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OPTIMAL ALLOCATION OF PHILIPPINE EDUCATIONAL RESOURCES

by

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N.B.: This paper should be read in conjunction with Discussion Paper No. 67-13.

Several optimal solutions to a model outlined in a previous discussion paper will be presented in this section to reveal enrollment patterns, their contribution to Philippine Gross National Product and the valuation of scarce educational resources under several different assumptions about the form of the objective function. Also, a comparison of the results obtained under the optimization model will be made to the rate of return approach.

Table 1 presents the optimal entrance pattern of students and yearly contributions to GNP when the individual profit* concept and a fifteen per cent discount rate is incorporated in the objective function (hereafter Solution I).** A more concise statement of this entrance pattern is presented in figure 1. Several important observations can be readily made. Public education takes on the burden of educating almost all of the available primary and intermediate school entrants each year. Moreover, all of the available six year old population and primary graduates are

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* The individual profit concept only deducts the costs borne by the student from his earnings. In most cases subsidy from the government makes individual the cost less than the total or social cost of education.

** Enrollment patterns may be easily deduced by summing the entrance levels over the appropriate number of school years. Hence, primary optimal enrollment would be realized after the 1967-70 period (primary school has a four

TABLE 1

IMUM ENROLLMENT PATTERNS FOR PHILIPPINE EDUCATION 1966-74

UNDER SOLUTION I [a/]

Year	X_3	X_4	X_5	X_6	X_7	X_8	X_9	X_{10}	X_{11}	X_{12}	* (in ₱ M) 1966
1966-67	138	264	139	992	--	--	267,600	41,748	39,155	38,260	11,451
1967-68	56,250	31,028	3,000	33,611	--	94,027	286,750	187,783	45,000	16,823	26,328
1968-69	84,375	39,583	3,000	34,452	--	26,130	736,086	96,483	35,523	31,218	28,458
1969-70	93,750	41,666	3,000	32,872	--	50,705	105,909	198,529	33,142	30,268	30,391
1970-71	06,250	39,196	3,333	34,482	--	--	821,749	114,803	33,306	33,146	31,199
1971-72	16,250	--	3,333	37,241	--	--	908,500	57,250	46,583	32,298	32,645
1972-73	19,375	41,309	3,333	37,931	--	--	976,315	--	46,183	45,801	35,243
1973-74	28,125	39,541	3,333	41,379	--	--	1,068,333	--	45,051	44,756	37,491
											233,116

ate and private profit concept to public education.

that vocational education could be switched on and off in this manner, thus, a lower bound on its operation is implied.

Teacher training, mainly in the private sector, after an initial increase continues at a stable level for the duration of the planning period. Teacher inputs become equated constraints in the model for the 1966-67 and 1970-71 periods (see Table 2) and hence teacher training is only briefly accelerated one year after these bottleneck periods. General college training continually rises over the planning period but only at a moderate rate. The conclusion from this low, but, stable expansion of teacher and general college training is that most secondary entrants enter the labor market after completion of high school.

The value of the optimal enrollment patterns for each year is revealed in Table 1. The major import of these estimated increments to Philippine GNP lie in their yearly comparative value. Thus, the reallocation of educational resources over the first four years of the planning period almost triples the values of the educational sector's output. After the initial reallocation of educational resources the remainder of the planning

period is characterized by a slow but steady increase in enrollment and value of the educational output.

Each educational activity is of course, bounded by some resource constraint. The value of educational resources can be imputed as was demonstrated earlier. The shadow prices derived from Solution I appear in Table 2. The pattern which emerges from this array of values is quite revealing. Current operating expenditures are not an important constraint in the model. With the exception of the initial year the marginal value of operating expenditures is zero. School buildings, a proxy for capital expenditures, though is an important constraint.* The lack of secondary, vocational and teacher training facilities constrains these activities over the entire planning period. The yield to an additional building in these categories is enormous. However, when this shadow price per building is converted into a shadow price per peso of capital expenditure (i.e. dividing the original shadow price by the cost of a building) the return is reduced considerably. Nevertheless, capital expenditures' shadow price exceeds the imputed value of a marginal operating peso.

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* It should be remembered that capital expenditures are treated in this manner due to the non-marginal shifts and time lags involved with capital expenditures.

TABLE 2

TIED RESOURCE VALUES (IN 1966 PESOS) BY PLANNING YEAR

(UNDER SOLUTION I)

Year	Teachers	Buildings		Operating Expenditures
1966-67	Private Vocational (185,809) Private College (329,528) Private Normal (37,406)			Public College (18) Public Secondary (70) Public Vocational (35) Public Normal (18)
1967-68	Public College (277,985) Private Normal (297,921) Private College (338,223)	Private Secondary Private Vocational Public Secondary Public Vocational Public Normal	(12,978,750) (3,011,666) (5,577,666 (9,028,695) (990,136)	
	Public College (277,985) Private Normal (297,921) Private College (338,223)	Private Secondary Public Secondary Public Normal Public Vocational Private Vocational	(9,028,695) (1,297,885) (5,557,666) (3,011,666) (990,136)	
1969-70	Public College (263,011) Private Normal (274,517) Private College (311,653)	Public Vocational Public Normal Private Secondary Private Vocational	(12,978,750) (3,011,666) (9,439,090) (10,622,941)	
	Public College (262,648) Private Normal (247,754) Private College (281,270) Private Secondary (353,472)	Public Secondary Public Normal Private Secondary	(8,461,250) (5,591,000) (6,769,000)	
1971-72	Public College (262,648) Private College (281,270) Private Normal (247,754)	Public Secondary Public Normal Private Secondary	(8,461,250) (5,591,000) (6,769,000)	

	Teachers		Buildings	Operating Expenditures
2)	Public College	(262,648)	Public Secondary	(8,461,250)
3)	Private Normal	(247,754)	Public Normal	(5,577,666)
	Private College	(281,270)	Private Secondary	(7,125,263)
3)				

2)	Public College	(262,648)	Public Secondary	(8,461,250)
3)	Private Normal	(247,754)	Public Normal	(5,591,000)
	Private College	(281,270)	Private Secondary	(7,521,111)
3)				

education exists; however, the lack of facilities, as is evidenced by the high shadow price for secondary schools, precludes the efficient use of intermediate school graduates. Only after the fourth period do intermediate students constrain secondary education.

The past specialization between the public and private sector will generally persist if economic factors control their expansion. However, there will be some small, but important alterations in past patterns under an optimal system. The present small private primary system would be phased out completely if resources are allocated efficiently. Also, private intermediate education would only be employed during brief periods when the public sector is unable to absorb all public primary graduates. This emergency status of private intermediate education suggests a lower bound on its operation to maintain its availability. Public vocational education although historically much smaller than the large private vocational system actually supplants the private sector at the end of the optimal planning period. College education quickly reaches a stable, but, moderate level of optimal enrollment by 1970. However, the historical dominance of the private sector is quickly reduced at the college level over the planning period. Thus, increased

public control over this crucial sector is assured under an optimal expansion of college enrollment.

The implications for the optimum allocation of scarce educational inputs under the model are quite startling. In most cases, teacher inputs and operating expenditures are not a constraint on the system. A shift in planned operating expenditures to the capital budget would allow an expansion of the highly profitable secondary and vocational levels of education. Secondly, a reduction in the lower level student-teacher ratios is quite feasible given the surplus teacher output for these levels. Finally, at the college level where there is an excess of physical facilities and a shortage of teachers, a rise in the student-teacher burden at this level seems inevitable. The pressure, especially in the private sector to reduce average fixed costs (i.e., use 100% of building capacity) will require a rise in the student-teacher ratio to realize this goal. The implications under a constant technology while not obvious suggest a deterioration in the quality of instruction in higher education.

The specification of an individual profit concept in Solution I reveals some of the recent economic forces

working in the Philippine educational system. The persistence of the private-public sector specialization both over the recent past and under Solution I indicates that decision makers historically followed at least the individual cost aspect of this individual profit concept. The rapid expansion of secondary education under the optimal model and its less than moderate increase in the recent past also indicates a lack of recognition of the income side of the individual profit concept. This interpretation of past and optimal enrollment patterns and specialization indicates the one sided view that Philippine educational policy makers have employed.

The importance of the profit concept used in the objective function is borne out in Table 3 and figure 2. In this case, the same rate of discount (15%) was used, however, a social profit concept replaced the individual profit formulation. In essence, this meant that the total cost of public and private education is now being deducted from the income profiles. The resulting changes in enrollment patterns under Solution II while not startling are revealing. The pronounced specialization between the public and private sectors is no longer evident. The private sector absorbs approximately ten to fourteen per cent of elementary enrollment as compared to an almost zero activity level under

TABLE 3

OPTIMUM ENROLLMENT PATTERNS FOR PHILIPPINE EDUCATION 1966-74 UNDER SOLUTION II[a/]

X_3	X_4	X_5	X_6	X_7	X_8	X_9	X_{10}	X_{11}	X_{12}	(in ₱ M)
138	264	13	99	117,714	85,805	267,600	41,748	39,155	39,153	10,320
56,250	31,028	--	--	117,222	94,027	286,250	187,783	47,398	22,000	16,552
184,375	7,099	3,000	34,452	118,356	95,068	736,086	96,438	35,523	35,523	23,096
193,750	--	3,000	32,872	119,459	98,378	805,909	78,339	33,142	33,142	25,571
206,250	16,855	3,333	34,482	120,800	97,066	821,749	87,142	33,386	33,146	25,463
186,198	--	3,333	37,421	120,129	96,953	908,500	--	46,583	32,298	26,090
219,375	--	3,333	37,931	121,410	97,692	976,315	41,307	46,183	45,801	29,948
228,125	--	3,333	41,379	122,025	100,759	906,833	39,539	45,051	44,756	31,193
										187,433

iiscount with private profit concept.

Solution I. In fact, the private sector's elementary enrollment share under Solution II exceeds its actual share in 1966 by eight per cent. The private sector also gains in general secondary and vocational training enrollment as the public sector is phased out of the latter field under Solution II. The total number of vocational and general secondary students produced in both sectors declines under the second solution. At the teacher training and general college level no shift in specialization or alternation in enrollment patterns is evident under the second solution.

The reduction in the educational sector's contribution to the gross national product over the eight year period is ₱45.6 billion under the social cost concept. This is quite dramatic evidence of the difference in the individual's and society's valuation of education and the effects of subsidy on the operation of the system. The subsidy inherent in the first solution resulted in an altered pattern of enrollment and a reallocation of resources from the economy to the educational sector on a vast scale.

The imputed values of resource inputs under the second solution differs only slightly from those reported for Solution I (see Table 4). In the cases where there

TABLE 4

IMPUTED RESOURCE VALUES (IN 1966 PESOS) BY PLANNING YEAR UNDER SOLUTION II

Student Graduates		Teacher Inputs		Building Inputs		Expenditures	
x year olds	(1,595)	Private College	(374,106)	Private Primary	(165,285)	Public Secondary	(30)
imary both	(.1,686)	Private Intermediate	(36,990)			Public Vocational	(4)
		Private Vocational	(185,809)			Public Normal	(16)
		Private Normal	(329,528)	Private Secondary	(8,306,400)	Public College	(5)
x year olds	(1,595)	Public Intermediate	(40,142)	Public Secondary	(4,429,375)		
condary both	(16,773)	Private Vocational	(178,029)	Private Primary	(160,694)		
				Private Intermediate	(403,194)		
				Private Secondary	(8,652,500)		
				Private College	(121,357)		
x year olds	(1,595)	Public College	(88,277)	Public Secondary	(4,429,375)		
imary both	(1,686)	Private Normal	(297,921)	Public Normal	(2,670,333)		
termediate both	(1,811)	Private College	(338,223)	Private Primary	(158,493)		
				Private Intermediate	(166,712)		
				Private Secondary	(8,241,304)		
				Private Vocational	(742,054)		
x year olds	(1,595)	Public College	(83,522)	Public Secondary	(1,043,750)		
imary both	(1,686)	Private Normal	(274,517)	Public Normal	(2,670,333)		
termediate both	(7,228)	Private College	(311,653)	Private Primary	(156,351)		
				Private Intermediate	(164,459)		
				Private Secondary	(6,153,636)		
x year olds	(1,595)	Public College	(83,406)	Public Secondary	(4,429,375)		
imary both	(1,686)	Private Secondary	(494,908)	Public Normal	(2,670,333)		
termediate both	(1,811)	Private Normal	(269,229)	Private Primary	(154,260)		
		Private College	(305,650)	Private Intermediate	(162,266)		
				Private Vocational	(859,841)		

	Teacher Inputs		Building Inputs	Expenditures
5)	Public College	(83,406)	Public Normal	(2,670,333)
5)	Private Normal	(260,450)	Private Primary	(150,259
3)	Private College	(29,565)	Private Intermediate	(158,051)
			Private Secondary	(5,934,000)
5)	Public College	(83,406)	Public Secondary	(1,043,750)
6)	Private Normal	(256,076)	Public Normal	(2,670,333)
8)	Private College	(290,717)	Private Primary	(148,333)
			Private Intermediate	(156,025)
			Private Secondary	(7,125,263)
5)	Public College	(83,406)	Public Secondary	(1,043,750)
6)	Private Normal	(247,754)	Public Normal	(2,670,333)
	Private College	(281,270)	Private Primary	(146,455)
8)			Private Intermediate	(154,050)
			Private Secondary	(7,521,111)

was a shift in enrollment between the private and public sectors (i.e. elementary and vocational levels) equated constraints were altered. Capital expenditures (buildings) become the foremost constraint in Solution II while there is a corresponding decline in the value of student and teacher inputs. The zero imputed value to operating expenditures remains.

This comparative analysis of the various patterns under the two solutions portrays several inherent features of the optimization model. First, the model is not very sensitive to differing profit concepts, at least, in terms of total enrollment. Although the type of output and the imputed value of educational resources are substantially altered the essential enrollment patterns are similar in either solution. Secondly, there is a differential effect between the private and public sectors when the social profit concept is employed. The enrollment gains of the private sector under Solution II imply that the public sector has the largest additional costs when the social profit concept is employed. It is evident that under these conditions conflicts will arise. From the individual student's view a public institution is the sector to obtain his education

and maximize his net gain. However, from the public or social viewpoint the private sector should be used more extensively. How to reconcile these two opposing trends and motivations to achieve an optimum use of scarce resources will involve subsidies, bounds, etc.

To further test the sensitivity of the optimization model a third set of solutions (Solution III) were obtained using an individual profit concept (as Solution I) but a nine and twenty per cent discount rate was employed in lieu of a fifteen per cent rate.

It will be remembered that a great deal of contraversy surrounded the selection of the appropriate rate of discount. Thus, several solutions under differing rates are offered as a possible method to resolve this issue.

A comparison of Solutions I & III indicated some important features of the optimization model under varying discount rates. First, enrollment patterns (not shown here) are identical under any of the three rates of discount. The discount range of nine to twenty per cent does not alter the relative profitability of any of the educational activities enough to cause a redirection of resources among activities. However, there is a significant difference in

TABLE 6

IMPUTED VALUES OF SELECTED EDUCATION RESOURCES

UNDER THREE RATES OF DISCOUNT FOR 1967-68

(IN 1966 PESOS)

Source	(1) Solution I (15%)	(2) Solution III (9%)	(3) Solution III (20%)
SIX YEAR OLD	2,752	6,451	1,601
PRIMARY GRADUATE	2,903	6,706	898
PUBLIC SECONDARY BUILDING	5,577,666	15,586,875	3,968,470
PUBLIC VOCATIONAL BUILDING	9,028,695	27,461,836	6,073,750
PUBLIC COLLEGE TEACHERS	277,985		179,645
PRIVATE NORMAL TEACHERS	297,921	728,362	101,650

Sources: Column 1 from Table 2 and Columns 2 & 3 derived from computer output.

the valuation of educational output under the three rates of discount as Table 5 illustrates. Increasing the rate of discount from fifteen to twenty per cent reduces the total value of the educational output by over one-half. At a nine per cent rate of discount the value of educational output is increased by approximately one-half. The educational resources which had a positive value in Solution I also yielded a positive value in Solution Set III. However, the absolute imputed values varied under the different solutions as is illustrated in Table 6. A twenty per cent rate of discount yielded shadow prices which were one-third to one-half the value of identical resources under a fifteen per cent discount rate. Values of these resources were increased threefold over Solution I when only a nine per cent rate of discount was employed.

Comparative results of Solutions I & III indicate that the internal allocation decision (i.e. enrollment patterns) can be made without regard to a wide range of discount rates. The valuation of educational output and resources however, are particularly sensitive to discount rates. Substantial changes in the contribution to GNP under small changes in discount rates indicate the crucial factor

TABLE 5

VALUE OF EDUCATIONAL OUTPUT UNDER 9, 15 & 20 PER CENT DISCOUNT RATES.

(MILLIONS OF 1966 PESOS)

Year	Solution I (15%)	Solution III (9%)	Solution III (20%)
1966-67	11,451	21,385	6,066
1967-68	26,328	34,139	10,256
1968-69	28,458	43,206	13,996
1969-70	30,391	45,396	14,283
1970-71	31,199	46,397	14,663
1971-72	32,645	48,121	15,343
1972-73	35,243	50,035	16,564
1973-74	37,491	52,686	17,620
TOTAL	233,116	341,365	108,791

of time in an educational model. Moreover, varying discount rates will effect the educational sector's imputed resource values more than other sectors of the economy which have shorter pay-off periods for investments.

Optimization versus Rate of Return

Internal rates of return to Philippine education are presented in Table 7. Comparing these rates of return to the patterns of enrollment found under Solutions I or II of the optimization model reveal quite striking differences in the two planning methods. The low rates of return to primary and intermediate education (7 to 9 per cent) are not indicative of the expansion that would take place under an optimization model. The latter model recognizes the intermediate input nature of elementary graduates and operates this level at full enrollment to feed into secondary education. General secondary education receives equal emphasis under both the rate of return and optimization models. However, vocational training and college education are treated quite differently under the two methods. The rate of return approach suggests equal allocation of resources between these two educational levels since they receive

TABLE 7

INTERNAL RATES OF RETURN TO PUBLIC AND PRIVATE EDUCATION IN THE PHILIPPINES, 1966 a/

Educational Option	Public Education		Private Education
	Individual Return	Social Return	Individual Return
1. Primary versus illiteracy	2%	6%	6%
2. Intermediate versus primary	9%	8%	8%
3. High school versus elementary education	29%	21%	27%
4. Vocational versus elementary education	12%	11%	11%
5. College versus high school education	12%	11%	13%

a/Source: J.G. Williamson & D.J. DeVoretz, "Education as an Asset in the Philippine Economy", *Second Population Conference Proceedings*, (Quezon City, University of the Philippines Press, 1968).

equal returns. However, the optimization model recognizes the difference in the production function of the two educational activities. Vocational training is seen as a residual activity, directly in competition with highly profitable general secondary education and thus run at a low level. College training which is not competitive with other educational activities is greatly expanded under optimization.

The pattern of specialization between the public and private sectors is also quite different under the two approaches. Only at the general secondary level does the rate of return method suggest a dominance of the private sector. At all other educational levels, the rate of return model indicates equal expansion of both public and private education. However, under any optimal solution there is a clear pattern of specialization between the two sectors. Nearly all elementary students are trained in the public sector while the private sector dominates vocational education. More importantly in the case of college education the optimization model enrolls most students in the public sector, clearly in contrast to the rate of return method which yields a premium to private college education.

The contrasts in sectoral specialization and enrollment patterns between the two models indicate several

basic differences in the approaches. Most of the divergence in the two methods can be revealed by reference to the shadow prices in Table 2. The optimization model recognizes the complex nature of the supply curve of educational inputs. The inclusion of intermediate student inputs, and inelastic supplies of buildings and teachers (i.e. step function) causes an entirely different pattern of resource allocation as imputed value of resources rise under the optimization model. On the other hand, the rate of return model assumes an elastic supply curve for educational inputs at a constant cost (i.e. infinite supply elasticity). Furthermore, the intermediate output of students is not incorporated in the rate of return production function. Clearly, this latter description of the educational production function and input supply curves for education is too simple to accurately indicate the efficient allocation of resources and accounts for the wide divergence in the results of the two methods.

The conclusions to be drawn from the several optimal solutions presented are on two levels. Some only pertain to the theoretical properties of the optimization model while other conclusions apply to the Philippine educational system and economy in general. At the theoretical level, it has been shown that the sensitivity of the optimi-

zation model in relation to parametric objective function changes (i.e. varying profit concept or discount rate) is not substantial. Thus, the described enrollment patterns will remain substantially unaltered even if correction for estimation errors must be made. Secondly, the acceptance of either the rate of return approach or optimization model depends on a consideration of what is an appropriate description of the production function for education. Since intermediate outputs, supply rigidies, etc., are readily recognizable in the production process of education than the results of the optimization are clearly superior.

The three sets of optimal solutions lead to several conclusions concerning the allocation of Philippine educational resources. First, the past allocation of elementary students without any planning was optimal in terms of the optimization model. However, it was pointed out that this was due to past decisions being based on a least cost basis and not highest net profit of education. If this least cost decision criterion continues, vast misallocation of resources will occur at the secondary and higher education levels. The divergence of the optimal solutions from the past low expansion of these levels of education indicates the foregone contribution to Philippine GNP.

Secondly, the assessment of the imputed value of educational resources leads to the conclusion that several resources are redundant in the Philippine system. If a constant teacher-student ratio is accepted then most teachers are in excess supply and should be redirected to other occupations. Also, operating expenditures will be in excess if they are appropriated as planned. However, this does not mean that expenditures should necessarily be curtailed in education. A reallocation of some operating funds to capital expenditures would yield a positive return and perhaps equate the operating expenditure constraint. Since graduates do have a positive resource value the reduction in the drop-out rate could increase the value of educational output provided that the cost does not exceed the shadow price. In general, it must be concluded that the value of educational resources, with the exception of capital funds is quite low since enticing an additional student into the system yields less than two thousand pesos while operating expenditures have a zero marginal return.. Although no counterpart measures are available in the economy it can be expected that in many sectors resource values will exceed the low value of educational resources. Thirdly, to realize the optimum enrollment when social costs are considered (Solution II)

will require a system of subsidies to the private sector to encourage students to enter certain educational levels in the private sector. Unless this is done, individual profit will entice students into the high social cost public sector due to the present subsidy to this sector. Finally, the often made contention that vocational education is a high yielding activity is fallacious in the Philippine context. It is true that the absolute profit value of vocational education is high. However, competition with general secondary education for similar resources reduces the activity level of vocational education to allow the expansion of the more highly profitable secondary education.

Whether the Philippine institutional structure is flexible enough to shift educational resources in the dramatic manner suggested by the above conclusions is doubtful. Nevertheless, the cost of following a non-optimal pattern can be measured in terms of foregone Philippine GNP. The crucial decision is whether the Philippine economy can afford the misallocation of resources inherent in lower than optimal value of educational output.