THE ECONOMIC IMPACTS OF EDUCATION ON SMALLHOLDER CROP PRODUCTION SYSTEMS IN AFRICA: EMPIRICAL EVIDENCE FROM BOTSWANA

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Massive expansion in educational programmes has been reported for Sub-Sahara African (SSA) countries in recent years. Yet, the economic role of education in agriculture – the main source of livelihood for the majority of SSA population is still debatable. The purpose of this paper is to provide empirical evidence on how formal education affects smallholder crop production systems in Africa. The analysis uses 1997/98 farm management survey data on 60 randomly selected rural households from Botswana. It is concluded from the results that education has a positive and significant effect on crop incomes of smallholder traditional farmers. Therefore, continuing investments in education among SSA countries are important and warrant supportive government action to improve the lives of millions of peasant farmers in SSA.

1. INTRODUCTION

Massive expansion in educational programmes has been reported for Sub-Sahara African (SSA) countries in recent years (UNDP, 1996). During the past two decades adult literacy more than doubled, from 27 to 55 per cent. Also, between 1960 and 1991 the net enrolment ratio at the primary level increased from 25 to 50%, and at the secondary level from 13 to 38% (UNDP, 1996). There are several well-known arguments for investing in education. It is generally recognised that education leads to significant social welfare benefits. As pointed out by Schultz (1961), improvement in human resources is a major contributing factor to *the* economic growth of nations. Also, Mellor (1976), argues that rural development can only be achieved in conjunction with large expansion of formal education.

The new economic growth theories developed by Paul Romer and Robert Lucas during the late 1980s and early 1990s confirm the human development position that the driving force of all economic growth is people. In the new theories what increase productivity is not an exogenous factor, but 'endogenous' ones, those related to the behaviour of people responsible for the accumulation of productive factors and knowledge. Significantly, this behaviour can be changed by policy.

Some of the new models argue that one of the crucial factors is an across-the board increase in human capital while others argue that the key source of

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productivity growth is research and development, though this too depends on human capital. The human capital models show how education allows the whole production process to benefit from positive externalities. Educated people use capital more efficiently, so it becomes more productive. They are also more likely to innovate, thus, to devise new and better forms of production. Moreover, they spread the benefits to their co-workers, who learn from them and also become more productive. Thus, the rising level of education causes a rise in the efficiency of all factors of production.

The role of education in enhancing agricultural productivity worldwide cannot be underestimated. Evidence from thirty-seven data sets from 13 low income countries shows that farm productivity increases on average by 8.7 per cent as a result of a farmer completing four years of elementary education (Jamison & Lau, 1982). The effect of education as reported by Jamison & Lau (1982) is supposed to be much stronger in modernising environment than in traditional ones.

Welch (1970) classifies education's contribution to agricultural production and productivity into worker and allocative effects. The worker effect is related to the enhanced capacity of production with a given set of inputs. It arises because education may improve the quality of *the* labour component. The allocative effect, on the other hand, refers to allocative efficiency. Thus, the ability of educated farmers to acquire, analyse and understand economically useful information about inputs, production and commodity-mix, which enhances their ability to make optimal decisions with regard to input use and product mix.

Given the recent focus among SSA countries on stimulating educational programmes, it is important to understand the economic impacts of education on smallholder agricultural production systems since more than 60% of the population of SSA live in the rural areas and depend mainly on agriculture for their livelihood. Much of the received wisdom on the economics of education from elsewhere in the world suggests a low payoff to schooling in a traditional production setting (Welch, 1970; Schultz, 1975 and Duraisamy, 1992). Also, the 'allocative' effect of schooling is reported to be particularly small in such a static environment (Welch, 1970; Schultz, 1975). Unfortunately, there is a virtual lack of published work on the economic role of education in smallholder crop production systems in SSA. This paper, using farm-level data on smallholder farmers from Botswana, constitutes an attempt to provide empirical evidence of such vital information which could be useful in designing future agricultural policies to benefit the many smallholder farmers in SSA.

2.   MODEL SPECIFICATION AND ESTIMATION, STUDY AREA AND DATA

2.1   Model specification and estimation

Two major approaches are known to be used in estimating and testing the worker and allocative effects of education, namely, the production function and profit function methods (Duraisamy, 1992). As reported by Duraisamy (1992), despite the advantages that the profit function method offers over the production function method in testing hypotheses related to various economic efficiencies, it is more appropriate to use *the* production function to measure the economic returns to education on output, not profit. Following this, the production function method was preferred in this study to any other methods. Two variations of the empirical model were specified namely: a simple income function with education as the only independent variable and an expanded model with other major factors in addition to education. The simple income function model is presented as follows:

$$\ln Inc_{inc} = \beta_0 + \beta_1 \ln Ed + \epsilon \tag{1}$$

where Ed_{inc} is the crop revenue or income with formal education (Ed), β_1, the income elasticity of education; Ed, the measure of education (school years) completed; and ϵ, the error term. The dependent variable, Ed_{inc}, equals the gross value of all individual crop yields multiplied by their respective prices. As advanced by Welch (1970), estimation of a production function for gross value of all crops captures both the worker and allocative effects of education.

It is assumed that all farming decisions are made by the household head and therefore the use of his (or her) years of education as the measure of education in the model. However, due to the positive spillover effects of education and the fact that most heads of household in rural Africa are illiterate, the years of education of *adult* household members are also considered. The education variable is treated both as continuous and dummy state in order to study the sensitivity of the income elasticity of education.

It is evident from equation 1, that the effects of some crucial influencing factors on crop income have been left out. This is not realistic since other variables like land, labour and etc., are not constant across households. Therefore, it becomes necessary to expand the simple model to incorporate those crucial factors, besides education, that have influence on crop production. Based on previous studies conducted on the smallholder farming systems in the study area (Panin *et al.*, 1993; Panin, 1995 and Panin & Mahabile, 1996); major variables considered in the

expanded model are: area of land cultivated, labour used, non-farm income and extension contact.

Area of land cultivated during the cropping period is expressed as a stock variable and *is* measured in hectares. All things being equal, farmers with larger farms are expected to harvest larger quantities of produce than those with small farms. Therefore, one would anticipate a positive relationship between crop income and farm size.

The labour input measured in terms of total adult-person hours used in production during the agricultural season was specified separately for male and female hours worked in order to test whether there is *a* productivity differential between the two groups of farm workers. *Total adult-person hours measures the* sum of family labour and hired labour. Ideally, one would prefer to use a disaggregated labour input by farm operation. Unfortunately, the labour input data collected did not permit such disaggregation. The effect of increased labour intensity on crop production is supposed to be positive.

Income from non-farm *employment* which includes such diverse activities as government, commerce, manufacturing and services and income transfers from relatives constitute the total non-farm income variable of the household. Non-farm income may have either beneficial or adverse effect on smallholder agricultural production systems. If farmers invest their non-farm incomes in farming activities, i.e. use the money to purchase fertilisers, high yield variety seeds, hire more labour etc., it is more likely that non-farm income will have a positive effect on agricultural production. On the other hand, it can serve as disincentive for some farmers to concentrate on their farming particularly in areas where the opportunity cost of labour in non-farm employment tends to be higher than returns to labour in agriculture.

Extension contact is used as a proxy for non-formal education and is measured as the number of times a household had contact with extension agents. Contact with extension agents is expected to have a positive effect on smallholder farming systems. Such contacts, by exposing farmers to availability of information on existing or new technologies can be expected to stimulate adoption.

The Cobb-Douglas functional form was used to fit the smallholder multi-crop income function for the study area. The specific expanded crop income model was specified as follows:

$$\ln Inc_{inc} = \beta_0 + \beta_1 \ln Ed + \beta_2 \ln AR + \beta_3 \ln FL + \beta_4 \ln ML + \beta_5 \ln NF + \beta_6 \ln EC + \in \qquad (2)$$

where Ed_{inc} and Ed are as already defined; AR is the area of land cultivated (in

hectares); **FL** is female hours worked; **ML** is male hours worked; **NF** is total non-farm income (in Pula); **EC** is extension contact; $\beta_1....\beta_6$ are parameters of the production function to be estimated and ϵ is an error term. *Both correlation and auxiliary regression analyses (Gujarati, 1995) were undertaken to* detect the presence of collinearity between the explanatory variables. The results of the correlation analysis (Table 1) did not reveal any severe degree of collinearity. Also, all the auxiliary R^2 values ranging between 0.13 to 0.41 were far less than the overall R^2s (0.90 to 0.91), that is, those obtained from the regression of crop revenue on all the regressors. Adopting 'Klein's rule of thumb' (Gujarati, 1995:337), this implied that there was no multicollinearity. The production function is estimated by Ordinary Least Squares (OLS) method.

Table 1:   Correlation Coefficients[1] of the explanatory variables in the regression models

	Area	Mahr	Fehr	N-F-I	Schyrhh	Schyrhm	Extct
Area	1.00						
Mahr	0.70	1.00					
Fehr	0.41	0.31	1.00				
N-F-I	0.44	0.25	0.21[n.s]	1.00			
Schyrhh	0.43	0.28	0.63	0.34	1.00		
Schyrhm	0.41	0.18[n.s]	0.41	0.60	0.54	1.00	
Extct	0.42	0.32	0.40	0.43	0.31	0.44	1.00

[1]   *All coefficients excerpt those indicated by [n.s] are significantly different from zero at or above the 5% confidence level; [n.s] = not significantly different from zero at or above 5% confidence level.*

Mahr = male hours worked, Fehr = female hours worked, N-F-I = non-farm income, Schyrhh = years of schooling of household head, Schyrhm = years of schooling of adult household members, and Extct = extension contact.

2.2   The study area and data used

The data utilised in this analysis are from a household survey conducted in 1997/98 in two rural agricultural districts of Botswana. They are Kweneng and Kgatleng districts, lying about 60 and 40 km east and west, respectively, from Gaborone, the capital of Botswana. The economy of the area is mainly based on subsistence farming, with about 90% of its total labour force directly or indirectly engaged in agriculture (Panin *et al.*, 1993). Farming practice in the area is characterised by a mixture of crop-livestock production systems. The major crops of the area are sorghum, maize, beans and millet which are often grown in mixtures.

The data were collected from 60 randomly selected households located in four villages from the two agricultural districts. The survey was conducted by personal interviews, using a structured questionnaire. Detailed information on household demographic characteristics, farm size, crop output, cash and non-cash inputs, off-farm incomes and respective prices of output and inputs were collected.

3.   EMPIRICAL RESULTS

3.1   Descriptive overview of surveyed farm-households

Table 2 shows that *sample* households are relatively large in size; *the* average household had 7.03 persons. The average age of a *household head* (58.3 years) indicates that most *land-holders* in the study area were fairly old. This finding is consistent with the findings of Singh (1988) and Panin (1988) who, respectively, reported an average age of 56.2 years for heads of household in Burkina Fasso and 51.2 years for their colleagues in northern Ghana. Most of the *household heads*, about 52% had no formal education. The average school years completed by a household head amounted to 2.28 and 6.35 years for a household member. Also, on average, more than 50 per cent of household members had not completed six years of formal schooling. These results also confirm the findings of other studies (i.e. Panin, *et al.*, 1993; Panin & Mahabile, 1996). Area cultivated ranged from *two* to 18 ha with a mean of 5.83 ha. On the average, women contributed more than double the total hours worked by their male counterparts.

Table 2:   Descriptive statistics of surveyed farm-households, Botswana, 1997/98

Variable	Mean values (N = 60)	Standard deviation
Number of persons/household	7.03	2.59
Age of household head (years)	58.25	12.20
Years of schooling of head	2.28	3.22
Average years of schooling of household members	6.35	3.94
Area (ha)	5.83	3.59
Female labour input (hrs)	724.65	679.06
Male labour input (hrs)	343.53	435.11
Number of contacts/household with extension staff	1.63	1.45
% of heads that have completed at least one year of schooling	48.3	
% of household members that have completed six years of schooling	48.52	

3.2   Estimates of the income function

The OLS parameter estimates of the income function for the smallholder farmers are presented in Tables 3 and 4. Table 3 provides the estimates of the simple income function specified in equation 1 while the results in equation 3 (the expanded model) with alternative specification of the education variable are presented in Table 4, columns 1-3. In addition to other variables specified in the model, column 1 of Table 4 considers the education of the head of household only, while column 2 looks at average education of household members, and column 3, the education of household head treated as a dummy *variable*. The signs of the estimated coefficients are consistent with a *priori* expectations.

3.2.1 *Economic impact of formal education*

The coefficient on formal education, whether of all the members of the household, or of the household head, remains stable and consistent across all the alternative model specifications of the estimating equation. In all the equations, the education coefficient is positive and statistically significant at the one per cent level *of probability*. The only exception, in terms of explanatory power, is the coefficient on education of household members (Table 3) which is significant at the 10% confidence level. The results highlight the allocative and worker (direct) effects of education in a typical traditional crop production systems in SSA. The schooling coefficients (Table 3) estimated through equation 1, as argued by Welch (1970), can be considered as the allocative effects of schooling, while those estimated through equation 2 (Table 4, columns 1-3) represent worker (direct) effects.

Table 3:   **Estimates of crop income function with education as the only independent variable, Botswana, 1997/98**

		Constant	Education	Adj R²	F-value	N
	Equation with:					
a)	Education of head	6.830 (53.092)*	0.083 (6.457)*	0.41	41.695	60
b)	Average education of household members	6.082 (37.343)*	0.074 (1.945)***	0.05	3.785	60

*, ***, significant at 1% and 10%, respectively. t-values are in parentheses.

Table 4:   Estimates of crop income function for traditional smallholder farmers: Botswana, 1997/98

Independent variable	Equation 2 with alternative education variable		
	1	2	3
Constant	2.127 (7.039)*	1.598 (7.266)*	1.893 (7.580)*
Land area	0.341 (3.402)*	0.366 (3.665)*	0.341 (3.399)*
Male hours worked	0.085 (3.335)*	0.105 (4.023)*	0.084 (3.291)*
Female hours worked	0.573 (12.131)*	0.613 (14.098)*	0.575 (12.275)*
Non-farm income	-0.024 (-4.107)*	-0.028 (-4.677)*	-0.02 4 (-4.102)*
Education of head	0.016 (2.524)*	----------	--------
Average education of household members	-------	0.038 (2.772)*	-------
Extension contact	0.014 (1.988)**	------	0.015 (2.008)**
Education dummy of head (0=uneducated and 1=educated)	-------	------	0.247 (2.531)*
Adj R²	0.91	0.90	0.91
F-value	95.81	113.07	95.87
N	60	60	60

*, **, Significant at 1% and 5%, respectively. t-values are in parentheses

The direct effects of education as revealed by the coefficients on schooling (Table 4) suggest that an additional year of schooling of a head of household and similar increase in the average school years of household members results in an increase of 1.6 and 3.3 percent, respectively, in crop production output. The allocative effect of either heads of household or household members' education far exceeds that of its direct (worker) effect. The estimated coefficient on education of a head of household and an adult household member (Table 3) is 8.3 and 7.4 percent, respectively. These results suggest that farmers benefit from education more in terms of its allocative efficiency than its direct effect.

Comparison of the direct and allocative effects of education for heads and household members indicates that the direct (worker) effect of schooling of heads of household is much smaller than that of household members. On the other hand, the allocative effect is greater for heads of household than household members. These findings seem plausible because the primary role of the heads of household is decision making regarding procurement and efficient allocation of inputs. Their direct contribution to active farm work (worker effect) in the traditional farm setting is, in most cases, limited by their old age.

In monetary terms, one year of additional education of a head of household was estimated to increase crop income by P11.39 (US$2.90) whereas a similar increase in the average years of schooling of a household member resulted in a gain of P5.39 (US$1.37). This indicates that education of the head of household is more crucial in traditional crop production systems than the average level of education of the household members.

As evident from the results, the income elasticities of education of a head of household are, statistically, highly significant but in terms of magnitude quite small. It is believed, were most heads of households educated, the impact of education would probably be greater than what is estimated by the model. The results with education of heads of household treated as a dummy variable (Table 4, column 3) and introduced as a shift parameter suggests clearly that educated farmers get about 25 *per cent* higher *sales* than the uneducated farmers. The difference in production can be attributed to the fact that a better educated farmer may be able to adopt a new and superior technology faster than *a* less educated one. Of course, the productivity differentials may be caused by the adoption of new technologies.

3.2.2 *Effects of other inputs*

The production elasticities of area cultivated, labour (male and female hours worked), and extension contact are positive (Table 4). On the contrary, the estimated coefficient on non-farm income is negative. All the estimated coefficients are, at least statistically significant at 5 percent level, indicating that these inputs are also crucial to smallholder traditional crop production systems. Together with the education variable, they account between 90-91% of total variation in total output of the traditional crop production systems.

4.   CONCLUSION

The economic contribution of a farmer and his/her household members' education to a typical traditional African smallholder crop production systems was investigated by estimating crop income (revenue) function. The empirical results based on smallholder farm level data from Botswana suggest that education has a positive and significant impact on traditional smallholder crop production systems in SSA. The results raise an intriguing idea that education of heads of household is more crucial in a traditional crop production systems than the average level of education of household members. This finding has considerable significance for policy-makers. It underlines the need for the continuing investment in education (both formal and informal) among SSA countries and also calls for more supportive government action to improve

education in the rural areas to uplift the lives of millions of people living in the rural areas. Although, the results are derived from data from a specific location, it is believed that the characteristics and factors affecting the smallholder production systems in the study area are common to most smallholder farming systems in SSA. Therefore, the main finding can be used as a policy instrument by all governments in SSA to stimulate agricultural growth in the region.

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