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THE CONTRIBUTION OF EDUCATION TO ALLOCATIVE AND TECHNICAL EFFICIENCY IN SUGARCANE PRODUCTION

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Education's contribution to agricultural productivity has been attributed to "worker" and "allocative" effects (Welch). The worker effect refers to technical efficiency - a more educated farmer's ability to achieve higher output for a given bundle of inputs. The allocative effect refers to allocative efficiency - the ability of the educated to obtain, analyze and understand economically useful information about inputs, production practices and commodity mix which enhances their ability to make optimal decisions with regard to input use and product mix.

Welch contends that the marginal value product (MVP) of education estimated from an engineering (single output) production function measures only the worker effect. He correctly argues further that such a function does not capture the allocative effect of education. However, he neither explicitly discusses the existence of an allocative effect[1] of education on a single output farm nor suggests how such an effect can be measured by employing a more appropriate model[2] than an engineering production function. The purpose of this paper is to test the hypothesis that education enhances farmers' allocative ability, and thus has a significant allocative effect, even on a single output farm. However, to capture the allocative effect one must utilize a more adequate production function or a profit function approach[3] rather than the engineering production function *per se*. Both methods are employed in this study. But it is hypothesized that the profit function model provides more precise measures of the worker and allocative effects than does the production function model.

Farmers facing imperfect information and technologically changing agriculture may make allocative errors in the sense of not being able to equate the MVP of variable inputs to their respective opportunity costs even if they produce a single crop. The presence of disequilibrium arising from changing technology may create incentive for farmers to learn about inputs and adjust their actual resource employment toward an optimum level. Education may enhance farmers' ability to acquire and analyze technical and market information about inputs and enable them to adjust quickly to disequilibria in input use. Consequently, education may have a much stronger impact on output through its allocative effect than through its worker effect.[4]

The data used in this study is obtained by interviewing 156 sugarcane cultivating farmers of Bara district in the central terai of Nepal for the crop year 1979-1980 (January 1979 - January 1980). A majority of farmers are growing improved varieties of sugarcane. They have an average education (schooling) of 5.32 years. Since farmers in the terai have been introducing bio-chemical and mechanical innovations for over a decade, the modernizing environment provides a congenial milue to determine whether education enhances sugarcane farmers' ability to adjust quickly to disequilibria[5] and thus in turn has a significant allocative effect in sugarcane production.

This paper has five sections. The first and second sections respectively discuss the production and profit function models estimated in this study. The third and fourth present empirical results from the production and profit functions respectively. The final section contains the concluding remarks.

I. THE PRODUCTION FUNCTION MODEL

This section presents an engineering sugarcane production function and describes how the estimates from such function can be utilized to examine whether education has an allocative effect in addition to the worker effect in sugarcane farming.

Let an engineering sugarcane production function be:

$$(1) \quad Y = f\ (X;\ Z,\ E)$$

where, Y is sugarcane output, X and Z represent variable and fixed inputs respectively, E is operator's education and P_Y is the output price.

The MVP of education, $P_Y \cdot \frac{\delta Y}{\delta E}$, from (1) represents only the worker effect (Welch). The estimation of the allocative effect of education involves further regression which utilizes the MVP of variable inputs from (1) plus their respective prices. A brief discussion of that further estimation follows.

If a producer is a profit maximizer, he/she attempts to equate the MVP of variable inputs to their respective opportunity costs (P_X):

$$(2) \quad P_Y \cdot \frac{\delta Y}{\delta X} = P_X$$

In other words, the difference (ε) between marginal value product of variable inputs and their respective prices must be zero if the producer is successful in maximizing profit or is absolute allocative efficient.

$$(3) \quad \varepsilon = \left[\frac{(\delta_Y/\delta_X)}{(P_X/P_Y)} - 1 \right] = 0$$

Thus, the absolute difference between the MVP of variable inputs and their respective prices can be used as a measure of allocative enefficiency and such a difference will be called an allocative error (ε) hereafter.

The changes occuring in farm technology or market conditions may have created disequilibrium in input use in sugarcane and the allocative error (ε) in the farms under study may not be zero. The existence of disequilibrium may have created incentives for farmers to learn about input characteristics and market conditions. If education enhances farmers decision making ability, or their ability to deal successfully with eocnomic disequilibria, the absolute allocative error must be a decreasing function of education:

$$(4) \quad |\varepsilon| = g(E)$$

where, $d\varepsilon \,/\, dE < 0$ i.e. the absolute size of allocative error must be inversely related to farm operator's education.

Assuming that the function (1) is of the Cobb - Douglas form, the following log-linear sugarcane production function specification is estimated to derive the MVP of education and variable inputs:

$$(5) \quad \ln Y = \ln c + \beta_1 \ln L + \beta_2 \ln NF + \beta_3 \ln K + \beta_4 \ln A + \alpha_1 \ln NH + \alpha_2 \ln B + \alpha_3 \ln F + \delta_1 E + \delta_2 X$$

Where, Y is sugarcane output in quintal, NF is manyears of available family labor, K is capital (12 percent of the total value of tools, equipments and machinary) in rupees,[6] A is operator's age in years, NH is mandays of hired labor, B is days of bullock use, F is fertilizer in kilograms, E is 1 if farm operator had schooling and zero otherwise, and X is 1 if farmer had extension contact and zero otherwise.

The MVP of education from (5) provides a measure of the worker effect while the MVP of variable inputs - hired labor (NH), fertilizer (F) and bullock (B) - from (5) are utilized to derive allocative errors (ε). The allocativer errors are then regressed on education as (6), which will be called allocative error functions hereafter,

$$(6) \quad \ln (\varepsilon^2) = a + \varepsilon \cdot E$$

to determine if education has any allocative effect in sugarcane production.

II. THE PROFIT FUNCTION

The profit function approach presents itself as an alternative to the production function and also may be more appropriate to analyze the worker (technical) and allocative effects (efficiencies) of education (educated) for four main reasons. Firstly, the normalized restricted profit function and input demand functions are functions of predetermined variables. Thus, they are econometrically better suited for estimation since estimation of such functions avoids possible simultaneous equation bias. Secondly, it permits testing of hypotheses concerning allocative and worker effects of education without having to estimate the allocative error functions (6). Thirdly, the profit and input demand functions estimated by seemingly unrelated regression provide asymptotically more efficient estimates than the production function estimated by OLS. Fourthly, this approach is able to take into account differences in technical efficiency, allocative efficiency and effective prices and permit determination of relative economic efficiency of the educated and illiterated farmers.

This section discusses how a normalized restricted profit function can be employed to test the hypothesis that education has a significant allocative effect in addition to a weak worker effect in the dynamic sugarcane farms or that the educated attain higher economic efficiency by being significantly more allocative efficient than the illiterates.

Let the normalized restricted profit function (7) and input demand functions[8] (8-10) for hired labor (NH), bullock (B) and fertilizer (F) for sugarcane be:

$$(7)\quad \ln \pi^* = \ln A^{*U} + \delta^E E + \alpha_N^* \ln P_n + \alpha_B^* \ln P_b + \alpha_F^* \ln P_f + \beta_L^* \ln L + \beta_N^* \ln NF + \beta_K^* \ln K + \beta_A^* \ln A + \delta_X^* \cdot X$$

$$(8)\quad \frac{-P_n \cdot NH}{\pi^*} = \alpha_N^{*E} E + \alpha_N^{*U} E_o$$

$$(9)\quad \frac{-P_b \cdot B}{\pi^*} = \alpha_B^{*E} E + \alpha_B^{*U} E_o$$

$$(10)\quad \frac{-P_f \cdot F}{\pi^*} = \alpha_F^{*E} E + \alpha_F^{*U} E_o$$

where π^* is a restricted profit normalized by the sugarcane price. The restricted profit is the difference between total sugarcane renenue ($P_Y \cdot Y$) minus the cost of variable inputs of hired labor, fertilizer and bullock. The variables L, NF, K, A, E and X as defined earlier in production function. E_o is 1 if illiterate farmers and 0 otherwise. The variables P_n, P_b and P_f are respectively price of labor, bullock and fertilizer normalized by sugarcane price. Superscripts E and U denote educated and illiterate farmers respectively.

Economic efficiency consists of two components: technical and allocative (price) efficiency. Farmers are allocatively efficient if they maximize profit (i.e. equate marginal value products of variable inputs to their respective opportunity costs) and the maximization of profit is referred to as absolute allocative efficiency hereafter. The hypothesis that both educated and illiterate sugarcane farmers are absolute allocative efficient[9] is tested by imposing restrictions (11) in (7-10).

$$\text{(11)} \quad \text{Ho:} \quad \alpha^*_N = \alpha^{*E}_N \ ; \quad \alpha^*_B = \alpha^{*E}_B \ ; \quad \alpha^*_B = \alpha^{*E}_B$$
$$\alpha^*_N = \alpha^{*U}_N \ ; \quad \alpha^*_B = \alpha^{*U}_B \ ; \quad \alpha^*_F = \alpha^{*U}_F$$

The hypothesis (11) can be rejected if either one of the group fails to maximize profit. Thus, the hypotheses that the educated farmers are absolute allocative efficient

$$\text{(12)} \quad \text{Ho:} \quad \alpha^*_N = \alpha^{*E}_N \ ; \quad \alpha^*_B = \alpha^{*E}_B \ ; \quad \alpha^*_F = \alpha^{*E}_F$$

and that the illiterates are absolute allocative efficient

$$\text{(13)} \quad \text{Ho:} \quad \alpha^*_N = \alpha^{*U}_N \qquad \alpha^*_B = \alpha^{*U}_B \qquad \alpha^*_F = \alpha^{*U}_F$$

are also tested separately to distinguish whether the educated or the illiterates fails to maximize profits.

The educated and illiterate farmers can be different in terms of economic efficiency if they do not have the same technical efficiency and/or face different prices even if they are absolute efficient. They can have different economic efficiency if they are allocative inefficient even if they have the same technical efficiency and face the same prices. The profit function model takes into account the differences in technical efficiency, allocative efficiency and effective prices and permits to test the relative economic efficiency differences between the educated and illiterate farmers. Consequently, the hypothesis of equal relative economic efficiency of educated and illiterates is tested as:

(14) Ho: $\delta^E = 0$

Since higher economic efficiency of educated farmers can emanate from their being technically and/or allocatively more efficient than the illiterates, the hypothesis of the equal relative allocative efficiency:

(15) Ho: $\overset{*}{\alpha}{}^E_N = \overset{*}{\alpha}{}^U_N \quad , \quad \overset{*}{\alpha}{}^E_B = \overset{*}{\alpha}{}^U_B \quad , \quad \overset{*}{\alpha}{}^E_F = \overset{*}{\alpha}{}^U_F$

and that of the equal relative allocative and technical efficiency:

(16) Ho: $\delta^E = 0$

and

$$\overset{*}{\alpha}{}^E_N = \overset{*}{\alpha}{}^U_N \quad , \quad \overset{*}{\alpha}{}^E_B = \overset{*}{\alpha}{}^U_B \quad , \quad \overset{*}{\alpha}{}^E_F = \overset{*}{\alpha}{}^U_F$$

are also tested to determine whether the higher relative economic efficiency of the educated emanates from their being allocatively and/or technically more efficient than the illiterates.

Since the issue of returns to scale has important policy implications the hypothesis of constant returns to scale:

(17) Ho: $\beta_L + \beta_K + \beta_N = 1$

is tested to determine if the returns to scale in sugarcane farming is constant or not.

III. ALLOCATIVE AND TECHNICAL EFFICIENCY OF EDUCATION FROM PRODUCTION FUNCTION

This section presents the results from the engineering sugarcane production function and allocative error function and draws conclusions concerning the relative significance of the allocative and worker effects in a changing environment based on the production function results.

The estimates based on the engineering production function are reported in Table 1. The first column includes education and extension as zero-one dummy variables while the second includes them as continuous variables. Both the regressions give similar estimates. However, the first has a slightly higher R^2 and thus the analysis in this paper is carried out specifying education and extension as dummy variables.

Most of the estimates from the engineering functions are reasonable in terms of their signs and significance. Land, labor, capital and fertilizer has significant contributions to sugarcane production indicating that these are crucial inputs in sugarcane cultivation. Operator's age (a proxy for experience) has no significant impact on sugarcane output. This suggests that farmers' experience may not be crucial in a dynamic environment where ability to deal with disequilibria is more vital. Bullock and extension, on the other hand, has negative but non-significant influence on sugarcane. This may be because that tractors are increasingly substituting bullocks and extension program has not been very effective in the absence of adequate trained manpower and a lack of proper coordination between extension and other related agencies (such as research, credit organizations).

Table 1. Estimates from engineering sugarcane production function.

Independent Variable	Regression Number 1	2
Land: L	0.437***	0.446***
	(0.070)	(0.070)
F Labor: NF	0.102	0.100
	(0.101)	(0.102)
Capital: K	0.059**	0.058**
	(0.028)	(0.029)
H Labor: NH	0.236***	0.242***
	(0.063)	(0.063)
Bullock: B	-0.009	-0.011
	(0.036)	(0.036)
Fertilizer: F	0.080***	0.076***
	(0.028)	(0.028)
Age: A	0.127	0.099
	(0.160)	(0.175)
Education: E	0.210	-
	(0.143)	-
Education: E_1	-	0.012
	-	(0.016)
Extension: X	-0.100	-
	(0.099)	-
Extension: X_1	-	-0.043
	-	(0.039)
Constant	-1.590	-1.455
R^2	0.7824	0.7803
F	58.3	57.6
Sum of Elasticities	1.032	-

Standard errors of estimates in parentheses
*** Significant at 1-percent level
** Significant at 5-percent level

Education has a positive coefficient and the coefficient's standard deviation is smaller than its magnitude. The result indicates that education has a weakly positive influence on the sugarcane output. Since the MVP[10] of education from such a (single output) production function measures the worker effect (Welch), the finding also means that education contributes to the output by weakly enhancing the direct productivity (worker effect) or technical efficiency of the sugarcane producers.

Education has negative coefficient in aggregate, fertilizer and hired labor allocative error functions (Table 2). This suggests that education enables farmers to reduce allocative error in the use of variable inputs as a whole, fertilizer and hired labor respectively. Put differently, the result also means that education enhances farmer ability to deal with economic disequilibria in the use of variable factors and enables them to get closer to the optimal resource use. Education coefficient has a wrong sign in bullock allocative error function. However, the coefficient is extremely small relative to its standard error to attach any significance to the sign of the coefficient. Considered that the education estimates in the allocative error functions have generally right sign but small t-values, the results demonstrate that education has a weak allocative effect in the modernizing sugarcane farms in the central terai (Bara district) of Nepal. The production function model (engineering production and allocative error functions) based results, thus leads us to the conclusion that education weakly contributes to the output through both the allocative and worker effects in a modernizing agriculture.

The sugarcane production function depicts a constant returns to scale (the sum of the elasticities added up to 1.032) suggesting that the

Table 2. Estimates from regression of allocative error on education.

Allocative Error Function	Education	Constant	R^2	F	N
Aggregate	-0.733 (0.703)	-0.589	0.008	1.21	156
Fertilizer	-0.227 (0.201)	-0.172	0.008	1.28	156
Hired Labor	-0.599 (0.683)	-0.619	0.005	0.77	156
Bullock	0.016 (0.087)	0.201	0.002	0.33	156

Standard error of estimates in parentheses.

sugarcane production can be increased proportionately by increasing all the inputs by a given factor.

IV. ALLOCATIVE AND TECHNICAL EFFICIENCY OF EDUCATION (EDUCATED) FROM PROFIT FUNCTION

The F-ratios computed for testing hypotheses concerning economic efficiency of educated and illiterate farmers in sugarcane production are reported in Table 3.[11] The hypotheses of equal relative economic efficiency and equal relative allocative efficiency are rejected in favor of a higher economic efficiency of the educated at 5-percent level. However, the hypothesis of equal relative allocative and technical efficiency of the educated and illiterate farmer is not rejected at that level of significance. The tests, thus, strongly support the contention that the educated farmers are able to attain higher economic efficiency relative to illiterates and that the educated farmers' higher economic efficiency results from their being significantly allocatively more efficient than the illiterates. However, the educated and illiterates are not significantly different in terms of technical efficiency. In other words, the tests of relative efficiency indicates that education contributes to the output significantly through it's allocative effect and only weakly through it's worker effect.

Similarily, the hypothesis of absolute allocative efficiency of the educated is not rejected, while that of the illiterates is rejected at 1- or 5-percent levels suggesting that the educated are able to maximize profits while the illiterates are not able to do so in the production of sugarcane (Table 3). The tests of various hypotheses of absolute and relative efficiency thus leads to the conclusion that there is room

Table 3. Testing of hypotheses of equal economic efficiency of educated and illiterate sugarcane farmers, Nepal.

Hypotheses	Computed F-ratios	Critical F-ratios at 5-percent level
1. Equal relative economic efficiency	$F(1,608) = 4.083$	$F(1,\infty) = 3.84$
2. Equal relative allocative efficiency	$F(3,608) = 2.600$	$F(2,\infty) = 3.00$
3. Equal relative allocative and technical efficiency	$F(4,608) = 2.155$	$F(3,\infty) = 2.60$
4. Absolute allocative efficiency of educated	$F(3,608) = 1.454$	$F(4,\infty) = 2.37$
5. Absolute allocative efficiency of illiterates	$F(3,608) = 3.752$	$F(6,\infty) = 2.10$
6. Absolute allocative efficiency of both educated and illiterates	$F(6,608) = 2.109$	
7. Constant returns to scale	$F(1,608) = 0.420$	

for allocative ability even in a single output modernizing (sugarcane) agriculture, education significantly enhances the allocative efficiency of the educated (sugarcane) farmers while it only weakly (not significantly) improves their technical efficiency. This also means that education significantly enhances farmers' ability to deal with economic disequilibria in sugarcane production and that ability (allocative effect) is a significantly important benefit of education while its direct impact on the farmers' productivity (worker effect) is not a crucial contributor in a changing environment.

Lastly, the hypothesis of constant returns to scale is not rejected and which suggests that sugarcane output in the terai of Nepal can be increased proportionately by increasing all the inputs by a given proportion.

In comparison, the evidence based on the profit and production functions are similar except for the fact that the former suggests a significant allocative effect while the latter implies a weak allocative effect of education in sugarcane production. Thus, the findings are consistent with the hypotheses that education enhances farmers' allocative ability even in a single output farm and that the profit function model more precisely measures the effects of education.

V. CONDLUDING REMARKS

The estimates from the allocative error functions and the engineering sugarcane production function demonstrate that education has weak allocative and worker effects in sugarcane production. However, the profit function tests strongly supports the hypotheses that education makes a significant contribution to sugarcane production through its allocative effect while its worker effect has only a weak impact. The results from the production and profit function approaches thus lead to the conclusions that: (i) farmers' education contributes to output most significantly through its allocative effect rather than through its worker effect even in a single output (sugarcane) farm characterized by changing technology, (ii) the profit function approach captures the effects of education more clearly than the production function model, and (iii) one must estimate both the engineering production function and allocative error functions to capture both effects of education if one employs the production function approach.

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Appendix I. Estimates from joint estimation of normalized restricted profit function and labor, bullock, and fertilizer demand functions for sugarcane, Nepal.

Profit Function N = 156	Restricted** seemingly unrelated regression estimates 1	2	3
Constant: $\ln A^{*U}$	-5.159	-6.652	-4.764
	(2.112)	(3.320)	(2.066)
Land: β_L^*	0.643	0.652	0.643
	(0.080)	(0.081)	(0.080)
F Labor: β_N^*	0.188	0.240	0.181
	(0.185)	(0.187)	(0.180)
Capital: β_K^*	0.138	0.148	0.136
	(0.048)	(0.049)	(0.048)
Extension: δ_X^*	-0.230	-0.270	-0.227
	(0.172)	(0.173)	(0.171)
Age: β_A^*	0.173	0.053	0.193
	(0.287)	(0.288)	(0.287)
H Labor: α_N^*	-0.675	-1.631	-0.302
	(0.849)	(1.137)	(0.837)
Bullock: α_B^*	-0.530	-0.844	-0.374
	(0.434)	(0.718)	(0.429)
Fertilizer: α_F^*	-0.223	-0.392	-0.139
	(0.223)	(0.378)	(0.226)
Education: δ^E	0.279	0.251	0.585
	(0.263)	(0.296)	(0.295)
Demand Function			
Labor: α_N^{*E}	-0.675	-0.375	-0.302
	(0.849)	(2.407)	(0.837)
α_N^{*U}	-0.675	-1.631	-1.471
	(0.849)	(1.137)	(5.644)
Bullock: α_B^{*E}	-0.530	-0.403	-0.374
	(0.434)	(1.227)	(0.429)
α_B^{*U}	-0.530	-0.844	-7.490
	(0.434)	(0.718)	(2.877)
Fertilizer: α_F^{*E}	-0.223	-0.157	-0.139
	(0.223)	(0.647)	(0.226)
α_F^{*U}	-0.223	-0.392	-3.904
	(0.223)	(0.378)	(1.518)

The numbers in parentheses are asymptotic standard errors of the estimates.

**The restriction imposed on columns 1, 2 and 3 are represented by equations 11, 13 and 12 on page 7 or by hypotheses numbers 6, 5 and 4 respectively in Table 3.

FOOTNOTES

[1]In a single output farm room for allocative ability may be smaller than in a multiproduct farm since the latter involves optimal allocation of resources among competing uses while the former involves allocation in a given enterprise only.

[2]Studies estimating engineering production function for rice (Halim, Sharma) and wheat (Sharma) reported a positive worker effect of education. Huffman estimating a dynamic partial adjustment model for corn found both the allocative and worker effects to be positive but the former to be much stronger than the latter. Huffman's findings reinforce the plausibility of the hypothesis that education has an allocative effect even in a (dynamic) single crop farming but one must estimate more appropriate model than the engineering function to capture the effect.

[3]There may be other models which may also capture the effects of education on a single output farm. However, only the production function and profit function models are utilized in this study.

[4]Pudasaini found the allocative effect of education to be contributing much more to output than the worker effect in a modernizing environment.

[5]Schultz stresses that education has a significant value in modernizing agriculture and a substantial contribution of education in such an environment comes from its allocative effect since it enhances farmers' ability to deal successfully with economic disequilibria. Nelson and Phelps have also emphasized the allocative value of education in a dynamic or changing environment.

[6]U.S. $1.00 = RS 12.00

[7]Since the theory underlying the profit function approach is well discussed in literature (Lau and Yotopoulos 1971, Yotopoulos and Lau 1973 and 1979, Pudasaini 1981), this section presents only the operational profit function model employed to test various hypotheses.

[8]Assuming an additive error with zero expectation and finite variance and the co-variance of the errors of two equations for the same farm to be non-zero while the co-variance of the errors of two equations corresponding to different farms to be zero, Zellner's asymptotically efficient (seemingly unrelated regression) method was employed for the joint estimation of the operational models (7-10).

[9]In other words, farmers are absolute allocative efficient also means that the allocative error in (6) is zero.

[10]The worker effect or MVP of education computed as:

[$\bar{MVP} = (\delta_1 \cdot \bar{Y} \cdot P_Y) / N$]: was RS 327; where δ_1 is education coefficient from column 1 in Table 1, $\bar{Y}$ is mean sugarcane output, P_Y is sugarcane price and N is average education of operators.

[11]Parameter estimates from profit function are presented in Appendix I.