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

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, analyse 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 funtion. The purpose of this paper is to test the hypothesis that education enhances the farmer's 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 rather than the engineering production function *per se*. Both methods are employed in this study. But it is hypothesized that the profit function model more precisely measures 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 analyse technical and market information about inputs and enable them to adjust quickly to disequilibria in

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1. In a single output farm the scope for allocative ability may be smaller than in a multi-product 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.

input use. Consequently, education may have a much stronger impact on output through its allocative effect than through its worker effect.

The data used in this study are 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 milieu to determine whether education enhances sugarcane farmers' ability to adjust quickly to disequilibria and thus in turn has a significant allocative effect in sugarcane production.[3]

The first and second sections of the paper respectively discuss the production and profit function models estimated in the 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

Since production function framework can be utilized to investigate whether education has an allocative effect in addition to the worker effect, let the engineering sugarcane production function be:

$$(1)\quad \ln Y = \ln c + \beta_1 \ln L + \beta_2 \ln NF + \beta_3 \ln K + \beta_4 \ln A + \alpha_1 \ln NH + \alpha_2 \ln B + \alpha_3 \ln F + \delta_1 E + \delta_2 X$$

where, Y is sugarcane output in quintal, NF is man-years of available family labour, K is capital (12 per cent of the total value of tools, equipments and machinery) in rupees, A is operator's age in years, NH is man-days of hired labour, B is days of bullock use, F is fertilizer in kilogram, E is 1 if farm operator had schooling and zero otherwise, and X is 1 if farmer had extension contact and zero otherwise.

If a producer is a profit maximizer, he attempts to equate the marginal value product (MVP) of variable inputs (hired labour, bullock and fertilizer) to their respective opportunity costs. The difference between MVP of variable inputs and their respective prices must be zero if the producer is successful in maximizing profits. Thus, the absolute difference between the MVP of variable inputs and their respective prices, which is called allocative error (ε) hereafter, can be used as a measure of allocative inefficiency.

The changes occurring in farm technology or market conditions may have created disequilibrium in input use in sugarcane and the allocative error (ε) in

3. 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 the 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. Pudasaini (August 1981) also found the allocative effect of education to be much more important, contributing to output than the worker effect in a modernizing environment.

the farms under study may not be zero. If education enhances the farmers' ability to deal successfully with economic disequilibria, the absolute allocative error must be a decreasing function of education or the absolute size of allocative error must be inversely related to farm operator's education. The allocative errors can thus be regressed on education as (2), which will be called allocative error functions hereafter,

$$(2)\quad \dot{\ln}\,(\varepsilon^2) = a + \varepsilon\,.E$$

to determine if education has any allocative effect in sugarcane production while the MVP of education can be computed from (1) to obtain the worker effect (Welch).

II

THE PROFIT FUNCTION

The profit function approach presents itself as superior alternative to the production function for analysing the effects of education for four main reasons. Firstly, the normalized restricted profit function and input demand functions are functions of pre-determined variables and estimation of such functions avoids possible simultaneous equation bias (Yotopoulos and Lau). Secondly, it permits testing of hypotheses concerning allocative and worker effects of education without having to estimate the allocative error function (2). Thirdly, the profit and input demand functions estimated by seemingly unrelated regression provide asymptotically more efficient estimates than the production function estimated by OLS (Zellner). Fourthly, this approach takes into account differences in technical efficiency, allocative efficiency and effective prices and also permits determination of relative economic efficiency (Yotopoulos and Lau) of the educated and illiterate farmers.

Thus, let us examine the normalized restricted profit function (3) and input demand functions (4-6) for hired labour (NH), bullock (B) and fertilizer (F) for sugarcane:

$$(3)\quad \ln \pi^* = \ln A^{*^U} + \delta^E E + \alpha_N^* \ln P_n + \alpha_B^* \ln P_b + \alpha_F^* \ln P_f + \beta_L^* \ln L + \beta_N^* \ln NF + \beta_K^* \ln K + \beta_A^* \ln A + \delta_X^* \cdot X$$

$$(4)\quad \frac{-P_n \cdot NH}{\pi^*} = \alpha_N^{*^E} E + \alpha_N^{*^U} E_0$$

$$(5)\quad \frac{-P_b \cdot B}{\pi^*} = \alpha_B^{*^E} E + \alpha_B^{*^U} E_0$$

$$(6)\quad \frac{-P_f \cdot F}{\pi^*} = \alpha_F^{*^E} E + \alpha_F^{*^U} E_0$$

where π^* is a restricted profit normalized by the sugarcane price. The restricted profit is the difference between total sugarcane revenue ($P_Y.Y$) minus the cost of variable inputs of hired labour, fertilizer and bullock. The variables L, NF, K, A, E and X are as defined earlier in the production function. E_0 is 1 if illiterate farmers and 0 otherwise. The variables P_n, P_b and P_f are respectively price of labour, bullock and fertilizer normalized by sugarcane price. Superscripts E and U denote educated and illiterate farmers respectively.

Farmers are absolute allocative efficient if they maximize profits (*i.e.*, equate marginal value products of variable inputs to their respective opportunity costs). The hypotheses that the educated farmers are absolute allocative efficient

$$(7) \quad H_0 : \alpha^*_N = \alpha^{*E}_N ; \quad \alpha^*_B = \alpha^{*E}_B ; \quad \alpha^*_F = \alpha^{*E}_F$$

and that the illiterates are absolute allocative efficient

$$(8) \quad H_0 : \alpha^*_N = \alpha^{*U}_N ; \quad \alpha^*_B = \alpha^{*U}_B ; \quad \alpha^*_F = \alpha^{*U}_F$$

can be tested to determine whether the educated or the illiterate fails to attain absolute allocative efficiency.

Since economic efficiency consists of allocative and technical components, 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 allocative 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 hypothesis of equal relative economic efficiency of educated and illiterate farmers as:

$$(9) \quad H_0 : \delta^E = 0.$$

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

$$(10) \quad H_0 : \alpha^{*E}_N = \alpha^{*U}_N , \quad \alpha^{*E}_B = \alpha^{*U}_B , \quad \alpha^{*E}_F = \alpha^{*U}_F$$

and that of the equal relative allocative and technical efficiency:

$$(11) \quad H_0 : \delta^E = 0 \text{ and } \alpha^{*E}_N = \alpha^{*U}_N , \quad \alpha^{*E}_B = \alpha^{*U}_B , \quad \alpha^{*E}_F = \alpha^{*U}_F$$

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.

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 I. 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

TABLE I—ESTIMATES FROM ENGINEERING SUGARCANE PRODUCTION FUNCTION

Independent variable	Regression number	
	1	2
Land: L	0·437*** (0·070)	0·446*** (0·070)
Family labour: NF	0·102 (0·101)	0·100 (0·102)
Capital: K	0·059** (0·028)	0·058** (0·029)
Hired labour: NH	0·236*** (0·063)	0·242*** (0·063)
Bullock: B	—0·009 (0·036)	—0·011 (0·036)
Fertilizer: F	0·080*** (0·028)	0·076*** (0·028)
Age: A	0·127 (0·160)	0·099 (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

Standard errors of estimates are in parentheses.
*** Significant at 1 per cent level.
** Significant at 5 per cent level.
* Significant at 20 per cent level.

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, labour, capital and fertilizer have 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 the 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, have negative but non-significant influence on sugarcane. This may be because that tractors are increasingly substituting bullocks and the extension programme has not been very effective in the absence of adequate trained manpower and due to lack of proper co-ordination between extension and other related agencies (such as research, credit organizations).

Education variable has a positive coefficient in regression 1 but it is significant only at 20 per cent level. This indicates positive influence of education on the sugarcane output. Since the MVP[4] of education from such a (single output) production function measures the worker effect (Welch), the finding suggests that education contributes to the output by enhancing direct productivity (worker effect) or technical efficiency of the sugarcane producers. Further, the allocative errors were regressed on education as indicated earlier in model (2). However, as multiple R^2s of the estimated regressions are extremely small, the results are not presented here. Since the estimates of regression coefficients of education have generally small t-values, and the allocative error function results are almost meaningless, it is difficult to attach great significance to the production function results. It is possible that such a weak result may be due to the reason that a single equation production function may not be as suited as joint estimation of the normalized restricted profit and input demand functions for capturing the effects of education as discussed earlier. To determine the validity of this contention let us now turn to the results obtained from the profit function model.

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 II. The hypotheses of equal relative economic efficiency and equal relative allocative efficiency are rejected in favour of a higher economic efficiency of the educated at 5 per cent level. However, the hypothesis of equal

4. The worker effect or MVP of education computed as:

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

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 the 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 indicate that education contributes to the output significantly through its allocative effect and only weakly through its worker effect.

Similarly, the hypothesis of absolute allocative efficiency of the educated is not rejected, while that of the illiterates is rejected at 1 or 5 per cent 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 II). The tests of various hypotheses of absolute and relative efficiency thus lead to the conclusion that there is room for allocative ability even in a single output farm. Education significantly enhances the allocative efficiency of the sugarcane farmers while it only weakly (not significantly) improves their technical efficiency. This also means that education significantly enhances the farmer's ability to deal with economic disequilibria in sugarcane production while its direct impact on the farmers' productivity (worker effect) is not significant in a changing environment.

TABLE II—TESTS OF HYPOTHESES OF EQUAL ECONOMIC EFFICIENCY OF EDUCATED AND ILLITERATE SUGARCANE FARMERS, NEPAL

Hypotheses	Computed F-ratios	Crucial F-ratios at 5 per cent level
1. Equal relative economic efficiency	F(1,608)=4·083	F(1, ∞)=3·84
2. Equal relative allocative efficiency	F(3,608)=2·600	F(2, ∞)=3·00
3. Equal relative allocative and technical efficiency	F(4,608)=2·155	F(3, ∞)=2·60
4. Absolute allocative efficiency of educated ..	F(3,608)=1·454	F(4, ∞)=2·37
5. Absolute allocative efficiency of illiterates ..	F(3,608)=3·752	F(6, ∞)=2·10

V

CONCLUDING REMARKS

This study was initiated with the objective of testing two hypotheses: one theoretical and the other empirical. Empirically, it was to test that education has a significant allocative effect even in a single output (sugarcane) farm. Theoretically, it was to test that a profit function approach is better suited for capturing such effect than a production function model.

While the production function demonstrates that education has a weak worker effect in sugarcane production, the results from allocative error functions are almost meaningless to provide any indication on whether education has any allocative effect due to non-significant education estimates and negligible R^2. However, the profit function tests suggest that education makes a significant contribution to sugarcane production through its allocative effect and a weak impact through its worker effect. The results from the production and profit functions 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, and (*ii*) the profit function approach captures the allocative effect of education more clearly than the production function model.

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