radio, and domestic servant. In the case of Ethiopia, as shown in Figure 1, the distribution of wealth index confirms that there is a significant disparity in living standards between urban and rural areas. Indeed, among the poorest only 0.7% live in urban areas, compared with 99.3% in rural areas. On the other hand, only 25.3% of the richest households live in rural areas, compared with 74.7% in urban areas.

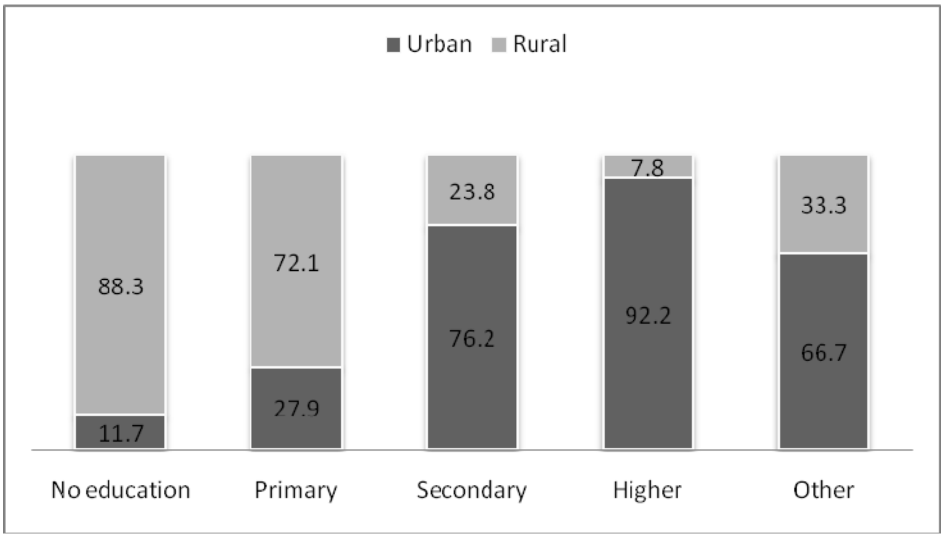


Source: Author's calculation from 2005 Ethiopian Demographic and Health Survey

Figure 1: Comparison of wealth index in urban and rural areas (%)

There is also inequality in educational attainment (Figure 2). For example, 88% of non-educated Ethiopians live in rural areas compared with about 12% in urban areas, whereas about 76% and 92% of the population with secondary and higher education, respectively, live in urban areas, and only about 24% and 8%, respectively, in rural areas.

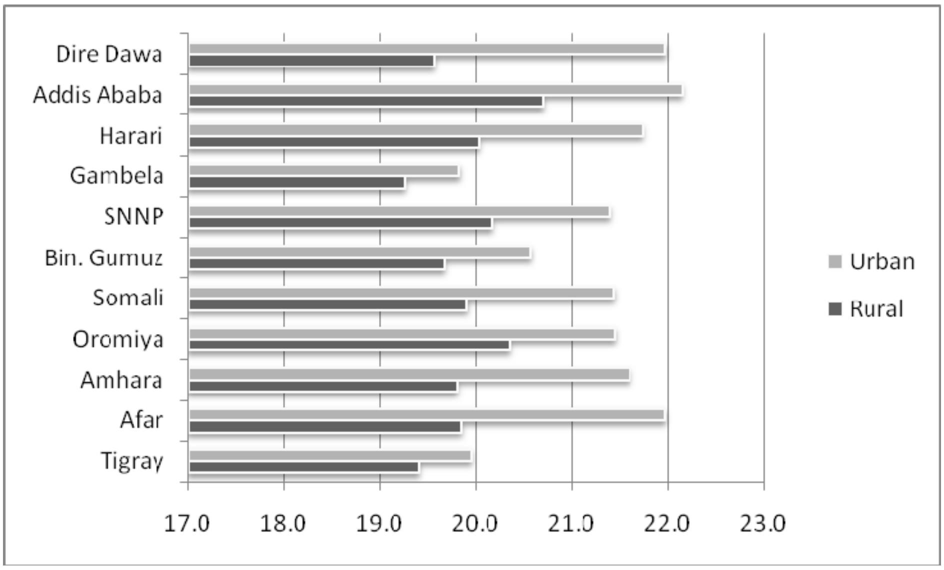
[1] Demographic and health survey.



Source: Author's calculation from 2005 Ethiopian Demographic and Health Survey

Figure 2: Comparison of educational attainment in urban and rural areas (%)

The BMI (body mass index) is used to evaluate and compare nutritional status in rural and urban areas. The BMI is defined as weight in kilograms divided by height in meters squared (kg/m^2). A cut-off point of 18.5 is used to define thinness or acute under-nutrition and a BMI of 25 or above usually indicates overweight or obesity. As shown in Figure 3, across regions, the average BMI index is within the cut-off points. However, it is clear that, compared to urban areas, rural areas are consistently at the lower end of the scale, which suggests a higher risk in terms of health degradation.



Source: Author's calculation from 2005 Ethiopian Demographic and Health Survey

Figure 3: Comparison of BMI (body mass index) in urban and rural areas (%)

Data used for estimation in this study are from the Ethiopian Rural Household Survey conducted in 1999. The survey is a longitudinal household dataset covering households in a number of villages in rural Ethiopia since 1989. In this paper, I use data from the fifth round only because some of the variables of interest were not collected in every round. The fifth round of the survey included about 1,500 rural households living in 20 peasant associations. Of these households, 80.4% are headed by males. Farming (77.6%) and domestic work (14.9%) are the main activities of the surveyed households. Of all working hours directly imputable to family labor (89.6%), males account for 72.9% of agricultural labor force compared to 18.3% for females and 8.8% for children. About 56.0% of farmers cultivate on rich land, compared with 29.4 and 14.6% respectively on mediocre and poor land. As expected, the difference in land quality means a great deal of heterogeneity in land productivity. As shown in Figure 4, except for maize, land productivity is systematically higher for rich land than for mediocre and poor land.

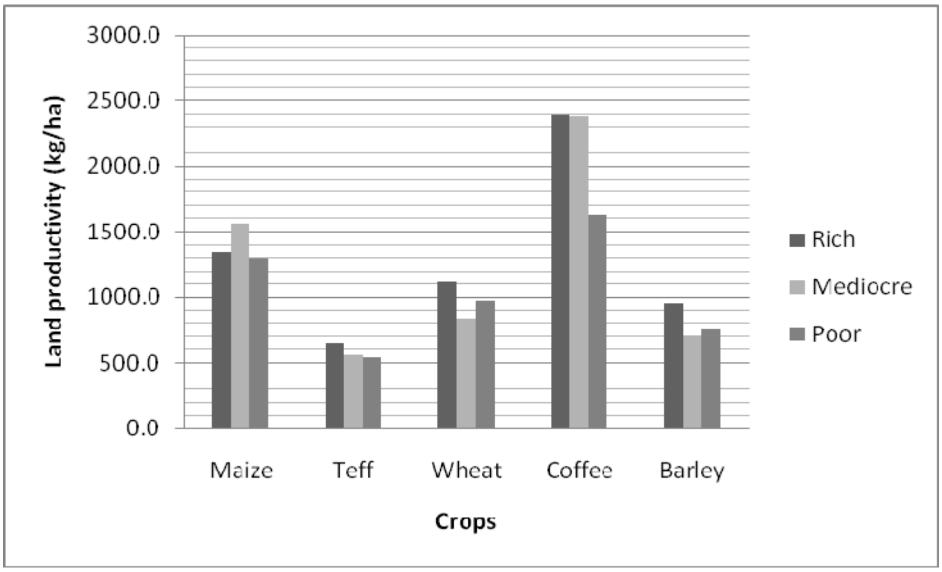


Figure 4: Land productivity by crops and land quality

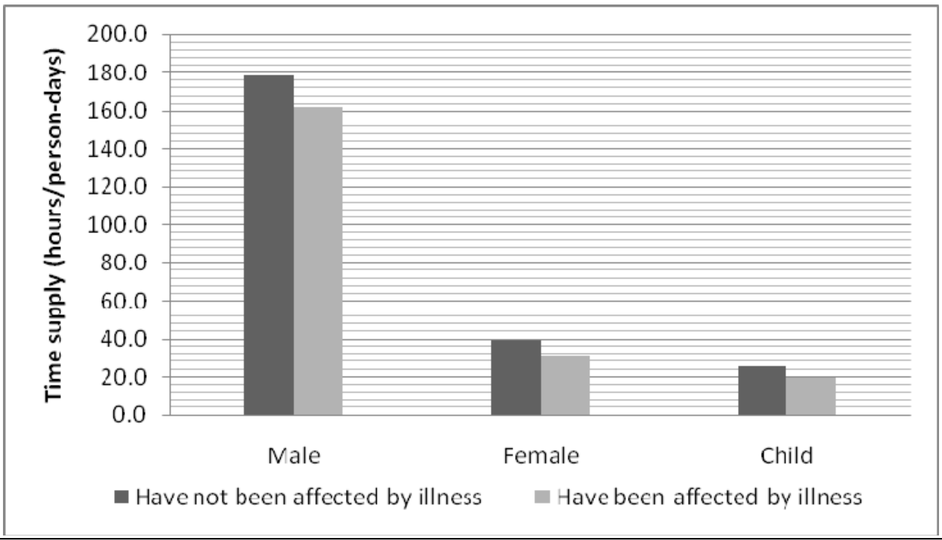
Among those who suffered from sickness, about 36.1% said they had problems hoeing the fields. On average, sickness caused a loss of 17 person-days of farming activity per year. Because a household member was ill at critical periods of farming activity, 17.8% of households experienced output loss.

Table 1: Sickness and labor supply by agricultural tasks (hours/person-day)

	Affected by illness	Not affected by illness
Clearing	5.8	4.8
Land preparation	19.6	16.4
Planting	10.3	9.1
Leveling	2.2	2.2
Weeding	28.6	26.6
Threshing	16.3	22.4
Shelling	21.0	18.1
Guarding	43.2	33.2
Harvesting	21.7	18.3
Storing	58.2	31.6

Source: Author's calculation from 1999 Ethiopian Rural Household Survey

Across activities, the results in Table 1 show a systematic decline in time supplied by farmers affected by sickness, except for threshing and leveling. The biggest differences between the two groups come from guarding and storing crops, for which healthy farmers allocated respectively 43.2 and 58.2 person-days compared to 33.2 and 31.6 respectively for farmers affected by sickness. Distribution within households (Figure 5) also indicates a decline in the time spent on the field for households affected by sickness. Healthy males supply 9.8% more time than their non-healthy counterparts. The difference is even wider for females (29.6%) and children (27.4%).



Source: Author's calculation from 1999 Ethiopian Rural Household Survey
Note: Labor time allocated to inputs application not included.

Figure 5: Labor supply and sickness (hours/person-day)

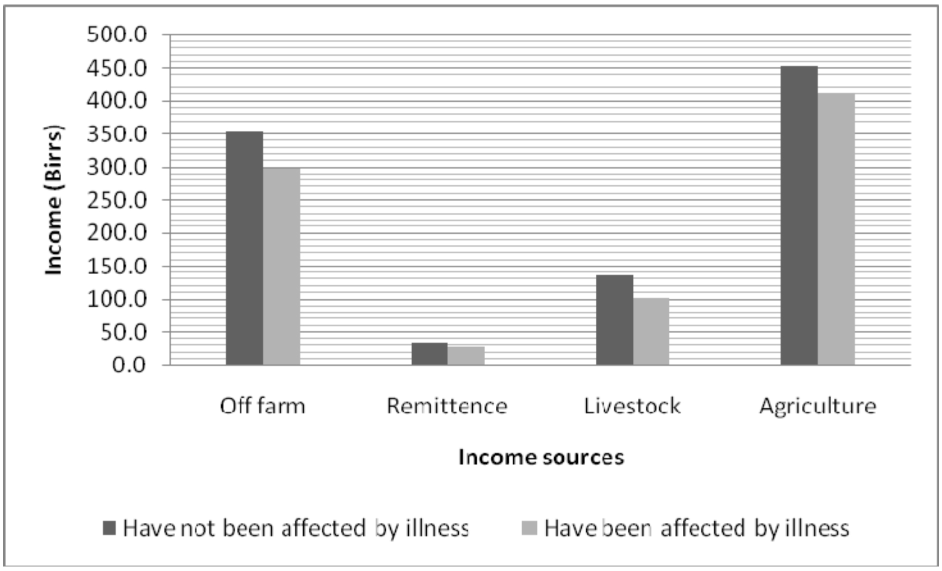
Table 2: Average agricultural product (birr per unit of input)

	Land	Labor	Fertilizer	Animal
Have not been affected by illness	8643.7	48.9	176.0	1019.1
Have been affected by illness	6839.6	27.3	75.1	788.8

Source: Author's calculation from 1999 Ethiopian Rural Household Survey

With respect to all major agricultural inputs, the results suggest that average agricultural product (birr/unit of input) is systematically higher for farmers not affected by sickness than for those affected (Table 2). The big differences observed in fertilizer and animal inputs would suggest that sickness may significantly impede farmers' ability to use these two inputs efficiently.

On average, healthy farmers earn 976 birr[1] a year compared to 838 birr for farmers affected by illness. For both groups, more than 80% of income is generated from agricultural and off-farm activities. Across all income sources, healthy farmers earn more than their non-healthy counterparts (Figure 6); the difference ranges from 56 birr (off-farm) to 6 birr (remittance). The difference in earning because of sickness may be the result of an imperfect labor market, which may not allow the substitution of healthy hired labor for sick family labor.



Source: Author's calculation from 1999 Ethiopian Rural Household Survey

Figure 6: Sickness and household incomes (birr)

[1] At the time of the survey (1999) the US$–birr exchange rate was 7.81 birrs to the dollar.

5. Estimation and simulation results

In addition to the above descriptive analysis, a Cobb-Douglas stochastic production frontier is jointly estimated with the farmers' efficiency index. As mentioned earlier, unlike the two-step procedure where the production function is estimated first and the resulting efficiency index is then explained using the treatment model approach, the one-step approach implemented in this paper allows the production frontier and the inefficiency effects to be estimated jointly. Table 3 presents summary statistics of all variables used in the production efficiency analysis.

The results (Table 4) show that production elasticities with respect to all inputs are positive but animal power and labor inputs are not significant. With a production elasticity of 0.37, land turns out to be a key factor in production.

Table 3: Summary statistics of the variables used in the efficiency analysis

Variable	# Observations	Mean	Standard error
Production (birr)	681	8187.0	53989
Animal (number)	681	9.6	7.8
Labor (hours/person-day)	681	389.4	721.8
Land (ha)	681	1.5	1.0
Seed (kg)	681	222.8	654.8
Fertilizer (kg)	681	125.2	135.4
Days lost (days)	681	18.3	40.3
Medical expenses (birr)	681	81.9	284.2
Female (binary)	681	-	-

Table 4: Maximum-likelihood estimates of the production frontier and inefficiency effects model

	Variables [a]	Coefficient [b]	Standard error
Production frontier			
	Animal	0.064	0.059
	Fertilizer	0.094*	0.055
	Land	0.387***	0.080
	Labor	0.059	0.051
	Seed	0.098**	0.040
	Intercept	7.127***	0.373
Inefficiency model			
	Gender (1 if female)	0.464**	0.228
	Medical expenses	-0.085	0.232
	Number of days lost to illness	0.005***	0.002
# Observations	681		
Wald statistic	140.2; p-value:0.00		
Log-likelihood	-1006.9		

[a] all variables in the production function are in log form.
[b] *, **, *** signify significance at 10%, 5% and 1% levels, respectively.

The results suggest that farmers' efficiency is significantly affected by the number of days lost to sickness. On the basis of the framework developed by Pitt and Rosenzweig (1986), change in farmers' health affects productivity only if inputs markets are not perfect and there are missing markets for any of the consumed commodities or inputs in health production. It follows that the link between farmers' health and agricultural productivity is much more complex than has been suggested in most previous studies. In this paper, the number of days farmers could not work because of sickness is used to capture farmers' health status. On average, farmers lost 17 days because of illness, and male farmers reported more loss than female farmers (18 and 12 days respectively). The results suggest that one more day lost due to illness increases farmers' inefficiency by 0.5%. Although the magnitude of the effect is small, it is highly significant. It may be that farmers have accumulated some technical and managerial skills that are not easily substitutable through either labor market or family and other social connection; their inability to perform agricultural activities because of sickness therefore has a significant negative impact on overall efficiency.

Figure 7 plots the density of farmers' technical efficiency.[1] The minimum efficiency level is 12.5% and the maximum is 86.9%. Figure 8 confirms the negative effect of days lost to illness on agricultural efficiency. Indeed, as farmers lose more days because of illness, their efficiency is expected to decline.

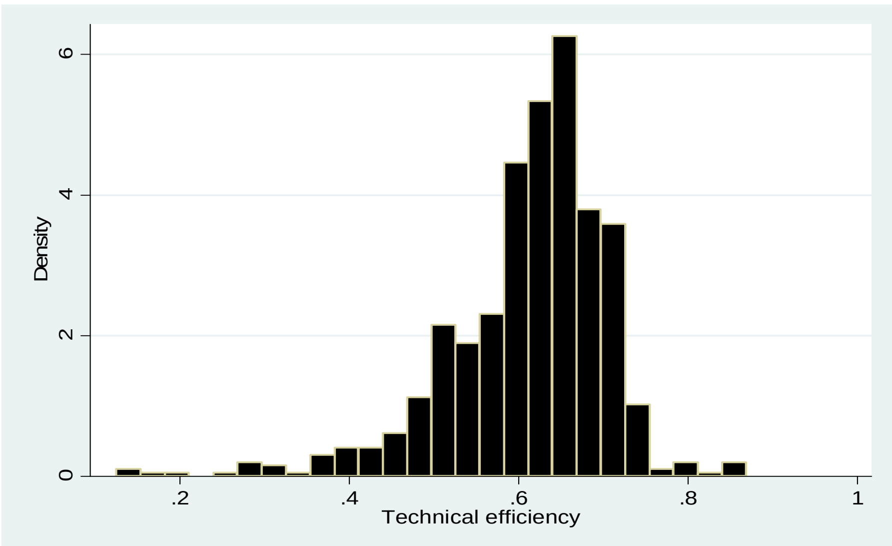


Figure 7: Density of technical efficiency

[1] The measure of technical efficiency is given by $E\{exp(-u_i)|\epsilon_i\}$, where $\epsilon_i = y_i - x_i\beta$.

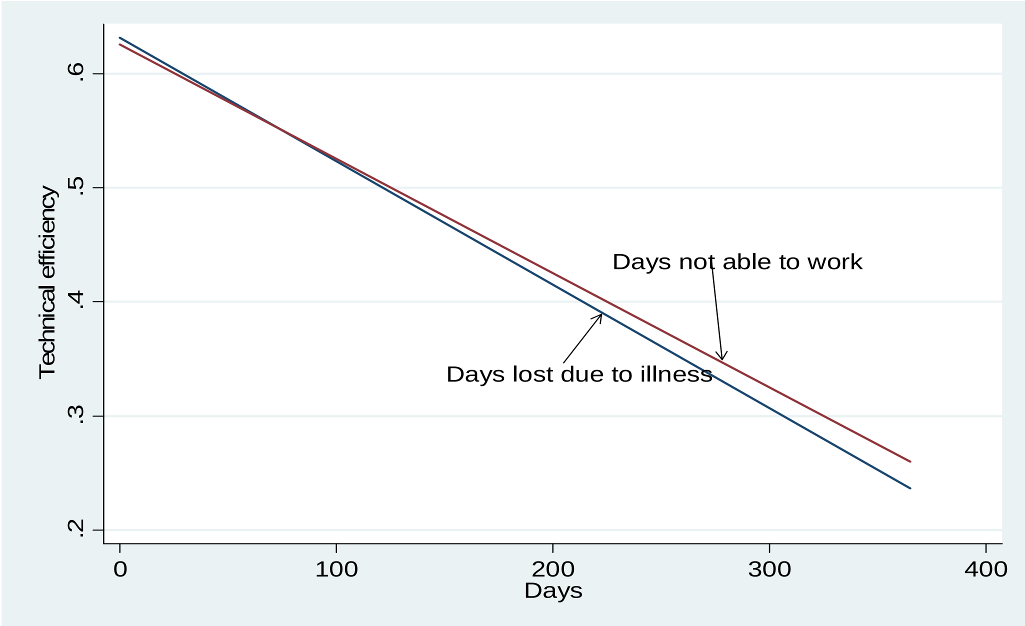


Figure 8: Technical efficiency and days lost to illness

Overall, healthy farmers tend to be more efficient than those affected by illness; however, the results suggest the existence of regional heterogeneity (Table 5). Across regions, the highest efficiency is observed among southern peoples for both healthy farmers (0.654) and those affected by illness (0.643), and the lowest in Tigray: 0.539 for healthy farmers and 0.485 for those affected by illness.

Table 5: Efficiency and sickness by region

	Not affected by illness	Affected by illness
Tigray	0.539	0.485
Amhara	0.630	0.616
Oromiya	0.612	0.613
Southern peoples[a]	0.654	0.643
Southern peoples[b]	0.586	0.565
Overall	*0.617*	*0.602*

[b] Gara Godo-Areka and Domma, [a]Indibir and Durame-Azedebos

Does access to agricultural services help mitigate the effect of illness on efficiency? As reported in Table 6, access to extension service has almost no significant impact; although, unlike healthy farmers, sick farmers with access to extension service appear less efficient than those who have no access to extension service.

The results suggest that, regardless of health status, farmers on non-irrigated land are more efficient than those practicing irrigation. The main purpose of intercropping is to produce a greater yield on a plot by making use of resources that would otherwise not be used by a single crop. The results confirm that farmers practicing intercropping are much more efficient than their counterparts, regardless of their health status.

Table 6: Efficiency and agricultural services

	Not affected by illness	Affected by illness
Extension		
Access to extension	0.621	0.592
No access to extension	0.616	0.604
Irrigation		
Irrigated land	0.584	0.496
Not irrigated land	0.617	0.609
Cropping system		
Not intercropping	0.614	0.597
Intercropping	0.636	0.624

6. Concluding remarks

Compared to previous studies, the present analysis has shed more light on the relationship between farmers' health status and agricultural production. The average value of agricultural production per unit of input tends to be higher for healthy farmers than for those affected by illness. The difference in input productivity is also observed in income, where healthy farmers earn 137 birr more per year than those affected by illness. The difference in income ranges from 56 birr (off-farm) to 6 birr (remittance). Sickness also means a lower supply of working time. Except for threshing and leveling, across agricultural activities the results show that farmers affected by sickness supply less time than healthy farmers.

Regression results confirm the negative impact of health impediments on farmers' agricultural efficiency. Indeed, efficiency is found to be significantly affected by the number of days lost to sickness. The results suggest that one more day lost because of illness will increase farmers' inefficiency by 0.5%; this implies that substitution of farmers' time through either labor market or family and other social connection may not be perfect.

In these rural communities, poor health reduces farmers' income and efficiency. It follows that investing in the health sector in rural areas will increase not only efficiency and income but also the rate of return on other investments such as education and extension services. However, more insights are still need in order to develop comprehensive health strategies tailored to boost agricultural productivity. For example, more research is needed to understand consumer perceptions and health risks and health phenomena in the context of small-scale farming. Analyzing the productivity effects of various health instruments such as prevention, health protection and health education is also a policy relevant research agenda.

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