EDUCATION AND THE AGGREGATE PRODUCTION FUNCTION: THE PHILIPPINES

EPICTETUS PATALINGHUG

I. INTRODUCTION

It has been frequently stressed that there is a significant empirical relationship between growth in formal education or schooling and growth in output. The accumulation of a tremendous amount of circumstantial evidence testifying to the economic value of education has aroused an increasing application of research on human capital to the developing economies. However, not much empirical work has been undertaken along sectoral disaggregation in human capital analysis. In this paper, the concept of production function is utilized as a way of nailing down the relative role of education in agriculture and in manufacturing.

A typical developing economy, the Philippines, provides the appropriate setting. Until recently, a growing concern among Philippine policy planners has been the pressing need to evaluate the economic implications of a substantial proportion of its national income allocated to education. The claim that it is an overeducated country puts to question the need to continue its policy of extending tax subsidy to private nonproprietary institutions. A satisfactory assessment of the appropriate contribution of education is not complete by looking at national data alone. Hence, this paper explores the sectoral approach of quantifying the role of education.

II. THE APPROACH AND THE DATA

The estimating procedure employs an unrestricted Cobb-Douglas production function and fits cross section data from Philippine agriculture and manufacturing into the estimating equation. The concept of the production function describes the transformation of a set of inputs into output. A Cobb-Douglas production function can be written as

$$Q=\beta_0 \prod_{i=1}^{n} X_i^{\beta_i}, \qquad (1)$$

where Q is the output, β_o is the constant term, X_i's are the inputs, and β_i's are

This paper originated at the University of Hawaii where the writer was a graduate student and later a faculty member. Comments from Daniel Suits, Andrew Mason, Peter Garrod, and Walter Miklius are gratefully acknowledged. The writer is solely responsible for the contents of this paper.

the non-negative output elasticities with respect to X_i's. An unrestricted production function would impose no further restrictions on the value of β_i's. What constitutes the main task of this study is the utilization of the unrestricted Cobb-Douglas form for Philippine agriculture and manufacturing, respectively. The estimation proceeds by explicitly adding two measures of education (secondary and higher) to the set of inputs for each sector. Griliches [6, pp. 334–35] has shown that it makes no difference whether education is introduced explicitly or considered to have qualitative adjustments to the already included inputs. Data availability limits our choice to the latter specification.

However, the utilization of the Cobb-Douglas form of the production function carries the implicit assumption that the elasticity of substitution between labor and all other inputs in (1) is equal to unity. To examine the validity of this assumption, the ACMS [1] condition[1] of constant elasticity under perfect competition is applied. Consider the following equation,

$$\ln (Y) = \delta + \sigma \ln W . \qquad (2)$$

The relationship between value added per worker (Y) and the wage (W) is represented by the coefficient σ (the elasticity of substitution) which should come close to unity.

Griliches [8, pp. 962–64] and Bautista [2, pp. 76–77] have shown a way to reduce a possible source of bias in the elasticity estimates by introducing a measure of education into equation (2) on the assumption that education takes into account qualitative differences in the labor input across regions. Our study goes further from their respective approaches by differentiating the education variable into secondary and higher education, respectively.

The data used for agriculture are taken mainly from the *1971 Census of Agriculture* [12], a nationwide sample survey which provides the relevant data for our purposes. It provides cross section observations for sixty-six Philippine provinces—our units of observations—and refers to crop-year 1970/71.

For manufacturing, the data employed are derived mainly from the *1968 Annual Survey of Manufactures* [11], a nationwide sample survey covering around 4,000 manufacturing establishments with five or more workers. It contains cross section data for fifty-seven reporting provinces, Manila and suburbs being included as the fifty-seventh "province."

Considering that the agricultural census data have no observations pertaining to a measure of education variables, such information is obtained from the *1970 Philippine Census of Population and Housing* [13].[2]

Table I shows the results of fitting equation (2) with some modifications to manufacturing data.[3] Most of the coefficients are statistically significant at the

1 See [1].

2 Since provincial boundaries changed between the period the agricultural census data and population census surveys were conducted, adjustments are made so that agricultural census provinces are consistent to those of population census.

3 *SCHL* and *TECH* are added in specifying the relationship between *VAL* and *PAYR* in equation (2). The anonymous referee has pointed out that the coefficients of *PAYR* should be taken in the context of the ACMS condition of constant elasticity under perfect com-

TABLE I

ESTIMATES OF THE ELASTICITY OF SUBSTITUTION IN PHILIPPINE MANUFACTURING, 1968

Coefficients of:	Specification			
	1	2	3	4
Constant	4.498	3.945	2.957	2.339
PAYR	0.772	0.777	0.848	0.854
	(0.121)	(0.120)	(0.123)	(0.122)
SCHL	0.336	0.337		
	(0.133)	(0.132)		
TECH	0.148*		0.105*	
	(0.189)		(0.198)	
R^2	0.531	0.529	0.475	0.473
Standard error	0.706	0.701	0.740	0.735
F-value	20.02	30.32	24.43	49.36

Notes: 1. The dependent variable is the census value added divided by the number of paid employees. *PAYR* is the total payrolls per paid employee; *SCHL*, percentage of the twenty-five years old and over population with secondary schooling; and *TECH*, percentage of the twenty-five years old and over population with at least six years of college.

2. Standard errors in parentheses.

* Statistically not significant at the 5 per cent level.

5 per cent level, and have the predicted signs. The crucial point in Table I is related to the estimates of the elasticity of substitution as indicated by the coefficient of the logarithm of the wage rate (*PAYR*). By statistically testing (at the 5 per cent level) we found that these estimates support the findings of previous studies [2] [15] that there exists a unitary elasticity of substitution in Philippine manufacturing. Thus, the stage is set for applying the Cobb-Douglas form in the following discussion.

III. THE SPECIFICATION

In agriculture, the basic equation is of the following form:

$$(AGQ)_i = \beta_0 (LND)_i^{\beta_1} (LKP)_i^{\beta_2} (LBR)_i^{\beta_3} (LEDUC)_i^{\beta_4} (LTECH)_i^{\beta_5} v_i \,, \qquad (3)$$

where for each province *i*, *AGQ* is the value of crops produced, *LND* is hectares of effective crop area, *LKP* is total number of farm equipment, *LBR* is farm labor, *LEDUC* is the average years of schooling of the farm operators, *LTECH* is the percentage of college-educated farm operators to the total farm population, and *v* is the error term.

Two available measures of the labor input in agriculture are alternatively

petition. This clarification is appreciated. Furthermore, the incorporation of the education variables in equation (2) is based on the hypothesis that both the quality and the quantity dimensions of labor can be entered either separately or combined into one variable without affecting the fitted relationship. Entering separate variables has been carried out for reasons of data availability and analytical convenience.

employed, one (LBR_1) uses the number of farm operators, while the other (LBR_2) employs the total number of farm workers. The former is considered a measure of "effective" labor input in Philippine agriculture considering that the agricultural census defines the farm operator as the individual having the economic responsibility for the operation of the farm firm.[4]

The underlying premise in defining *LTECH* is that higher education in agriculture is more relevant in accelerating the process of technological change [10, p. 70], and therefore should be differentiated from the lower levels of schooling of those farmers who are actually engaged in physical production.

The immediate concern of this analysis is to arrive at a rough measure of the relevance of an increment of schooling over and above the average schooling level in each sector. This is precisely the reason why higher schooling levels in each sector are specified to measure their relevance to production directly or through their innovative effects. Since the average level of schooling in manufacturing is higher than that in agriculture, the higher education variable (*TECH*) in manufacturing is specified at a higher level than the one (*LTECH*) specified in agriculture.

In manufacturing, the basic equation is of the following form:

$$(OUTN)_i = \gamma_0 (CAPN)_i^{\gamma_1} (LABN)_i^{\gamma_2} (SCHL)_i^{\gamma_3} (TECH)_i^{\gamma_4} w_i \,, \qquad (4)$$

where for each province *i*, *OUTN* is the value of gross output per establishment, *CAPN* is the total book value of fixed assets per establishment, *LABN* is total number of paid employees per establishment, *SCHL* is the fraction of those twenty-five years old and over that has completed secondary education, *TECH* is the fraction of those twenty-five years old and over that has completed at least six years of college education, and *w* is the error term.

It has been shown that the appropriate concept of capital inputs for production analysis is the gross capital value which corresponds closely to the capital services of the equipment [5, pp. 289–93] [14, pp. 23–29]. However, the book value which is less than the gross value by accumulated depreciations was used instead due to unavailability of data.

IV. THE EMPIRICAL RESULTS

A. *Agriculture*

Unlike the case of manufacturing, agriculture data do not contain observations on wage rates. Thus, we could not fit equation (2) to agriculture data. However, it is assumed that the manufacturing estimates of equation (2) support the choice of the Cobb-Douglas production function as our appropriate form in agriculture.

Table II summarizes the empirical results of fitting a Cobb-Douglas type of production function (3) to 1971 Philippine data on farm output and inputs across sixty-six Philippine provinces. Apparently, the great surprise of the regression

[4] For a complete explanation and description of output and input data in agriculture, see [12].

TABLE

ESTIMATES OF THE AGGREGATE AGRICULTURAL

Coefficients of:	1	2	3	4	5
Constant	13.641	18.191	12.109	16.526	8.144
LND	0.855	0.849	0.743	0.724	0.720
	(0.104)	(0.111)	(0.083)	(0.088)	(0.081)
LKP	0.292	0.256	0.344	0.311	0.347
	(0.115)	(0.121)	(0.112)	(0.118)	(0.112)
LTECH	0.401		0.417		0.503
	(0.139)		(0.140)		(0.119)
LXPER	0.673*	0.736*			
	(0.374)	(0.396)			
LAGE	−0.879*	−0.908*			
	(1.058)	(1.122)			
LBR_1					
LBR_2	−0.069*	−0.0485*	−0.0282*	−0.0019*	−0.0251*
	(0.128)	(0.136)	(0.127)	(0.135)	(0.128)
LEDUC	1.149*	2.242	0.822*	1.928	
	(0.720)	(0.649)	(0.704)	(0.636)	
R^2	0.889	0.874	0.883	0.866	0.880
Standard error	0.325	0.344	0.328	0.349	0.329
F-value	66.36	68.21	90.56	98.56	111.83
F'-value	5.62	4.37	9.49	9.11	17.28

Notes: 1. Figures in parentheses refer to standard errors. Two-tail test applies to all variables.

2. F' is the F-statistics for testing the effect of a variable added to the regression equation; *LXPER*, the average years of farming for all form operators; and *LAGE*, the average age for all form operators.

analysis is the unexpected signs of the coefficient of the labor variable, expressed in either measure, in all specifications tried. But these estimates are not really surprising if one considers that they are cross section coefficients. The underlying interpretation of these estimates is that the larger the province, the less productive its labor resources—presumably for several reasons, including the lack of work opportunities in the agricultural sector as well as general level of economic backwardness. A further explanation is that these estimates positively confirm the existence of a zero marginal product of agricultural labor in a labor-surplus less developed economy, such as that of the Philippines.

The expectation to obtain functional relationship between level of education and farm output is evident. Secondary education (*LEDUC*) is found to be highly significant in specifications 2, 4, 8, and 10 which have deleted the higher education (*LTECH*) variable. On the other hand, *LTECH* is highly significant in all equations fitted. Furthermore, the values of the coefficient of determination in Table II are relatively high (not less than 0.85), and are completely different from the findings of Bautista [2]. Is it due to specification problem? A check of the F-values and the adjusted coefficient of determination (not shown) shows

II
PRODUCTION FUNCTION, PHILIPPINES, 1971

Specification						
6	7	8	9	10	11	12
6.613	14.121	18.452	11.538	15.741	7.950	6.396
0.636	1.069	1.120	0.800	0.810	0.797	0.805
(0.088)	(0.163)	(0.170)	(0.117)	(0.124)	(0.117)	(0.130)
0.298	0.375	0.377	0.381	0.381	0.399	0.437
(0.126)	(0.110)	(0.116)	(0.109)	(0.115)	(0.108)	(0.120)
	0.366		0.408		0.482	
	(0.136)		(0.139)		(0.120)	
	0.910	1.026				
	(0.391)	(0.409)				
	−0.724*	−0.719*				
	(1.037)	(1.090)				
	−0.410*	−0.489	−0.144*	−0.185*	−0.179*	−0.322*
	(0.233)	(0.243)	(0.204)	(0.216)	(0.202)	(0.221)
−0.0261*						
(0.143)						
	1.059*	2.04	0.737*	1.8001		
	(0.702)	(0.631)	(0.711)	(0.648)		
0.846	0.894	0.881	0.884	0.867	0.882	0.851
0.371	0.317	0.333	0.327	0.347	0.327	0.365
111.53	69.88	72.80	91.45	99.41	113.99	118.04
	5.88	4.96	8.53	7.34	16.02	

* Statistically not significant at the 5 per cent level.

that the functional relationships in all equations are indeed highly significant. The *F*-statistics (*F*′) for testing different specifications are likewise highly significant.

Table II also shows that land (*LND*) and capital (*LKP*) inputs in agriculture have the expected signs, and their coefficients are also statistically significant at the 5 per cent level. Other significant relationships are likewise interesting. For instance, the sum of the estimated coefficients (excluding those of education, age, and experience) is statistically not different from unity, and supports the application of the Cobb-Douglas form in modeling Philippine agriculture.

To account for the qualitative influences of age and experience on farm output, *LAGE* and *LXPER* are introduced in equation (3). Their coefficients are insignificant in most equations, except in specifications 7 and 8 where LBR_1 is employed as the labor input.

In theory, *LAGE* and *LXPER* may not be expected to explain considerably inter-provincial output variation because age-output profiles are expected to turn down earlier as the nature of the work in agriculture does not need higher levels of schooling nor experience [3, pp. 138–44]. Earnings are expected to increase with age in sectors which require more skills and flexibility, such as manufac-

TABLE III
PRODUCTION FUNCTION ESTIMATE: PHILIPPINE MANUFACTURING, 1968

Coefficients of:	Specification 1	2	3	4
Constant	7.277	5.606	6.215	4.372
CAPN	0.587	0.586	0.629	0.630
	(0.076)	(0.0776)	(0.07596)	(0.0774)
LABN	0.473	0.457	0.438	0.419
	(0.143)	(0.146)	(0.147)	(0.149)
SCHL	0.273	0.285		
	(0.129)	(0.131)		
TECH	0.306*		0.327*	
	(0.182)		(0.188)	
R^2	0.953	0.840	0.836	0.826
Standard error	0.596	0.688	0.698	0.711
F-value	263.60	92.75	90.06	128.17
F'-value	140.51	4.64	3.23*	

Note: F' is F-statistics for testing the effect of a variable added to the regression equation. Standard errors in parentheses.
* Statistically not significant at the 5 per cent level.

turing. Moreover, age and experience are not crucial variables in periods of unemployment. In 1971, a rough estimate of total unemployment in the rural sector is approximately 32 per cent which supports our hypothesis.[5]

To the extent that age and experience are proxies for the depreciation and obsolescence of learning and training, then the fact that agriculture is characterized by low level of schooling and job training explains the insignificant coefficients of *LAGE* and *LXPER*. Another explanation is the possibility that as proxies of schooling and training, the effect of *LAGE* and *LXPER* are already captured by *LEDUC* and *LTECH*. If indeed, agricultural labor has near-zero marginal productivity (as indicated by the *LBR* coefficients), then it is evident that a young inexperienced labor is no different from an old experienced labor.

Having examined the evidence from the agriculture sector, let us now turn to investigating the production relationship in the manufacturing sector.

B. *Manufacturing*

Table III presents the estimates of fitting equation (4) to manufacturing data. The highly significant influence of secondary education in manufacturing validates the results of Table I. And applying the t-statistic for testing if the coefficients of *LABN* and *SCHL* are equal, the results lend empirical support to Griliches's earlier findings [6, p. 335] that both quality and quantity dimensions of labor are not statistically different (see footnote 3).

The extent of the influence of secondary education is evident from Table III which shows the improvement in the goodness of fit of the regression when the

[5] See [8, pp. 5–9]. ILO Report defines total unemployment as the sum of underemployment and open employment.

variable is added to the equation. Apparently, the values of the standard error of the coefficients remain fairly stable in any specification. As Table III also indicates, the influence of our explanatory variables, though relevant, are twice as strong compared to the influence of the random disturbances. No evidence of substantial economies of scale exists, and the assumption that the factors are paid their products is not refuted. Another interesting finding is that the sum of the estimated coefficients, excluding those of education and technology, is consistently not significant from unity (at the 5 per cent level). Thus, the relative contribution of specific variables (e.g., secondary education) rather than the scale of the production function differentiates this study from those of others. As far as satisfying the immediate task of employing the aggregate production function analysis to further the search for the "true" influence of education with respect to output, it has partly been achieved by the specification chosen in this study. In the final analysis, the results suggest that secondary education is more significant than higher education in Philippine manufacturing. A possible explanation could be the degree of relative abundance of educated individuals in manufacturing. An obvious implication of such a phenomenon would be the diminishing importance of an increment of schooling beyond the level (secondary education) sufficient enough to productively engage in manufacturing activities.

CONCLUSION

The aggregate production function was utilized in this paper as a device to identify the sectoral influence of schooling on production in the Philippines. The temptation to generalize the Philippines as a highly educated country would have been inescapable had we not carried out a sectoral approach.[6] Several instructive implications can be drawn from our results. First, the production relationship in either Philippine agriculture or manufacturing is characterized by constant returns to scale. Second, secondary education has been identified by the regression model as a significant variable explaining major differences in output in each sector. And finally, higher education (perhaps a technology proxy) is less significant in manufacturing than in agriculture.

The relevance of secondary education brings to focus the suggestion [8] [9] to improve the quality of primary and secondary education. Public policy makers should give serious look at this suggestion as the elimination of the weaknesses of the training process and the selection system at the primary and secondary levels will also correct the same weaknesses at the college level.

[6] See [8, p. 305] and [4, p. 285]. Both these studies stressed the rural-urban disparities in Philippine educational attainment. In particular, the ILO Report [8] pointed out that the claim that the Philippines is a relatively well- or over-educated country is basically true to Manila, Central Luzon, and Southern Tagalog.

REFERENCES

1. ARROW, K.; CHENERY, H.; MINHAS, B.; and SOLOW, R. "Capital-Labor Substitution and Economic Efficiency," *Review of Economics and Statistics,* Vol. 43, No. 3 (August 1961).
2. BAUTISTA, R. "The Influence of Education on Manufacturing Productivity: The Philippines," *Developing Economies,* Vol. 12, No. 1 (March 1974).
3. BECKER, G. S. *Human Capital: A Theoretical and Empirical Analysis, with Special Reference to Education* (New York: National Bureau of Economic Research, 1964).
4. CHEETHAM, R., and HAWKINS, E., et al. *The Philippines: Priorities and Prospects for Development* (Washington, D.C.: Johns Hopkins University Press, 1976).
5. DENISON, E. F. *The Sources of Economic Growth in the United States and the Alternatives before Us* (New York: Committee for Economic Development, 1962).
6. GRILICHES, Z. "The Sources of Measured Productivity Growth: United States Agriculture, 1940–60," *Journal of Political Economy,* Vol. 71, No. 4 (August 1963).
7. ————. "Research Expenditures, Education, and the Aggregate Agricultural Production Function," *American Economic Review,* Vol. 54, No. 6 (December 1964).
8. International Labour Office. *Sharing in Development: A Programme of Employment, Equity and Growth for the Philippines* (Geneva, 1974).
9. JALLADE, J. "Financing Higher Education: The Equity Aspects," *Comparative Education Review,* Vol. 22, No. 2 (June 1978).
10. NELSON, R., and PHELPS, E. "Investment in Humans, Technological Diffusion and Economic Growth," *American Economic Review,* Vol. 56, No. 2 (May 1966).
11. National Census and Statistics Office. *Annual Survey of Manufactures: 1968* (Manila, 1971).
12. ————. *1971 Census of Agriculture* (Manila, 1974).
13. ————. *1970 Census of Population and Housing* (Manila, 1975).
14. WALTERS, A. A. "Production and Cost Functions: An Econometric Survey," *Econometrica,* Vol. 31, No. 1–2 (January-April 1963).
15. WILLIAMSON, J. "Dimensions of Postwar Philippine Economic Progress," *Quarterly Journal of Economics,* Vol. 83, No. 1 (February 1969).