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INTRODUCTION AND SUMMARY

This doctoral thesis is a collection of three essays dealing with the structure of labor markets, minimum wage legislations, the opportunity cost of labor and the returns to investments in education in developing countries.

The first two essays represent a theoretical and empirical analysis of the proper measurement of the true returns to investments in education under segmented labor markets. The third essay is of a different nature. It analyzes theoretically and empirically some educational reforms aimed at increasing the returns of educational resources in developing countries. In the next pages each essay is briefly summarized.

Essay I: Unemployment, Labor Market Segmentation, The Opportunity Cost of Labor and the Social Returns to Investments in Education.

The following question is addressed: What is the (shadow) marginal product of labor classified by education and its relation to observed market wages when: (a) educated and non-educated labor are different inputs in the production function of the urban economy; (b) unorganized or free entry labor markets for each skill coexist with restricted-entry labor markets with wages above clearing levels; (c) we observe unemployment of both types of labor.

By specifying the unemployment behavior and a production function for the free entry sector, the marginal product of labor by education is derived. The discrepancy between such marginal product and the free entry wage stems from the fact that: (a) An extra worker in the labor force can induce additional employment, of that type of labor, in an amount larger or smaller than one; (b) it can also affect the employment of the other skill to the extent both labors are complements or substitutes.

An empirical evaluation of the above discrepancy is undertaken. The basic parameters for such evaluation are: (a) The relative size of the restricted entry labor market; (b) its relative "educational intensity"; (c) the unemployment rates; (d) the initial wage differentials between the two sectors, and; (e) the demand elasticity for labor in the free entry sector. The findings are that such discrepancy is fairly constant under reasonable variations of the basic parameters except for the demand elasticity for labor. For a wide range of such elasticity, the use of observed wages in the unprotected sector to measure the true contribution of each type of labor represents an upper bound. Nevertheless, the use of the free entry sector relative wages to assess the true relative contribution of labor classified by schooling involves a lesser degree of error.

Essay II: Minimum Wage, Labor Market Segmentation: The Earnings Function and the Social Returns to Education.

The estimation of earnings generating functions has become an important tool in the analysis of wage differentials and personal income distribution. The schooling coefficient obtained from these functions has usually been interpreted as an estimate of the marginal contribution of education to the economy and therefore used to assess the social return to investment in education.

This essay addresses the following question: To what extent the above interpretation is correct when we accept the notion of labor markets characterized by segmentation? Segmentation is defined as the coexistence in an urban economy of a protected sector where a minimum wage legislation is being enforced with an unprotected sector where it is not.

Two problems distinctive in nature arise under this scenario. First, an econometric bias in the measurement of the schooling coefficient. Second, a structural bias due to a mis-specification of the underlying labor market structure and the impact that additional schooling has on the allocation of labor between sectors.

The net impact of these two sources of errors is shown to depend on: (a) The relative education of those benefiting from the minimum wage legislation vis a vis those who do not; (b) the variance of the educational levels of these two groups; and (c) the factors determining the probability of entering the protected sector earning the minimum wage.

An empirical evaluation of these biases is undertaken for two developing countries. The findings are that the errors involved in the use of the standard schooling coefficient to assess the social contribution of education are extremely significant.

Essay III: The Economic Cost of the "Internal" Brain Drain: Its Magnitude in Developing Countries.

The economic implications of the outflow of highly educated individuals from LDC's, i.e., the "external" brain drain, has received a considerable amount of attention in the developing literature. Here we call attention to another type of brain drain that by analogy might be called the "internal" brain drain, i.e., a drain that takes place within a country.

The central notion of the paper is the hypothesis of factor complementarity between preschool ability and education in determining the productivity of an individual. Under this hypothesis, an optimal allocation of existing educational resources across individuals with different abilities--(in the sense of maximizing the value added of these resources)--must induce a positive and perfect correlation between ability and schooling. The existence of an educational system where the amount of schooling an individual receives (or the "selection process" of the system) is determined by factors other than ability, induces a misallocation of the existing educational resources. For a given degree of "factor complementarity" and "selection error" the magnitude of such misallocation will be larger the stronger the lack of openness of the educational system.

The economic cost of the "internal" brain drain is defined as the loss of value added of the existing educational system relative to the optimal system under which students at all levels of the educational system are selected according to their preschool ability levels. The educational reform required to achieve such a system is defined as the "full reform" and represents the pure meritocratic solution.

An analytical framework is specified to derive orders of magnitude for the gains in value added due to a "full reform" as well as intermediate or partial reforms. Throughout the exercise, the capacity of the educational system is held constant so as to isolate the pure qualitative (costless) effects of such reforms. The quantitative effects of the reforms appear to be substantial. A full reform is able to double the net value added of the educational system. For a wdie typology of countries a fully reformed educational system increases the long run contribution of labor to the economy by 11 percent; given a labor share of 0.5 this implies a long run gain in output equal to 5.5 percent. This value is substantial if compared to other estimates of the welfare costs of resource misallocations in LDC's.

ESSAY I

UNEMPLOYMENT, LABOR MARKET SEGMENTATION, THE OPPORTUNITY COST OF LABOR, AND THE SOCIAL RETURNS TO INVESTMENTS IN EDUCATION

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I. Introduction

There appears to be a growing concern among economists about the appropriateness of traditional macroeconomic models for the analysis of open urban unemployment, particularly in less developed countries (LDC's).[1] The seeming irrationality of the coexistance of rural urban migration with open urban unemployment, has stimulated the development of new kinds of models in which migration and urban unemployment are analyzed simultaneously. These models, known as job search models, have shifted the emphasis from demand to supply size considerations in the explanation of urban unemployment.[2] They generally include a rural and an urban sector, the latter characterized by an institutionally fixed wage above the market clearing level. In these models, migration and search unemployment are viewed as a result of a rational economic maximizing behavior. Migration proceeds in response to the rural-urban expected wage differential with the urban unemployment rate acting as the equilibrating force in the

*This essay is based on a joint paper with Marcelo Selowsky.

[1]See, for example, Hall (1975), Harris and Sabot (1976).

[2]See Todaro (1968), (1969), Harris and Todaro (1970), Phelps (1970), Todaro (1971), Johnson (1971).

the regulation of such migration.

The best known version of these models, the Harris-Todaro model, predicted rates of unemployment that substantially exceeded the urban unemployment rates existing in most LDC's.[1] These significant gaps between predicted and observed rates of unemployment, once again stimulated economists' imagination leading them to sacrifice simplicity for realism in the development of search models with improved predictive performance.[2]

The most important modification is related to the initial simplistic view that urban unemployment is the only alternative to wage employment in the modern sector. The insufficient attention paid to urban alternatives to modern sector employment was remedied by incorporating two urban sectors: A modern-protected-formal or organized sector where wages are institutionally fixed above the market clearing level and therefore, with restrictions to entry, and a traditional-unprotected-informal-unorganized or murky sector where wages perform a market clearing role, characterized by free entry. (Zarembka, Mazumdar, Fields, Harris and Sabot). The other extensions to the initial Harris-Todaro model are related to the recognition of the heterogeneity of migrants (Mazumdar, Stiglitz); a more general approach to job search (Stiglitz, Harris and Sabot); the labor turnover (Stiglitz) Fields); the preferential treatment of the better educated on the part of employers (Fields, Harris and Sabot); the financing of the investment in job search and the direct costs of migration (Harris and Sabot); the probability of a rural resident of obtaining an urban job (Fields); and

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[1]See Turham (1971).

[2]See, for example, Zarembka (1972); Mazumdar (1974); Fields (1975); Stiglitz (1976); Harris and Sabot (1976).

finally the appropriateness of the use of present vs. current values in the migrant decision making process (Fields).

With respect to the introduction of an informal-unprotected sector, the basic premise that has been used is that the same kind of forces that explain the equilibrium allocation of workers between the rural and urban sector, can also explain their choices between employment in the unprotected sector and unemployment while searching for a better job in the protected sector.[1] The notion that urban unemployment in the presence of unprotected free-entry sectors can be viewed as the result of an economically rational process of job search appears to be a fruitful framework within which to analyze several questions concerning the urban economy.

In this paper we use the same basic framework to derive the marginal contributions to output of additional educated and non-educated workers and the relationship between these contributions to their respective observed wage renumerations in the unprotected free entry sector. Knowledge of these marginal social contributions or shadow prices of educated and non-educated labor is essential in the context of project evaluation, (opportunity cost of labor with different degrees of schooling) particularly in the educational development area. The relative marginal contributions of these two types of labor are the crucial variables in the assessment of the contribution of educational investment to the economy and they will in general differ from their respective observed wages.

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[1]Fields (1975) analyzes these two decisions in a simultaneous framework.

Assume we are evaluating an educational project which will produce laborers with a given educational level in an urban economy where i) unemployment of that type of labor is being observed ii) we observe a spectrum of wage earnings for a given level of education. Which one of these wages or combination of them should be used to compute the social marginal contribution of that labor when he enters the labor force? Before presenting an explicit analysis of this question we review briefly intuitive suggestions that have been advanced to measure the social marginal contribution of labor with a given educational level.

a) The marginal contribution is zero as long as unemployment of that type of labor is being observed. The implicit hypothesis here is that unemployment is of an involuntary nature, i.e., at the prevailing wages, there is excess supply of that labor in each and every market. Under these circumstances, an extra worker either becomes unemployed or

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[1] It is important to notice that this issue is independent and different from the one being discussed in the present debate concerning the "value added" of education, the "screening hypothesis" being one of such arguments.

It has been argued that, even if one accepts the notion that wage differentials by schooling reflect productivity differences, these differentials do not necessarily represent a positive value added of education from the point of view of the production function. The screening hypothesis is perhaps the best known of these arguments: "it suggests that intereducational earnings differentials, even when standardized for differences due to non-educational factors, reflect no direct productivity-enhancing effects of education but only its effects as a device for signaling preexisting ability differences" (Layard and Psacharopoulos 1974).

The "value added" arguments, those embodying the hypothesis that wage differentials overstate the true contribution of education can, in principle, be tested. They are empirical rather than theoretical considerations. They basically represent a "missing variable bias" argument: If one had data on all background variables correlated with education and having an <u>independent</u> effect on wages (including pre-school levels of ability to take care of the screening hypothesis) one could arrive to an estimate of the true value added of schooling.

by finding a vacancy prevents the employment of another laborer. Since we are concerned here with voluntary unemployment in the context of free entry competitive markets coexisting with restricted ones, this suggestion is not relevant to our analysis.

b) The marginal contribution should be measured as a weighted average of the wage earnings of that type of labor in each market including zero for the unemployed, where the weights are the fraction of laborers in each market. Implicitly this view assumes that extra workers entering the labor force will be allocated among different markets in the same proportion as the existing labor force. As demonstrated below a theoretical framework of job search unemployment does not sustain this hypothesis.

c) The marginal contribution should be measured by the free entry market wage as long as such a market exists. This view is justified arguing that if the worker is lucky and fills a highly paid vacancy in a restricted market, his net contribution is still the free entry wage; he has simply replaced a colleague working in the free entry sector. If he enters this last sector then the free entry wage again reflects his contribution. Finally, if he becomes unemployed, he induces a presently unemployed worker to accept a free entry sector job. Therefore, his net contribution is still reflected by the free entry sector wage. Implicit in this argument, is the notion of a constant absolute volume of unemployment.[1]

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[1]Harberger (1971) concluded that "the unprotected sector wages, for a given skill classification of labor, and in a given labor market area, is the best available measure of the social opportunity cost of that type of labor in that area" (Harberger (1971) p. 563). However this conclusion was reached in the context of the supply price of labor.

As we said before, the notion that free entry labor markets coexist with restricted labor market appears to correctly reflect the situation of the urban economies in most LDC's and has become an acceptable working hypothesis in dealing with them. However, the acceptance of free entry labor markets obviously precludes the notion of involuntary unemployment. A new type of unemployment behavior must be specified. Given these circumstances, what we do want to question about the last intuitive suggestion mentioned above, is its proposition that in such a framework, the free entry sector wage does represent the marginal contribution of labor, i.e., an extra worker in the labor supply induces additional employment in the free entry sector by one worker. Our contention is that this last proposition is not at all obvious. It assumes a particular unemployment behavior that results in a constant volume of unemployment in spite of an extra worker in the labor force.

The purpose of this paper is to explicitly model this employment-unemployment behavior and to derive the true marginal contribution to the economy of an additional worker in the labor supply as well as the relative marginal contributions of workers with different educational levels stemming from such specification. Section II analyzes the nature of labor market segmentation and the existance of voluntary unemployment. Section III spells out an employment-unemployment strategy characterizing the behavior of workers outside the protected sector. Section IV integrates the above behavior into a production function framework for the assessment of the marginal contribution of different types of labor. Finally, Section V attempts an empirical evaluation of these social contributions and summarizes our conclusions.

II. Segmented Labor Market and the Existance of Voluntary Unemployment

For the purpose of the analysis we will assume that for each type of labor classified by schooling (for simplicity we can refer to "educated" and "uneducated" laborers) there exists basically two markets with different wages prevailing in each of them. There are the unprotected market clearing wage[1] and the protected market characterized by entry restrictions and a higher non-competitive wage rate.

There is ample evidence to support this contention. A wide variety of reasons have been advanced in the context of rural-urban migration to explain these sectorial wage differentials. The most widely held view is of an institutional nature; labor unions, minimum wages and political pressures on governments by organized labor keep the protected sector wages above the market clearing level.[2] Other explanations advanced are related to a) the technological gap between the two sectors; firms utilizing technologies for which the on-the-job-training costs are high may offer wages above the equilibrium level as a mean of reducing labor turnovers. b) The efficiency wage hypothesis; higher wages lead to higher productivity, therefore there is a wage that minimizes total labor costs in the protected sector which need not correspond to the one prevailing in the unprotected sector.[3]

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[1]This market includes self-employed as well as hired labor as long as the free entry assumption holds.

[2]See page   in this dissertation, for a more detailed analysis of the discriminatory effect of these institutional pressures in the protected and unprotected sector.

[3]See, for example, Stiglitz (1971), (1976); Herrick (1974); Mazumdar (1974); Harris and Sabot (1976); Webb (1974); Leibenstein (1957); Turnham (1970); Harberger (1971).

The literature on LDC's wage policies contains several attempts to separate the impact of government intervention, union strength and market forces on the wage level of the protected sector.[1] Regardless of the particular reason or combination of reasons which explain these wage differentials in an urban economy, the protected sector can be identified. As Harberger clearly points out: "Protected jobs can readily be identified because so many people want them. Companies paying wages higher than market levels for equivalent skills and working conditions tend to have very low labor turnover and long lists of applicants waiting for an opening to arise" (Harberger (1971) p. 563).

The existance of free entry labor markets implies that observed unemployment must be of a voluntary nature and a result of a process of job search. The idea behind this is that a worker increases the probability of obtaining a job in the protected sector by being unemployed and investing in search. Unemployment becomes the result of a process of job search where the costs are the present foregone earnings in the free entry sector and the benefits the present value of a higher probability of finding a job in the protected sector.

III. The Employment-Unemployment Decision Making Process

1. The expected flow of earnings out of alternative employment plans

Let us suppose that in any particular period the workers outside the protected sector compare the following set of employment plans:

(a) Plan One: To become unemployed during the present period so

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[1]See, for example, Berg (1970); Turner and Jackson (1970); Frank (1968); Ramos (1970); Isbister (1971); Kilby (1967); Knight (1967); Sabot (1975).

as to increase, due to search activities, the probability of obtaining a job in the protected sector during next period. If in that period no job in the protected sector is found, the plan--as seen from today--does not involve additional periods of unemployment. The worker will then enter the free entry sector and remain there with lower probabilities of getting a job in the protected sector.

We assume that unemployment today, although it increases the prob ability of getting a job in the protected sector next period, does not affect that probability once he again enters the free entry sector.

(b) Plan Two: To accept employment in the free entry sector and remain there unless one succeeds in getting a job in the protected sector. In equilibrium the expected present value of earnings must be equal for both options because otherwise workers would keep moving from unemployment to employment in the free sector or vice versa.[1]

We will define the following variables:

Π_T = expected probability of getting a protected job in any future period T after spending period T-1 in the free entry sector, where T = 1, 2...

β = number of times the above probability increases when the worker remains unemployed in period T-1 devoting all of his time to search.

$\beta\Pi_1$ = expected probability of getting next year a job in the protected sector if one decides to reamin unemployed during the present period.

$\hat{W}_0$, W_0 = present wage in the protected and ffree entry sector.

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[1]Stoikov (1975), critizes the assumption that individuals attempt to maximize the discounted stream of future income and develops a search model in which individuals attempt to maximize the discounted stream of future utility or satisfaction.

$\hat{W}_T$, W_T = expected wage in the protected and free entry sector in any future period T, where T = 1, 2 ...

Table I shows the path of expected earnings implicit in both plans under the assumption that Π remains constant over time.

In equilibrium the expected present value of both options must be equal namely:

$$(1) \quad \sum_{T=1}^{\infty} \frac{\hat{W}_T - (\hat{W}_T - W_T)\ (1-\beta\Pi)\ (1-\Pi)^{T-1}}{(1+r)^T} = W_0 + \sum_{T=1}^{\infty} \frac{\hat{W}_T - (\hat{W}_T - W_T)\ (1-\Pi)^T}{(1+r)^T}$$

The left hand side of expression (1) represents the expected present value of the first plan; the right hand side, the value of the second plan; r represents the discount rate. Rearranging terms we can write:

$$(2) \quad -1 + \frac{(\beta-1)\Pi}{(1-\Pi)} \sum_{T=1}^{\infty} \left(\frac{1-\Pi}{1+r}\right)^T \frac{\left(\hat{W}_T - W_T\right)}{W_0} = 0$$

Defining $\delta = (\hat{W}_0 - W_0)/W_0$ as the present percentage wage differential between the two sectors and g as the expected growth rate of real wages, we can write

$$(3) \quad \frac{\delta\Pi(\beta-1)}{(1-\Pi)} \sum_{T=1}^{\infty} \left[\frac{(1-\Pi)(1+g)}{(1+r)}\right]^T = 1$$

$$(4) \quad \frac{\delta\Pi(\beta-1)(1+g)}{(1+r)-(1-\Pi)(1+g)} = 1$$

$$(5) \quad \Pi(1+g)\ a = (r-g) \quad \text{where } a = (\beta-1)\delta - 1$$

It is important to notice again that, except for δ, all of the parameters entering expression (5) represent expected magnitudes; they need not represent actual or effective parameters.

TABLE I; PATH OF EXPECTED EARNINGS UNDER ALTERNATIVE EMPLOYMENT PLANS

Type of Plan	PERIODS				
	0 (Present)	1	2	3	Total expected earning period T
Choice of unemployment in the present; if bad luck return to the free entry sector	0	$\beta\Pi \hat{W}_1$ $(1-\beta\Pi) W_1$	$\beta\Pi \hat{W}_2$ $(1-\beta\Pi)\Pi \hat{W}_2$ $(1-\beta\Pi)(1-\Pi)W_2$	$\beta\Pi \hat{W}_3$ $(1-\beta\Pi)\Pi \hat{W}_3$ $(1-\beta\Pi)(1-\Pi)\Pi \hat{W}_3$ $(1-\beta\Pi)(1-\Pi)^2 W_3$	$\hat{W}_T-(\hat{W}_T-W_T)(1-\beta\Pi)(1-\Pi)^{T-1}$
To stay in the free entry sector until one succeeds in obtaining a protected job	W_0	$\Pi \hat{W}_1$ $(1-\Pi) W_1$	$\Pi \hat{W}_2$ $(1-\Pi)\Pi \hat{W}_2$ $(1-\Pi)^2 W_2$	$\Pi \hat{W}_3$ $(1-\Pi)\Pi \hat{W}_3$ $(1-\Pi)^2\Pi \hat{W}_3$ $(1-\Pi)^3 W_3$	$\hat{W}_T-(\hat{W}_T-W)(1-\Pi)^T$

In contrast with the original Harris Todaro specification in which all protected jobs turn over every period, we are assuming that individuals once they get a protected job remain in that job for an extended period. Therefore, the employment probability in each period will not be the ratio of all jobs to the entire labor force, but rather, the ratio of job hiring to the labor force outside the protected sector. For this reason we use sequential probabilities for the individual entering the protected sector.

Two further assumptions have been made in arriving at expression (5): First, that the expected probabilities entering the plan remain constant and equal to today's expected probability of finding next period a protected job. Second, expectations about equal growth rates for the protected and unprotected wage enter the plan. These assumptions are not independent; a rational behavior implies that the second assumption is required for the first one to hold.

2. The relation between expected and effective probabilities.

We will define P as the present effective probability of obtaining employment in the protected sector in the next period if the worker spends this period working in the unprotected sector. This probability is equal to:

$$(6) \quad P = \frac{V}{S}$$

Where V are the vacancies to be open next period in the protected sector arising from labor rotation, retirements and net employment growth in that sector. S represents today's equivalent searchers for such jobs, namely:

$$(7) \quad S = L + \beta U$$

where L are today's employed workers in the unprotected sector and U the present amount of voluntarily unemployed workers investing fully in search.

We are now able to connect the expected probabilities with presently observed magnitudes. We will assume that all workers behave as if today's probabilities will prevail forever.[1] Therefore:

$$(8)\quad \Pi = P$$

$$(9)\quad \Pi = P = \frac{V}{L+\beta U} = \frac{(V/\overline{L})}{\mu(\beta-1)+1}$$

where μ, the unemployment rate, is equal to $U/\overline{L}$ and $\overline{L} = L + U$ is the "out of the protected sector labor force." Defining L_p as the employment in the protected sector, the rate of openings in that employment ($\lambda = V/L_p$), and $L_p/\overline{L}$ as the relative "size" of that sector we can write:

$$(10)\quad \Pi = P = \frac{\lambda\ L_p/\overline{L}}{\mu(\beta-1)+1}$$

To rationalize this unemployment behavior, it is crucial that β be greater than one, i.e., a worker increases his probability of obtaining a protected job by becoming unemployed and investing in search. The value of β will depend on the extent to which employment in the unprotected sector places a constraint on the capacity to search for a protected

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[1]Imperfections of information mean that individuals might misperceive the actual probability of obtaining a job in the protected sector. For the optimistic ones, the subjective probability will overestimate the true one, the opposite being true for the pessimistic ones. The notion that subjective probabilities are equal to the effective ones implicitly assumes some kind of bayesian learning process that tends to guarantee this equality.

job.[1] The stronger this constraint, the larger the value of β. The strength of this constraint and therefore the value of β will depend on institutional factors about the labor market; basically information, hiring practices and geographical distance between the two sectors. If information about protected jobs is not perfect, its acquisition will require time and that might interfere with an unprotected job, the same would be true if employer's in the protected sector tend to hire the first in the queue during working days. Finally, the geographical location of the two sectors within the urban economy might also affect the strength of the constraint and therefore the value of β. The mere fact of the existance of a signifcant level of open unemployment constitutes indirect evidence that the perceived probability of finding a protected job is higher for the unemployed. Kritz and Ramos (1976), provide more indirect evidence to support this contention. The three employment surveys undertaken by P.R.E.A.L.C. showed very high rates of open urban unemployment: 20 percent in Managua, 15 percent in Santo Domingo, and 12 percent in Asuncion. However, 35 percent of the unemployed in Managua, 51 percent of the unemployed in Santo Domingo and 60 percent of the unemployed in Asuncion left their previous jobs voluntarily to search for a better job but where not laid off.

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[1]This is a basic assumption of search models developed for LDC's. See Mazumdar (1974), Fields (1975), Sabot (1975), Harris and Sabot (1976). It is also a crucial assumption of a number of more general job search models based on Stigler's classic paper on information on the labor market (Stigler (1962)). Most of these more general search models, view the unemployed as sampling from a probability distribution of prospective wages. Under certain conditions, the optimal search rule is to establish a reservation wage. However, these job opportunities would not exist had the worker not been unemployed and investing in search. See, for example, Mortensen (1970); Gronau (1971); Holt (1970); McCall (1970); Phelps (1970); Kahn and Shavell (1974); Lucas and Prescott (1974); Eaton and Neher (1975).

IV. The Model

Assume the aggregate production function in the free entry sector can be described as:

$$(11) \quad X = F[N, E, K]$$

where N and E represent uneducated and educated labor and K an index of non-labor inputs. The level of employment in such sector is determined where the marginal product of labor is equal to the wage rate W.

$$(12) \quad F_N[N, E, K] = W_N$$

$$(13) \quad F_E[N, E, K] = W_E$$

The factor endowments or the labor force in that sector is defined as:

$$(14) \quad E + E_U = \overline{E}$$

$$(15) \quad N + N_U = \overline{N}$$

$$(16) \quad \overline{E} + \overline{N} = \overline{L}$$

Where E_U and N_U represent the amount of unemployed workers of each skill and $\overline{E} + \overline{N} = \overline{L}$ represents the total labor force outside the protected sector.

An equilibrium level of (voluntary) unemployment requires that the present value of both employment plans must be equal.[1] Recalling expression (5) we obtain

$$(17) \quad (r-g_N) = P_N\,(1+g_N)\,a_N \qquad a_N = (\beta_N-1)\,\delta_N$$

$$(18) \quad (r-g_E) = P_E\,(1+g_E)\,a_E \qquad a_E = (\beta_E-1)\,\delta_E$$

[1]Notice that from now on the parameters defined in Section III have a subscript N or E reflecting its "skill specific" characteristic.

where:

P_N, P_E = the probability of getting next period a job in the protected sector if this period has been spent working in the free entry sector, for both types of skills respectively.

β_N, β_E = the number of times the above probability increases when the worker remains unemployed during this period and devotes all of his time to search, for both types of skills respectively.

δ_N, δ_E = today's percentage wage differential between the protected and unprotected sector, for both types of skills respectively.

g_N, g_E = growth rate in wages; for each type of labor this rate is equal for the unprotected and protected sector.

The probabilities P_N and P_E can be written as:

$$(19) \quad P_N = \frac{V_N}{S_N} = \frac{V_N}{\beta_N N_U + N} = \frac{V_N}{\beta_N \overline{N} + (1-\beta_N) N}$$

$$(20) \quad P_E = \frac{V_E}{S_E} = \frac{V_E}{\beta_E E_U + E} = \frac{V_E}{\beta_E \overline{E} + (1-\beta_E) E}$$

where S_N and S_E are the "equivalent searchers" for the protected sector vacancies, for both types of labor respectively. We are assuming that the free entry wage for educated workers is higher than the wage for non-educated workers in the protected sector. This means that there is no incentive for educated workers to compete with non-educated workers for their "protected" jobs. This assumption, although it can change the magnitude of our conclusions, does not change the basic nature of the issues we want to address. This assumption was made because it corresponds to the situation of the urban economy of Asuncion-Paraquay, which will be used for the empirical evaluation of the model.[1]

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[1] See Situacion y Perpectivas de empleo en Paraguay P.R.E.A.L.C., I.L.O. (1975).

We are interested in evaluating the total contribution to output of an additional worker of each educational level that enters the labor force, namely $d\overline{N}$ and $d\overline{E}$. These contributions will be different from observed wages in the unprotected sector (W_N, W_E) and will depend on the additional employment that extra worker induces. This induced employment effect is the result of two sets of forces: First, the extra worker changes the probability of his colleagues of finding a protected job, affecting therefore their expected gains of being unemployed. Second, to the extent there are diminishing returns and factor complementarity or substitutability, that extra worker changes the equilibrium wages of both types of labor. This change has a further employment effect by changing the relative payoff of the unemployment option. The above effects can be summarized as:

$$(21) \quad \frac{dX}{d\overline{N}} = W_N \frac{dN}{d\overline{N}} + W_E \frac{dE}{d\overline{N}}$$

$$(22) \quad \frac{dX}{d\overline{E}} = W_E \frac{dE}{d\overline{E}} + W_N \frac{dN}{d\overline{E}}$$

where $\frac{dN}{d\overline{N}}$ and $\frac{dE}{d\overline{E}}$ are the "own employment effects" of an extra labor of each type and $\frac{dE}{d\overline{N}}$ and $\frac{dN}{d\overline{E}}$ represent their "cross employment effects."

Given that W_E and W_N are observable market data, the evaluation of $\frac{dX}{d\overline{N}}$ and $\frac{dX}{d\overline{E}}$ requires knowledge on the "employment terms" described above.

Substituting (19) into (17) and (20) into (18) and differentiating with respect to $\overline{N}$ and $\overline{E}$ we get the following expression for the "own employment" terms:

$$(23)\quad \frac{dN}{d\bar{N}} = \frac{\beta_N}{\beta_N - 1} \quad \frac{1}{1 - A_N/\eta_{NN}} \left[1 + \frac{A_N A_E/\eta_{NE}\eta_{EN}}{\Delta} \right]$$

$$(24)\quad \frac{dE}{d\bar{E}} = \frac{\beta_E}{\beta_E - 1} \quad \frac{1}{1 - A_E/\eta_{EE}} \left[1 + \frac{A_N A_E/\eta_{NE}\eta_{EN}}{\Delta} \right]$$

where:

$$A_N = \frac{S_N}{N} \frac{(\delta_N + 1)}{a_N} > 0 \qquad A_E = \frac{S_E}{E} \frac{(\delta_E + 1)}{a_E} > 0$$

$a_N,\ a_E > 0$[1]

and

$$\Delta = \left(1 - \frac{A_E}{\eta_{EE}}\right)\left(1 - \frac{A_N}{\eta_{NN}}\right) - \frac{A_E A_N}{\eta_{EN}\eta_{NE}}$$

The parameters η_{EE} and η_{NN} represent the own price elasticity of demand for each type of labor in the unprotected sector; η_{ij} $(i \neq j)$ represents the inverse of the (cross) elasticity of the marginal product of labor i with respect to the employment of labor j. Therefore:

$$(25)\quad \eta_{ii} < 0$$

$$(26)\quad \eta_{ij} \begin{cases} = 0, & \text{both labor factors are independent.} \\ > 0, & \text{both types of labor are complements.} \\ < 0, & \text{both types of labor are substitutes.} \end{cases}$$

---

[1]From the equilibrium condition (5) we can see that a_N and a_E will be positive as long as (r-g) is positive. Such condition characterizes most empirical situations; at the same time it is also a sufficient condition of convergance for the series being used to transform (3) into (4).

Both expressions (23) and (24) are positive if $\Delta > 0$, this condition being fulfilled by any concave production function.[1]

A more intuitive form of examining expressions (23) and (24) is to interpret their terms as:

$$\begin{bmatrix}\text{Total own}\\ \text{employment}\\ \text{effect}\end{bmatrix} = \begin{bmatrix}\text{Probability}\\ \text{effect}\end{bmatrix} \cdot \underbrace{\begin{bmatrix}\text{Own wage}\\ \text{effect}\end{bmatrix} \times \begin{bmatrix}\text{Cross wage}\\ \text{effect}\end{bmatrix}}_{\text{Total wage effect}}$$

The own employment effect consists of three multiplicative effects: (a) A probability effect which is positive and larger than one, i.e., one additional worker in the labor force induces an increase in employment in that type of labor by an amount larger than one. This effect operates because an additional worker in the labor supply increases the number of "protected job searchers" and lowers the probability of getting such a job. The change in the probability induces additional labor into accepting a job in the unprotected sector.

An explanation for this effect can be derived if we assume the "total wage effect," to be absent. This will be true if $\eta_{ii} = \infty$ (additional employment does not drive down the wage rate) and if $\eta_{ij} = \infty$, the productivity of one type of labor is independent of the quantity of the other one. If the total wage effect is absent, additional employment does not affect the equilibrium wage rate in the unprotected sector, i.e., δ (the percentage wage differential) and the value of a remains constant.

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[1] A sufficient condition for $\Delta > 0$ is the following relationship among the second derivatives of the production function:

$F_{EN}^2 \leq F_{EE}F_{NN}$. This condition is fulfilled by any concave production function.

An intuitive explanation of the probability effect can now be derived by examining the employment-unemployment equilibrium conditions (17) and (18). If the value of a remains constant, preservation of the employment-unemployment equilibrium conditions implies that an extra labor must leave the probability P invariant; this also means that S must remain constant in face of a new worker in the labor supply.

By examining as an example the value of $S_N = \beta_N\overline{N} + (1-\beta_N)N$, we can evaluate the required change in employment ΔN which is needed to leave S_N invariant ($\Delta S_N=0$) when $\overline{N}$ changes by $\Delta\overline{N}$.

$$(27) \quad \Delta S_N = \beta_N\Delta\overline{N} + (1-\beta_N)\Delta N = 0$$

$$(28) \quad \frac{\Delta N}{\Delta\overline{N}} = \frac{\beta_N}{\beta_N-1}$$

Therefore, an extra member of the labor supply has to increase employment by a number bigger than one to preserve the employment-unemployment equilibrium condition.

(b) A wage effect that corrects the above probability effect. Such effect can be subdivided into an "own wage effect" and a "cross wage effect."

If η_{ii} is less than infinite, additional employment will drive down the equilibrium wage rate in the unprotected sector; this change increases the incentives to remain unemployed and offsets some of the positive impact of the probability effect. This offsetting effect, that corrects the probability effect, is the one defined as the "own wage effect." The correction factor is always smaller than one and becomes smaller the less elastic is the demand for that type of labor.

The "cross wage effect" is positive and larger than one, i.e., it reinforces the positive contribution of the probability effect. Notice that this corrective factor increases the employment term of labor i, independently of labor i and j being complements or substitutes (the product $\eta_{ij}\eta_{ji}$ is always positive). If both are complements, additional employment of labor i increases the productivity of labor j and therefore the employment of labor j; this increased employment tends to increase the (productivity) wage of labor i and therefore its employment. If they are substitutes, additional employment of i tends to reduce the productivity and employment of labor j. Such a reduction in employment of j increases the (productivity) wage of i and reinforces the employment effect.

Finally it is important to notice that the correction factor represented by the "cross wage effect" is identical for both types of labor.

Let us now explore the cross employment effects $\frac{dE}{dN}$ and $\frac{dN}{dE}$. Differentiating expressions (17) and (18) we obtain:

$$(29) \quad \frac{dE}{dN} = \frac{\beta_N}{\beta_N - 1} \quad \frac{A_E}{\Delta\eta_{EN}} \quad \frac{E}{N} \qquad \begin{matrix} > 0, \text{ complements} \\ < 0, \text{ substitutes} \end{matrix}$$

$$(30) \quad \frac{dN}{dE} \quad \frac{\beta_E}{\beta_E - 1} \quad \frac{A_N}{\Delta\eta_{NE}} \quad \frac{N}{E} \qquad \begin{matrix} > 0, \text{ complements} \\ < 0, \text{ substitutes} \end{matrix}$$

The sign of the cross employment effects depends solely on the sign of η_{ij}, i.e., on both types of labor being complements or substitutes.

The employment effects described above can also be shown graphically by deriving a supply schedule for both types of labor. Let us derive such supply schedule for one type of labor, let us say labor N. (It is symetric with respect to labor E.)

From the behavioral (equilibrium) condition (17) we can solve for N:

$$(31)\quad N^s = \frac{\beta_N(1+g_N)V_N}{(\beta_N-1)(r-g_N)} + \frac{\beta_N}{\beta_N-1}\ \overline{N} - \frac{V_N(1+g_N)\hat{W}_N}{r-g_N}\ \frac{1}{W_N}$$

where N^s must be interpreted as the amount of uneducated laborers willing to accept employment in the unprotected sector at a wage W_N, given the total stock $\overline{N}$ and the protected wage $\hat{W}_N$.[1]

The demand for such labor can be derived from the wage determination equation (12) and can be written as:

$$(32)\quad N^d = N^d(\overline{K}, E, W_N)$$

where $\overline{K}$ is the capital stock and E the level of employment of educated labor.

Figure 1 shows the schedules for N^s and N^d; N^s is drawn given the protected sector wage and the stock of labor $\overline{N}$. N^d is drawn given $\overline{K}$ and E. We can now show the three effects described before determining the change in employment (ΔN) induced by an extra labor entering the labor supply ($\Delta\overline{N}$).

The horizontal shift of the supply curve in face of an additional laborer $\Delta\overline{N}$ is equal to the pure probability effect. Such effect is equal to $\frac{\beta_N}{\beta_N-1}\Delta\overline{N}$, the change in employment that would have taken place had the

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[1]This supply function is defined for the range $0 < W_N < \hat{W}_N$. In the limit we get:

$$\lim_{W_N \to \hat{W}_N} N = \overline{N} \qquad \lim_{W_N \to 0} N = 0$$

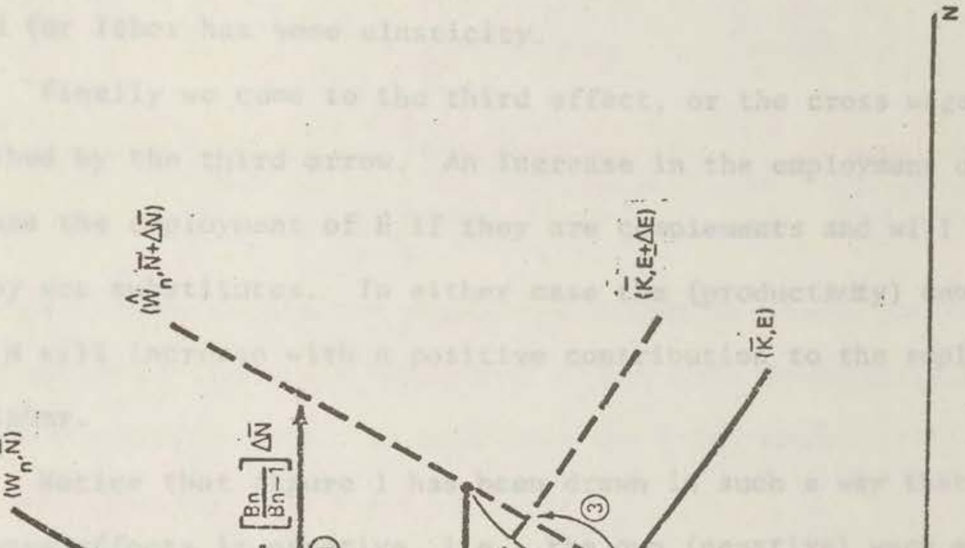

DIAGRAM 1

wage rate remained constant. If the demand for labor is not completely elastic the wage rate W_N will tend to decline having a negative effect on employment. This is the "own wage effect," described by the second arrow. The net result of both effects must increase employment if the demand for labor has some elasticity.

Finally we come to the third effect, or the cross wage effect described by the third arrow. An increase in the employment of N will increase the employment of E if they are complements and will decrease it if they are substitutes. In either case the (productivity) demand for labor N will increase with a positive contribution to the employment of that labor.

Notice that figure 1 has been drawn in such a way that the sum of both wage effects is negative, i.e., the own (negative) wage effect is stronger than the (positive) cross wage effect. This does not have to be necessarily so; if the cross wage effect is larger than the own wage effect the net contribution of the total wage effect would have been positive, reinforcing the positive probability effect.

From the above we can conclude that if the "cross wage effect" is equal to or larger than the "own wage effect" (a zero or positive "total wage effect") an extra worker in the labor force will induce an increase in employment, of that type of labor, more than one laborer.

We want now to explore the sign of the marginal contribution to output of both factors and their relationship to observed wages in the unprotected sector.

Substituting (23), (24), (29) and (30) into (21) and (22) we get:

$$(33) \quad \frac{dX}{d\bar{E}} = \frac{\beta_E}{\beta_E - 1} \frac{1}{\Delta} \left[\left[1 - \frac{A_N}{\eta_{NN}} \right] W_E + \frac{N}{E} \frac{A_N}{\eta_{NE}} W_N \right]$$

$$(34) \quad \frac{dX}{d\bar{N}} = \frac{\beta_N}{\beta_N - 1} \frac{1}{\Delta} \left[\left[1 - \frac{A_E}{\eta_{EE}} \right] W_N + \frac{E}{N} \frac{A_E}{\eta_{EN}} W_E \right]$$

$$= \frac{\beta}{\beta - 1} \frac{1}{\Delta} \left[\text{Contribution of the own employment effect.} + \text{Contribution of the cross employment effect.} \right]$$

The contribution of the own employment effect is always positive. The contribution of the cross employment effect will be positive if the two labor factors are complements. In this case the total contribution is unambiguously positive for both types of labor.

If both factors are (technologically) substitutes the contribution of the cross employment effect is negative. In this case a sufficient condition for a positive total contribution, meaning a dominant (positive) contribution of the own employment effect, is:

$$(35) \quad \frac{F_{NN}}{W_N} < \frac{F_{NE}}{E_E} \qquad \text{for the case of labor E}$$

$$(36) \quad \frac{F_{EE}}{W_E} < \frac{F_{EN}}{W_N} \qquad \text{for the case of labor N}$$

these conditions are fulfilled by any type of one or two stage CES production function among the three factors.

A priori, we cannot speculate whether the true contribution to output of an additional laborer will be larger or smaller than its observed wage in the unprotected sector. However we can predict that the more elastic is the demand for labor, the more complementary the technical relation between both types of labor, the smaller the rate of job openings in the protected sector, the smaller the rate of growth of wages, the larger the rate of discount, the smaller the relative size of the protected sector and the smaller the premium to search, the more likely that the marginal contribution will exceed the observed wage in the unprotected sector.

V. Empirical Evaluation and Conclusions

1. A simplified case

For the purposes of simplicity (and because of lack of information) we will proceed with the assumption that $F_{NE} = 0$. Such an assumption can be consistent with two types of descriptions of the unprotected sector: One where, although N and E enter the same production function, both types of labor are technologically independent. A second description is that the unprotected sector consists of two subsectors: One employing capital and educated labor and the other capital and uneducated labor.

From expressions (33) and (34) we observe that if both types of labor are in fact substitutes from a technological point of view ($\eta_{NE}<0$), then this assumption ($\eta_{NE}=0$) will tend to bias our results upwards. On the other hand, if both types of labor are complements from a technological point of view ($\eta_{NE}>0$), then this assumption ($\eta_{NE}=0$) will tend to bias our results downwards. The notion of capital and an aggregate labor input entering the production function ($Y = F[K, L(N,E)]$) tends to support the notion of both labor inputs being substitutes. If the real world is characterized by this kind of production function specification, then our results will overestimate the true contribution of both types of labor.[1]

Under this assumption, the "employment terms" become:

$$(37)\quad \frac{dN}{d\bar{N}} = \frac{\beta_N}{(\beta_N-1)} \frac{1}{1-\frac{A_N}{\eta_{NN}}}$$

$$(38)\quad \frac{dE}{d\bar{E}} = \frac{\beta_E}{(\beta_E-1)} \frac{1}{1-\frac{A_E}{\eta_{EE}}}$$

Recalling expressions (29) and (30) we observe that given the assumption of technological independence between the two factors, the cross employment effects vanish $\left(\frac{dE}{d\bar{N}} = \frac{dN}{d\bar{E}} = 0\right)$. Therefore we can write (33) and (34), the marginal contribution to output as:

$$(39)\quad \frac{dX}{d\bar{N}} = \frac{\beta_N}{(\beta_N-1)} \frac{1}{1-\frac{A_N}{\eta_{NN}}} W_N$$

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[1]An alternative specification of the production function, considering capital and educated labor as one input entering the production function and uneducated labor as the other (Y = F[Q(K,E),N]) tends to support the complementary notion. In this case, our results will underestimate the true contribution of both types of labor.

$$(40) \quad \frac{dX}{d\bar{E}} = \frac{\beta_E}{(\beta_E-1)} \quad \frac{1}{1-\frac{A_E}{\eta_{EE}}} \quad W_E$$

We observe that the pure probability effect is greater than one but it is multiplied by a corrective factor (the own "wage effect") smaller than one. Hence we cannot say a priori whether the marginal contributions will be greater or smaller than the corresponding observed wages in the unprotected sector.

Before proceeding to the evaluation of these last two expressions we must assure the consistency of the parameters to be used. Recall that the general equilibrium condition, expression (5), can be written as:

$$(41) \quad P\ [(\beta-1)(1+g)\delta - (1+g)] = (r-g)$$

Arbitrarily choosing labor E and substituting for P_E we get:

$$(42) \quad \frac{e\lambda_E}{(\beta_E-1)\mu_E+1} \quad ((\beta_E-1)(1+g_E)\delta_F - (1+g_E)) = (r-g_E)$$

where:

$$(43) \quad e = \frac{E_P}{\bar{E}}$$ relative employment of educated workers in the protected sector.

$$(44) \quad \mu_E = \frac{E_U}{\bar{E}}$$ unemployment of educated workers as a fraction of the labor force--of that type of labor--outside the protected sector.

$$(45) \quad \lambda_E = \frac{V_E}{E_P}$$ vacancies as a fraction of employment of the educated laborers in the protected sector, i.e., the rate of openings.

We can observe e, μ_E and δ_E and have a pretty good notion of the values of λ_E, g_E and r. In order to assure that the equilibrium condition (42) holds, β_E must be endogenously determined as a residual parameter, i.e., the implicit search premium consistent with observable data if the world behave like the model. For this purpose we can write:

$$(46)\quad (\beta_E - 1) = \frac{e\lambda_E(1+g_E) + (r-g_E)}{e\lambda_E(1+g_E)\delta_E - (r-g_E)\mu_E}$$

The value of β_E so determined, automatically assures the consistency of the model and will be the value used in our estimates of expressions (39) and (40). Obviously this implies the same exercise must be undertaken for labor N. If we were to arbitrarily assign a value to β_E we could predict equilibrium unemployment levels. We are doing just the opposite since β_E is an unobservable parameter.

2. <u>The urban labor market in Asuncion, Paraguay</u>

The standard employment survey used in most LDC's does not collect the kind of information needed for an empirical evaluation of the theoretical framework presented above. Fortunately, there is an unorthodox study undertaken by Prealc in Asuncion, Paraguay that provides us with most of the necessary information for this task.[1] This information consists basically of:

[1]See Situacion y Perpectivas de Empleo en Paraguay. P.R.E.A.L.C. International Labor Office 1975.

(a) The employment in the protected sector relatively to the total labor force outside that sector, $L_P/\overline{L}$. We define this ratio as the "relative size of the protected sector."

(b) The employment of educated workers in the protected sector relative to the amount of educated workers outside that sector, namely e. The value of e can be written, given $L_P/\overline{L}$, as a function of the "relative educational intensity" of the protected sector:

$$(47)\quad e = \frac{E_P}{\overline{E}} = \frac{L_P}{\overline{L}} \quad \frac{(E_P/L_P)}{(\overline{E}/\overline{L})}$$

correspondingly we can define n as:

$$(48)\quad n = \frac{N_P}{\overline{N}} = \frac{L_P}{\overline{L}} \quad \frac{1-(E_P/L_P)}{1-(\overline{E}/\overline{L})}$$

(c) The rate of "voluntary" unemployment defined as a fraction of the labor force outside the protected sector namely:

$$(49)\quad \mu_E = \frac{E_U}{\overline{E}} = \mu_E^{'}(1+e)$$

$$(50)\quad \mu_N = \frac{N_U}{\overline{N}} = \mu_N^{'}(1+n)$$

where $\mu_E^{'}$ and $\mu_N^{'}$ represent the rate defined with respect to the total labor force.[1]

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[1]If we assume a rate of seasonal and frictional unemployment of μ^* we can rewrite (49) and (50) as:

$$(49)\quad \mu_E = (1+e)\,(\mu_E^{'} - \mu^*) \qquad (50)\quad \mu_N = (1+n)\,(\mu_N^{'} - \mu^*)$$

Where the rates of voluntary unemployment are expressed in function of the observed rate and the one that can be attributed to seasonal and frictional unemployment.

(d) The percentage wage differentials between the two sectors for both types of labor: δ_E, δ_N.

(e) The rate of growth of real wages for both types of labor: g_E, g_N.

(f) The number of vacancies in the protected sector as a percentage of its labor force: λ_E, λ_N.

(g) The own price demand elasticities for both types of labor: η_{EE}, η_{NN}.

(h) The rate of discount: r.

From "Situacion y Perpectivas de Empleo en Paraguay," (P.R.E.A.L.C., I.L.O. 1975) we can obtain the following information: The informal or unprotected sector in Asuncion represents approximately 57 percent of total employment. The protected sector represents 43 percent of total employment (17 percent, the government plus 26 percent, the private formal sector). The unemployment rate is 12 percent in Asuncion. The average unemployment rate for the country is 6 percent. Table (2) presents the educational distribution of the labor force according to its employment status. Using the information from Table (2) plus the rate of unemployment and the education distribution of the labor force by sectors, we can derive Table (3) which shows this educational distribution but includes the unemployed as a separate sector. Using Tables (2) and (3) we can derive Table (4) which shows the educational distribution of the labor force by sectors as a percentage of the total labor force. From Table (4) we can obtain values for the relative educational intensity of the protected sector which together with the relative size of

TABLE 2

ASUNCION: EDUCATIONAL DISTRIBUTION OF THE LABOR FORCE

ACCORDING TO EMPLOYMENT STATUS (PERCENTAGES)

Employment Status	Years of Schooling				Total
	0-3	4-6	7-12	13 or more	
Active	16	36	36	12	100
Employed	16	36	35	13	100
Unemployed	15	36	43	6	100
Population at working age	17	38	36	9	100

SOURCE: Situacion y Perpectivas del Empleo en Paraguay. P.R.E. A.L.C. International Labor Office 1975. Active population differs from population at working age because the former is either employed or actively looking for employment.

TABLE 3

ASUNCION: EDUCATIONAL DISTRIBUTION OF THE LABOR

FORCE CLASSIFIED BY SECTORS (PERCENTAGES)

Years of Schooling	Informal Sector	Formal Sector	Unemployed	Total
0-3	69.2	19.5	11.3	100
4-6	60.7	27.3	12.0	100
7-12	36.0	49.7	14.3	100
13 or more	22.6	71.4	6.0	100

SOURCE: Elaborations from PREALC: Encuesta Experimental de mano de obra en Asuncion Mayo 1973 and Situacion y perpectivas de empleo en Paraguay. P.R.E.A.L.C. (1975).

TABLE 4

ASUNCION: EDUCATIONAL STRUCTURE OF THE LABOR FORCE BY SECTORS (AS A PERCENTAGE OF THE TOTAL LABOR FORCE)

Years of Schooling	Informal Sector	Unemployed	Informal and Unemployed Sector	Formal Sector
0 - 3	11.1	1.8	12.9	3.1
4 - 6	21.8	4.3	26.1	9.8
0 - 6	32.9	6.1	39.0	12.9
7 - 12	13.0	5.1	18.1	17.9
13 or more	2.7	0.8	3.5	8.6
7 or more	15.7	5.9	21.6	26.5
Total	48.6	12.0	60.6	39.4

SOURCE: Tables (2) and (3).

this sector provides values for the parameters e and η. Recalling expressions (47) and (48) we obtain:

$$(51) \quad e = 0.65 \frac{0.67}{0.36} = 1.2$$

$$(52) \quad \eta = 0.65 \frac{(1-0.67)}{(1-0.36)} = 0.34$$

The unemployment rate in Asuncion is 12 percent for both types of labor. If we assume that half of it is not voluntary but rather frictional or seasonal unemployment then, recalling expressions (49) and (50) we can obtain values for the relevant unemployment rates defined in the text.

$$(53) \quad u_E = 2.2[0.12-0.06] = 0.132$$

$$(54) \quad u_N = 1.34[0.12-0.06] = 0.080$$

Table 5 presents the average weekly earnings of workers classified by schooling and sectors in Asuncion. From Table 5 we can obtain values for the percentage wage differentials:

$$(55) \quad \delta_E = 1.0$$

$$(56) \quad \delta_N = 1.08$$

The average rate of growth of real wages in Latin America is approximately 3 percent. (See Table 6.) Unfortunately, we lack this information for the urban sector in Paraguay. However, we know that the rate of growth of urban real per capita income in Paraguay between 1962 and 1971 was 2.3 percent.[1] This figure does not represent exactly the trend

[1]See Banco Central del Paraguay. Cuentas Naciona les 1962-1972. Direccion General de Estadistica y Censo. Censos de Poblacion 1962 y 1972.

TABLE 5

ASUNCION: AVERAGE WEEKLY EARNINGS OF WORKERS CLASSIFIED BY SCHOOLING AND SECTORS (GUARANIES 1973)

Years of Schooling	Informal Sector	Formal Sector
0-3	980	2295
4-6	1396	2713[1]
0-6	1255[2]	2615[2]
7-12	2389	3608
13 or more	4798	9797[1]
7 or more	2803[2]	5617[2]

SOURCE; PREALC: Encuesta Experimental de Mano de obra en Asuncion 1973.

[1]Does not include government due to lack of information.

[2]Weighted average of the two groups.

in real wages since it is affected by an increasing rural-urban migration that results in an increasing volume of unemployment. On the other hand, due to changing relative endowments, wages for uneducated labor are expected to grow faster than those for educated labor. Considering these facts, two sets of values for wages growth rates will be used:

i) $g_E = 0.025$ ii) $g_E = 0.0275$

$g_N = 0.030$ $g_N = 0.0325$

The results will prove to be extremely insensitive to small changes in these values. The rate of growth of output in those sectors most

TABLE 6

RATE OF GROWTH OF REAL WAGES IN SOME DEVELOPING COUNTRIES

Country	1956-1964	1964-1972	1956-1972
Group I (Latin America)			
Chile	1.5	7.7	4.6
Colombia	7.4	1.2	4.7
Peru	1.8	6.3	4.1
Ecuador	1.6	6.6	4.1
Mexico	5.5	2.0	3.8
Dom. Rep.	9.0	-2.6	3.6
Brazil	1.4	4.1	2.3
Guatemala	1.9	1.6	1.8
Argentina	1.5	-0.6	0.5
Uruguay	-	-4.3	-
Venezuela	-	2.7	-
Mean			3.2
Standard Deviation			(1.3)
Group II (Others)			
Tanzania	12.5	4.4	9.4
Zambia	8.3	4.6	6.5
Korea	3.5	6.8	4.2
Taiwan	2.8	3.8	3.2
Ghana	1.7	1.0	1.4
Pakistan	2.2	-0.7	1.0
India	-1.8	-0.7	-1.3
Philippines	-2.0	-0.8	-1.4

SOURCE: Webb, R. (1974). He used the following sources: 1) 1956-1964 Smith, A.D. (ed.): Wage Policy Issues in Economic Development. London: MacMillan. 2) 1964-1972 from International Labor Organization Yearbook of Labor Statistics, and United Nations Growth of World Industry and Bruton, H. Industrialization Policy and Income Distribution. 3) For Taiwan from Griffin, K. (1973) An Assessment of Development in Taiwan, World Development Vol. 1, N. 6. For Chile, French Davis, R. (1973) Politicas Economicas En Chile 1952-1970, Santiago-Ceplan.

identified with the protected sector for the period 1962-1972 ranges from 5.4 to 6.4 percent.[1] Those figures do not represent the rate of growth of employment in these sectors which normally trails the rate of growth of output. On the other hand, λ, the rate of vacancy openings in the protected sector includes not only the net rate of growth of employment but also the retirement and rotation rates. Given the above considerations two values will be used for this rate of openings

i) $\lambda = 0.05$ ii) $\lambda = 0.07$

Following most of the empirical studies in LDC's a 10 percent rate of discount will be used.

Finally, we need to obtain values for the demand price elasticity for each type of labor. In the absence of information on these parameters, we present a series of estimates based on a wide range of reasonable demand elasticity values. Although the quantitative results vary with different elasticity values the qualitative results prove insensitive to these values.

Table (7) presents the implicit values of β consistent with the "observable" parameters being used. They show the required increase in the probability of finding a protected job, by being unemployed and investing fully in search, that would generate a rate of voluntary

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[1]According to Banco Central del Paraguay, Cuentas Nacionales the average rate of growth for this period was mining, industry and constructon 5.5 percent; electricity, water supply and other public utilities, transport and communications 6.4 percent; banking and government 5.4 percent.

TABLE 7

VALUES OF β CONSISTENT WITH OBSERVED PARAMETERS

(δ_E=1; δ_N=1.08; u_E=0.132; u_N=0.084; e=1.2; η=0.34; r=0.10)

	g_E = 0.025 g_N = 0.030	g_E = 0.0275 g_N = 0.0325
λ = 0.05	β_E = 3.6 β_N = 7.6	β_E = 3.6 β_N = 7.4
λ = 0.07	β_E = 3.1 β_N = 5.6	β_E = 3.1 β_N = 5.4

unemployment equal to the observed rate. The values of β are larger the smaller the value of λ. β must be larger so as to induce a given rate of voluntary unemployment in spite of a smaller number of openings in the protected sector. Tables (8) and (9) show the marginal contribution of educated and uneducated labor in terms of their respective observed free entry sector wages. Table (10) shows the relative marginal contribution of educated and uneducated labor in terms of their observed free entry sector relative wages.

3. Conclusions

Given the results presented in Tables (8) and (9), we can derive the following conclusions. First, the relationship between the true social marginal contributions of educated and uneducated labor and their respective free entry sector wages is highly sensitive to the demand elasticity

TABLE 8

MARGINAL CONTRIBUTION OF EDUCATED LABOR IN TERMS OF ITS FREE SECTOR WAGE

(δ_E=1; δ_N=1.08; u_E=0.132; u_N=0.08; e=1.2; n=0.34; r=0.10)

Labor Demand Elasticity	Protected Sector Rate of Openings	g_E = 0.025 g_N = 0.030	g_E = 0.0275 g_N = 0.0325
η_{EE} = -1.0	λ = 0.05	0.48 W_E	0.047 W_E
	λ = 0.07	0.40 W_E	0.40 W_E
η_{EE} = -2.0	λ = 0.05	0.71 W_E	0.70 W_E
	λ = 0.07	0.63 W_E	0.63 W_E
η_{EE} = -3.0	λ = 0.05	0.85 W_E	0.84 W_E
	λ = 0.07	0.78 W_E	0.78 W_E
η_{EE} = -4.0	λ = 0.05	0.94 W_E	0.93 W_E
	λ = 0.07	0.89 W_E	0.88 W_E
η_{EE} = -5.0	λ = 0.05	1.0 W_E	1.0 W_E
	λ = 0.07	0.96 W_E	0.96 W_E
η_{EE} = -5.5	λ = 0.05	1.03 W_E	1.02 W_E
	λ 0.07	1.0 W_E	1.0 W_E
η_{EE} = -6	λ = 0.05	1.05 W_E	1.05 W_E
	λ = 0.07	1.02 W_E	1.02 W_E
η_{EE} = $-\infty$	λ = 0.05	1.38 W_E	1.39 W_E
	λ = 0.07	1.47 W_E	1.48 W_E

TABLE 9

MARGINAL CONTRIBUTION OF UNEDUCATED LABOR IN TERMS OF ITS FREE ENTRY SECTOR WAGE

(δ_E=1; δ_N=1.08; u_E=0.132; u_N=0.084; e=1.2; n=0.34; r=0.10)

Labor Demand Elasticity	Protected Sector Rate of Openings	g_E = 0.025 g_N = 0.030	g_E = 0.0275 g_N = 0.0325
η_{NN} = -1.0	λ = 0.05	0.73 W_N	0.73 W_N
	λ = 0.07	0.68 W_N	0.67 W_N
η_{NN} = -2.0	λ = 0.05	0.90 W_N	0.89 W_N
	λ = 0.07	0.87 W_N	0.87 W_N
η_{NN} = -3.0	λ = 0.05	0.97 W_N	0.97 W_N
	λ = 0.07	0.96 W_N	0.96 W_N
η_{NN} = -3.5	λ = 0.05	0.99 W_N	0.99 W_N
	λ = 0.07	0.99 W_N	0.99 W_N
η_{NN} = -4.0	λ = 0.05	1.0 W_N	1.0 W_N
	λ = 0.07	1.02 W_N	1.02 W_N
η_{NN} = -5.0	λ = 0.05	1.03 W_N	1.03 W_N
	λ = 0.07	1.05 W_N	1.05 W_N
η_{NN} = -6	λ = 0.05	1.05 W_N	1.05 W_N
	λ = 0.07	1.08 W_N	1.08 W_N
η_{NN} = $-\infty$	λ = 0.05	1.15 W_N	1.16 W_N
	λ = 0.07	1.22 W_N	1.23 W_N

TABLE 10

RELATIVE MARGINAL CONTRIBUTION OF EDUCATED AND UNEDUCATED LABOR IN TERMS OF THEIR RELATIVE FREE ENTRY SECTOR WAGES

(δ_E=1.0; δ_N=1.08; u_E=0.132; u_N=0.084; e=1.2; n=0.34; r=0.10)

Labor Demand Elasticity	Protected Sector Rate of Openings	g_E = 0.025 g_N = 0.030	g_E = 0.0275 g_N = 0.0325
η = -1.0	λ = 0.05	0.66 W_E/W_N	0.64 W_E/W_N
	λ = 0.07	0.59 W_E/W_N	0.60 W_E/W_N
η = -2.0	λ = 0.05	0.79 W_E/W_N	0.79 W_E/W_N
	λ = 0.07	0.72 W_E/W_N	0.72 W_E/W_N
η = -3.0	λ = 0.05	0.88 W_E/W_N	0.87 W_E/W_N
	λ = 0.07	0.81 W_E/W_N	0.81 W_E/W_N
η = -4.0	λ = 0.05	0.94 W_E/W_N	0.93 W_E/W_N
	λ = 0.07	0.87 W_E/W_N	0.86 W_E/W_N
η = -5.0	λ = 0.05	0.97 W_E/W_N	0.97 W_E/W_N
	λ = 0.07	0.91 W_E/W_N	0.91 W_E/W_N
η = -6.0	λ = 0.05	1.0 W_E/W_N	1.0 W_E/W_N
	λ = 0.07	0.95 W_E/W_N	0.99 W_E/W_N
η = -8.0	λ = 0.05	1.05 W_E/W_N	1.04 W_E/W_N
	λ = 0.07	1.0 W_E/W_N	0.99 W_E/W_N
η = -8.5	λ = 0.05	1.05 W_E/W_N	1.05 W_E/W_N
	λ = 0.07	1.01 W_E/W_N	1.0 W_E/W_N
η = $-\infty$	λ = 0.05	1.20 W_E/W_N	1.20 W_E/W_N
	λ = 0.07	1.20 W_E/W_N	1.20 W_E/W_N

for labor but relatively insensitive to reasonable changes in the values of the other parameters (g, λ). This means that, having selected the demand elasticity for labor, the corrective factors that must be applied to the free entry wages in order to derive the social contributions of educated an uneducated labor, is relatively constant across different reasonable combinations of the other parameters (g, λ). Second, the corrective factor is smaller than one for demand elasticities smaller than 5 for educated labor, and 4 for uneducated labor. This means that within that elasticity range the observed free entry sector wages over-estimate the true social marginal contributions of educated and uneducated labor. The overestimation involved is consistently larger for educated than for uneducated labor. For elasticities between 1 and 5, the corrective factor for educated labor ranges approximately from one half to one. For uneducated labor, it ranges approximately from two-thirds to one.

The basic magnitude determining the profitability of investments in education is the relative marginal contributions of educated and non-educated labor. Table (10) presents the relationship between the true relative contributions of educated and uneducated labor and their relative free entry sector wages. The corrective factor is smaller than one for elasticity values between 1 and 8. It ranges approximately from two-thirds to one. This implies that, within that elasticity range, the free entry sector relative wages for educated and non-educated labor overestimates the true benefits of investments in education.

Summarizing our conclusions, for a wide range of elasticity values, the wages in the free entry sector overestimate the true social marginal contributions of educated and uneducated labor. Furthermore, the relative wages in that sector also overestimate the true social benefits of investments in education. The more rigid the demand for labor, the larger the errors involved.

REFERENCES

Berg, E. (1970) "Wages, Policy and Employment in Less Developed Countries." Paper presented to the conference on prospects for employment opportunities in the nineteen seventies. Univeristy of Cambridge.

Eaton, C. and Neher, P. (1975) "Unemployment, Under Employment, and Optimal Job Search." Journal of Political Economy (April): pp. 355-375.

Fields, G. (1975) "Rural-Urban Migration, Urban Unemployment and Under-Employment, and Job-Search Activity in LDC's." Journal of Development Economics 2: pp. 165-187.

Frank, C. (1968) "Urban Unemployment and Economic Growth in Africa." Paper N. 120, Yale Economic Growth Center: pp. 262-265.

Gronau, R. (1971) "Information and Frictional Unemployment." American Economic Review (June): pp. 290-301.

Hall, R. (1975) "The Rigidity of Wages and the Persistence of Unemployment." Department of Economics, M.I.T., prepared for the Brookings Panel on Economic Activity.

Harberger, A. (1971) "On measuring the social opportunity Cost of Labor." International Labor Review 130, N. 6: pp. 559-579.

Harris, J. and Sabot, R. (1976) "Urban Unemployment in LDC's: Toward A More General Search Model." Employment and Rural Development Division. Development Economics Department. World Bank.

_______, and Todaro, M. (1970) "Migration, Unemployment and Development: A Two Sector Analysis." American Economic Review 60: pp. 126-143.

Herrick, B. (1974) "Urban Self Employment and Changing Expectations As Influences on Urban Migration." Department of Economics, University of California, Los Angeles.

Holt, C. (1970) "Job Search, Phillips Wage Relation and Union Influence: Theory and Evidence." In Phelps, E., et.al., Microeconomics Foundation of Employment and Inflation Theory. New York, Norton.

Isbister, J. (1971) "Urban Wages and Employment in a Developing Economy: The Case of Mexico." Economic Development and Cultural Change (October), pp. 24-46.

Johnson, G. (1971) "The Structure of Rural Urban Migration Models." Eastern Africa Economic Review (June): pp. 21-28.

Kilby, P. (1967) "Industrial Relations and Wage Determination: Failure of the Anglo-Sazon Model." J.D.A. I: pp. 489-520.

Knight, J. (1967) "The Determination of Wages and Salaries in Uganda." Bulletin of Oxford Institue of Economics and Statistics Vol. 19: p. 250.

Kohn, M. and Shavell, S. (1974) "The Theory of Search." Journal of Economic Theory 9: pp. 93-123.

Kritz, E. and Ramos J. "Measures of Urban Underemployment: A Report on 3 Experimental Surveys." To be published in The International Labor Review.

Layard, R. and Psacharopoulos, G. (1974) "The Screening Hypothesis and the Returns to Education." Journal of Political Economy 82: pp. 985-988.

Leibenstein, H. (1957) Economic Backwardness and Economic Growth. Wiley and Sons, New York.

Lucas, R. and Prescott, E. (1974) "Equilibrium Search and Unemployment." Journal of Economic Theory (February): pp. 188-209.

Mazumdar, D. (1974) "The Theory of Urban Underemployment in Less Developed Countries." Employment and Rural Development Department, World Bank.

McCall, J. (1970) "Economics of Information and Job Search." Quarterly Journal of Economics 84: pp. 113-126.

Mortensen, D. (1970) "Job Search, The Duration of Unemployment, and the Phillips Curve." American Economic Review 60: p. 847-862.

Phelps, E. (1970) Microeconomic Foundations of Employment and Inflation Theory. New York, W.W. Norton and Co.

Ramos, J. (1970) Labor and Development in Latin America. New York, Columbia University Press.

Sabot, R. (1975) "The Meaning and Measurement of Urban Surplus Labor." Economics Department, I.B.R.D.

Stigler, G. (1962) "The Economics of Information." Journal of Political Economy 69: pp. 312 325.

Stiglitz, J. (1969) "Rural-Urban Migration, Surplus Labour, and the Relationship between Urban and Rural Wages," Eastern Africa Economic Review 1, No. 2: pp. 1-27.

_______. (1974) "Alternative Theories of Wage Determination and Unemployment in LDC's: The Labor Turnover Model." Quarterly Journal of Economics (May): pp. 194-227.

________. (1976) "The Structure of Labor Markets and Shadow Prices in LDC's." Employment and Rural Development Division. I.B.R.D.

Stoikov, V. (1975) "Job Search Models and Frictional Unemployment." Cornell University.

Todaro, M. (1968) "An Analysis of Industrialization, Employment and Unemployment in Less Developed Countries." Yale Economic Essays (Fall).

________. (1969) "A Model of Labor Migration and Urban Unemployment in Less Developed Countries." American Economic Review 59: pp. 138-148.

________. (1971) "Education and Rural Urban Migration: Theoretical Constructs and Empirical Evidence from Kenya," Paper prepared for a conference on urban unemployment in Africa. Institute for Development Studies, University of Sussex.

Turner, H. and Jackson, D. (1970) "On the Determination of the General Wage Level: A World Analysis; or Unlimited Labor Forever." Economic Journal (December): pp. 827-849.

Turnham, D. (1974) "The Employment Problem in Less Developed Countries: A Review of Evidence." O.E.C.D.

Webb, R. (1974) "Wage Policy and Income Distribution in Developing Countries." Prepared for the Princeton, Brookings Income Distribution Study. Woodrow Wilson School, Princeton University.

Zarembka, P. (1972) Toward A Theory of Economic Development. San Franciso, Holden-Day.

ESSAY II

MINIMUM WAGE, LABOR MARKET SEGMENTATION, THE EARNINGS FUNCTION AND THE SOCIAL RETURNS TO EDUCATION

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MINIMUM WAGE, LABOR MARKET SEGMENTATION, THE EARNINGS FUNCTION AND THE SOCIAL RETURNS TO EDUCATION

I. Introduction

Estimates of earnings or wage generating functions using earnings as regressand and schooling, experience, age and other background variables as regressors, has become a popular tool in the analysis of wage differentials, discrimination and personal income distribution.[1]

The coefficient of the schooling variable in such functions can be interpreted as the expected increase in earnings due to an additional year of schooling. In several studies dealing with the returns to investment in education, many of them undertaken in less developed countries (LDC's), this coefficient has also been explicitly or implicitly interpreted as an estimate of the contribution of marginal schooling to the economy and therefore used to assess the social return to investment in education.[2]

One problem arising from the use of the schooling coefficient to assess the returns to investment in education, which has been fully explored in the literature is that it may be subject to bias due to the exclusion from the regression of other variables having an independent

[1]See for example, Mincer (1957), (1958), (1970); Griliches (1970), (1975); Corbo (1974); Welch (1971).

[2]See for example, Carnoy (1967); Schultz (1968); Thias and Carnoy (1969); Blaugh (1971); Sorkin (1974). A good summary of many of these studies is presented in Psacharopoulos (1973).

impact on earnings and correlated with schooling. These variables include ability, quality of schooling, different student motivation, different parental educational levels, different family environments and other background variables.[1] If these variables have a positive independent impact on earnings and are positively correlated with schooling, then the schooling coefficient will be biased upward. The literature on the economics of education has fully recognized these possible sources of bias. Consequently, observed earnings differentials have been reduced by an adjustment factor that has become known in the literature as the alpha coefficient. This coefficient shows the proportion of earnings differentials that should be attributed to education alone. An exhaustive review of the methodologies used for the estimation of the alpha coefficient as well as the evidence of its empirical values is presented in Psacharopoulos, G. (1975),: "The overall average value of alpha is equal to 0.77. In other words, regardless of the level of education or the ability plus other factors distinction, education is responsible for over three quarters of observed earnings differentials" (Psacharopoulos (1975), p. 54).

Some studies have used earnings differentials by levels of schooling, corrected to reflect pre tax earnings, as a measure of the social benefits of education. However, this methodology is subject to the same pitfalls analyzed in this paper in the context of the schooling coefficient of the earnings generating function.

[1]See for example, Wolfe and Smith (1956); Becker (1964a); Duncan, Featherman, and Duncan (1968); Weisbrod and Scalon (1970); Griliches (1970); Hause (1971); Griliches and Mason (1972); Hause (1972); Taubman and Wales (1973); Griliches (1975).

This paper explores another question: To what extent the interpretation of the schooling coefficient as a measure of the marginal contribution of education to the economy is correct when the data used to generate those estimates arise from segmented labor markets? Segmentation is defined as the coexistance in an urban economy of a protected sector where a minimum wage legislation is being enforced with an unprotected sector where this legislation cannot be enforced. Two problems distinctive in nature arise under this framework. First, an econometric bias in the measurement of the schooling coefficient. Second, a structural bias due to a mis-specification of the underlying labor market structure and the impact that additional schooling has on the allocation of labor between the two sectors. The net impact of these two sources of errors is shown to depend on: (a) the relative education of those benefiting from the minimum wage legislation vis a vis those who don't; (b) the variance of the educational levels of these two groups; and (c) the factors determining the probability of entering the protected sector earning the minimum wage.

Section II describes the nature and causes of the segmentation phenomenon and presents a technological framework. Section III analyzes the econometric bias involved in such a framework. Section IV explores the relationship between the true schooling coefficient and the true contribution of education to the economy, given the nature of the segmentation phenomenon. Section V describes different employer's attitudes or behaviors toward excess education and analyzes their implications for the biases mentioned above. Section VI attempts an empirical evaluation for the urban economies of two Latin American countries: Chile and Mexico. Finally, section VII summarizes the conclusions.

II. The Minimum Wage and the Technological Framework.

In most less developed countries (LDC's), the government plays a central role in the determination of the level and structure of wages. Its influence is directly felt when decisions on wages of government employees are involved, and indirectly when it imposes different wage policies for the private sector.[1] However, the labor market structure characterizing most of these countries imposes a substantial constraint on the effectiveness of government wage policies.

The effectiveness of these policies is significantly limited by a) the relatively large self employment component of the labor force which for many countries exceeds half of the active population, and b) the size of the modern sector relative to the entire wage earning sector. The reason for the first factor is obvious. Since self employed are not wage earners, they are not directly affected by wage policies. The reason for the second is less evident. The capacity to enforce minimum wage policies is positively correlated with the relative size of the modern sector because this sector is normally composed of large firms. The capacity to enforce minimum wage policies rises dramatically with the size of the firm for two reasons: first, because large firms are more visible and more accessible; and second, because there exists a frequent legal discrimination between large and small firms with respect to unionization. Unionization tends to facilitate enforcement and is usually legally restricted to firms exceeding a minimum size.

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[1]See, for example, Berg (1969), (1970); Turner and Jackson, (1970); Frank (1968); Ramos, (1970); Isbister, (1971).

In an excellent survey paper, Webb, R. (1974) concluded that: "Discriminatory enforcement has two components: one is indeed a departure from the announced or legislated policy intent that can be explained in part as an administrative failure, but mostly as an accomodation to differential feasibility of enforcement.... A second, and perhaps major component of discriminatory enforcement...is rather a deliberate administrative expression of a wage policy that wishes to give due allowance to the capacity to pay. In other words, to a large extent, enforcement is not intended for much of the small scale and rural sector, despite the all-embracing language of legislation" (Webb, R. (1974), p. 20). This provides a third reason for stronger enforcement of minimum wages in the modern sector which is characterized by a larger surplus per worker[1] and therefore, by a greater capacity to pay.

The literature on minimum wage policies contains some attempts to assess the impact of minimum wages and their coverage in LDC's. It appears to be very significant in some African countries where the minimum wage is the effective wage for more than one half of the workers.[2] On the other hand, there is some evidence that the impact of minimum wages in Latin America is limited to a smaller number of workers in the modern sector. A large proportion of wage earners in these countries are earning less than the minimum wage. A recent study undertaken by the Mexican government shows that the number of workers earning less than the minimum wage

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[1] Webb also argues that market distortions create lesser tension in the modern sector. This fact facilitates enforcement in this sector.

[2] See, Berg (1969).

exceeds 25 percent of the total in thirteen out of the twenty cities which have more than 200,000 inhabitants. This figure was equal to 35 percent for Mexico City.[1] Similar results can be obtained from survey evidence for Peru and other countries.[2] Table 1 presents the orders of magnitude for some variables discussed in the text for selected developing countries. In general there appears to be a consensus among economists dealing with wage policies in LDC's that any wage policy including a minimum wage policy that attempts a significant departure from market clearing wages, can normally be enforced only in a particular sector of the urban economy. This sector can be called the modern, formal, or protected sector.

Given the framework discussed above, let us assume that we observe an urban economy where there is a minimum wage legislation that can only be implemented in a particular sector of that economy. We define this sector as the protected sector of that economy. Therefore, the protected sector is defined by those characteristics that permit minimum wage legislation to be implemented.[3] The urban economy in most LDC's can be more

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[1]See, Grupo de Estudio del problema del Emleo: El Problema Occupacional en Mexico, Magnitud y Recomendaciones. Version preliminar. Mexico 1973.

[2]Unpublished tabulations of 1969 national sample survey.

[3]An important aspect to consider is related to the leverage effect of minimum wages. To what extent will a minimum wage in the protected sector also raise the wages of those workers for whom it is not binding in order to maintain relative or absolute wage differentials constant within the sector or satisfy union requirements? In this case, both sectors would have a completely different earnings function. There is some evidence that this might be the case in some Latin American cities like Buenos Aires, Rio de Janeiro, Mexico City and Caracas (See Calabi, S., Lima, R., Uthoff, A., and Zaghen, P. (1974) and Singapore (See Pang Eng Fong., and Liu Pak Wai (1975).

Table 1

STRUCTURE OF THE LABOR FORCE IN SOME DEVELOPING COUNTRIES (AS A PERCENTAGE OF THE TOTAL LABOR FORCE)

Country	Census Year (1)	Total Employees (2)	Non-Farm Employ. (3)	Urban Self Empl. $(4)=(1-(2)\frac{(3)}{(4)})$	Urban Labor Force (5)=(3)+(4)	Modern Sect. Empl. (7)	Trad. Sect. Labor Force (8)=(5)-(7)	$\frac{MSE}{NFE}$ $(9)=\frac{(7)}{(3)}$	$\frac{MSE}{ULF}$ $(10)=\frac{(7)}{(5)}$
Group I (Latin America)									
Chile	1960	73	54	20	74	27	47	0.500	0.365
Colombia	1964	57	37	28	65	18	47	0.486	0.277
Panama	1960	48	40	43	83	21	62	0.525	0.253
Peru	1961	48	32	35	67	18	49	0.562	0.269
Venezuela	1961	61	50	32	82	28	54	0.560	0.342
Mean									
Standard Deviation								0.526 (0.03)	0.301 (0.04)
Group II (Others)									
Iran	1966	48	37	40	77	16	61	0.432	0.208
Egypt	1960	49	30	31	61	20	41	0.666	0.328
Ghana	1960	21	15	56	71	8	63	0.533	0.113
Korea	1966	32	27	57	84	16	68	0.592	0.191
India	1961	30	12	28	40	6	34	0.500	0.150
Thailand	1960	12	9	66	75	5	70	0.555	0.067
Turkey	1960	19	14	60	74	6	68	0.428	0.081
Overall Mean									
Overall Standard Deviation								0.528 (0.06)	0.22 (0.09)

Sources:

(1) Columns (1), (2), (3) and (7) from Webb (1974). Webb used the following procedure to obtain modern sector employment:

Non agricultural employees were broken down by broad industrial categories according to the United Nations International Standard Industrial Classification (ISIC). The employees in each category were then classified as modern or traditional according to the following methodology: ISIC 1: MINING: all modern sector; ISIC 2-3: MANUFACTURING: modern sector identified with enterprises above a given size. (This was usually 5 or 10 workers, but for India it was 20 and for Venezuela it was all the reporting firms); ISIC 4: CONSTRUCTION: all traditional sector; ISIC 5: ELECTRICITY, GAS, WATER AND SANITARY SERVICES: all modern sector; ISIC 6: COMMERCE: 20% modern sector and 80% traditional sector; ISIC 7: TRANSPORT, STORAGE AND COMMUNICATION: 80% modern sector and 20% traditional sector; ISIC 8: SERVICES: government: all modern sector, domestic servants: all traditional sector, the remaining portion of services was distributed one-third modern sector and two-thirds traditional sector; ISIC 9: ACTIVITIES NOT ADEQUATELY DESCRIBED: One-half modern sector, the other half traditional sector.

For Columns (1), (2) and (3) Webb used the International Labour Organization Year Book of Labor Statistics (1966, 1971, 1972). For column (7): Data on Employees in Manufacturing by Size of Firm he used The Growth of World Industry 1970 Edition, Vol. I: General Industrial Statistics. U.N. Statistical Office, New York, 1972, except for Venezuela were Anuario Estadistico 1971, Direccion General de Estadistica y Censos, Caracas, 1973. Data on government and domestic employees was obtained directly from the censuses of the respective countries except for Egypt, where an estimate made by Doctor and Gallis (1966) was used.

(2) Column (4) (Urban Self Employment) was obtained assuming that self employed were distributed between the farm and non farm sector in the same proportion as the employees.

The traditional sector labor force (Column (8)) was obtained assuming that all self employed belong to the traditional sector.

generally thought as characterized by the existence of a large spectrum of sectors with different degrees of entry restrictions, different institutionally fixed wage structures and excess labor supply in the most restricted sectors. However, all the issues to be explored in this paper can be analyzed under this simplified version of the segmentation phenomenon mentioned above without changing their qualitative nature.

We will define occupations in each sector according to that minimum level of education required in a technological sense for the performance of each occupation.[1] (This may be thought more generally as a minimum requirement of human capital, which can be acquired through formal, informal or pre-school education, experience, on-the-job training or any other channel.) Higher level occupations will therefore imply higher levels of technologically required schooling.

Under these circumstances we will observe the protected sector paying the minimum wage in a number of occupations and the market clearing wage in all those occupations where the minimum wage is not binding. In the unprotected sector, the wage structure will perform a clearing role in all occupations, higher wages being paid for higher occupational levels.

Let us define $\hat{S}_i$ as the technologically required level of education to perform occupation i and S_i as the actual level of education of those performing occupation i

$$\hat{S}_i = S_i \qquad \text{in the unprotected sector}$$

$$\hat{S}_i \leq S_i \qquad \text{in the protected sector}$$

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[1]This is somewhat similar to the technological framework used by Tinbergen (1973).

This condition reflects the fact that required and actual schooling will be the same in the unprotected sector; given the wage structure, workers will not enter occupations with school requirements lower than their actual levels. This need not be true in the protected sector. As long as the minimum wage is higher than the wage paid in a range of occupations in the unprotected sector, workers in those occupations will be willing to apply to (and some of them enter) any occupation in the protected sector including those with schooling requirements smaller than their actual levels of schooling.[1]

This situation is illustrated in diagram (1):

W_m is the minimum wage or some function of the minimum wage.

W_i is the wage or some function of the wage in the unprotected sector for a level of schooling S_i. It is also the wage in the protected sector for those levels of schooling for which the minimum wage is not binding.

S_{i*} is that level of schooling (occupation) for which the wage in the unprotected sector is equal to the minimum wage.

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[1]We are assuming that workers act in such a way as to maximize their wages, without considering their occupational status.

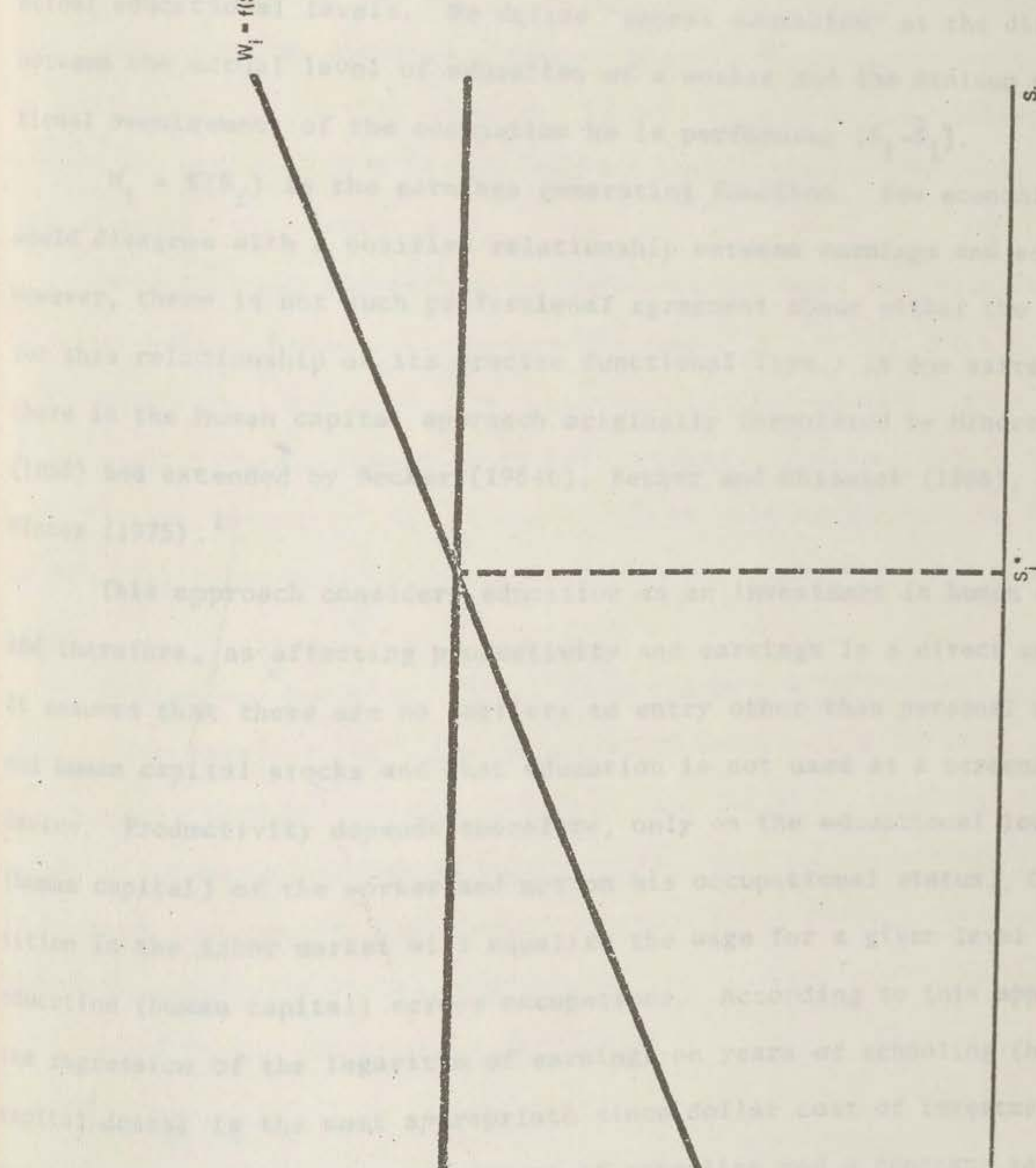

DIAGRAM 1

All those workers in the unprotected sector with a level of schooling smaller than S_{i*} will be willing to enter any occupation in the protected sector including those with educational requirements lower than their actual educational levels. We define "excess education" as the difference between the actual level of education of a worker and the minimum educational requirement of the occupation he is performing $[S_i - \hat{S}_i]$.

$W_i = f(S_i)$ is the earnings generating function. Few economists would disagree with a positive relationship between earnings and education. However, there is not such professional agreement about either the reasons for this relationship or its precise functional form. At one extreme there is the human capital approach originally formulated by Mincer (1957), (1958) and extended by Becker (1964b), Becker and Chiswick (1966), and Mincer (1975).[1]

This approach considers education as an investment in human capital and therefore, as affecting productivity and earnings in a direct manner. It assumes that there are no barriers to entry other than personal skills and human capital stocks and that education is not used as a screening device. Productivity depends therefore, only on the educational level (human capital) of the worker and not on his occupational status. Competition in the labor market will equalize the wage for a given level of education (human capital) across occupations. According to this approach, the regression of the logarithm of earnings on years of schooling (human capital doses) is the most appropriate since dollar cost of investment are measured in time-equivalent years of schooling and a constant rate of return applicable for investment in education exists.

[1]For an excellent survey of this approach, see Mincer (1970).

At the other extreme, there is the screening hypothesis: it assumes for purposes of argument, that individual productive ability is completely unaffected by education but depends only on the occupational status which the person can achieve and on the on-the-job training which the person receives once he has obtained access to a given occupation. The essence of this hypothesis is that education is used as a screening device, i.e., persons are excluded from high-productive occupations on the basis of their lack of educational achievements.[1]

Note that our approach is an intermediate, more realistic one. Education matters because it technically qualifies workers for higher level occupations, but given the occupation, excess education does not affect productivity. Depending on the employer's behavior toward non-productive excess education, it could also be used as a screening device to select those workers entering the protected sector under the minimum wage.

Heckman and Polachek, (1974) using the survey of Economic Opportunity (SEO) data for 1967, the one-in-1,000 Census data for 1960, and a random sample from the one-in-100 Census tape for 1970, concluded that under the normality assumption, the natural logarithm of earnings (wages) is the most appropriate simple transformation to be used in the earnings generating function's specification. Therefore, we will use the standard functional form for the earnings function:

$$(1) \quad W_i = a + bS_i + E_i$$

[1]See for ecample, Arrow, (1973); Stiglitz, (1973); Thurow and Lucas, (1972); Berg, (1971); Taubman and Wales, (1973); Wiles, (1974); Layard and Psacharopoulos, (1974).

where W_i is the natural logarithm of the wage, S_i the level of schooling, E_i a normally distributed zero mean random error and a and b parameters. This earnings function applies to all workers except those earning the minimum wage in the protected sector.

III. Bias in the Estimation of the Coefficient b due to Labor Market Segmentation.

Suppose that in order to estimate the earnings generating function we follow the standard procedure and obtain a random sample of all individuals including all kinds of occupations in both sectors without knowing the sector origin of each sample's observation and run the following regression:

$$(2) \quad W_i = \alpha + \beta S_i + e_i$$

We know that the true world is characterized by the following expressions:

$$(3) \quad W_{ik} = a + bS_{ik} + E_{ik} \qquad \text{for } \begin{array}{l} i = 0\ldots\eta,\ k = 0 \\ i = i^*\ldots\eta,\ k = 1 \end{array}$$

$$(4) \quad W_{ik} = W_m + \eta_{ik} \qquad \text{for } i = 0\ldots i^*,\ k = 1$$

where k takes the value of zero if the observation comes from the unprotected sector and the value one if it comes from the protected sector. W_m is the natural logarithm of the minimum wage. E_{ik} and η_{ik} are random errors normally distributed with zero mean and standard deviations G_E and G_η respectively.

We can rewrite expressions (2), (3) and (4) in terms of deviations from the sample means obtaining the following expressions:

$$(5)\quad w_i = \beta s_i + e_i \qquad \text{for } i = 0\ldots\eta,\ k = 0,1$$

$$(6)\quad w_{ik} = bs_{ik} + E_{ik} \qquad \text{for } \begin{matrix} i = 0\ldots\eta, & k = 0 \\ i = i^*\ldots\eta, & k = 1 \end{matrix}$$

$$(7)\quad w_{ik} = w_m = \eta_{ik} \qquad \text{for } i = 0\ldots i^*,\ k = 1$$

where

$w_i = W_i - \overline{W}$

$W_{ik} = W_{ik} - \overline{W}$

$S_{ik} = W_{ik} - \overline{S}$, the bars indicate sample means.

The question to explore in this section is: If we estimate expression (5) with the sample data, given that the true world is represented by expressions (6) and (7), what will be the relationship between β and the true b? The ordinary least square estimate for β is:

$$(8)\quad \hat{\beta} = \frac{\sum_{i=0}^{n} \sum_{k=0}^{1} w_{ik} s_{ik}}{\sum_{i=0}^{n} \sum_{k=0}^{1} s_{ik}^2}$$

using expressions (6) and (7) expression (8) is rewritten as follows:

$$(9)\quad \hat{\beta} = \frac{\sum_{i=o}^{n} (bs^2_{io} + E_{io}s_{io}) + \sum_{i=i^*}^{n} (bs^2_{i1} + E_{i1}s_{i1}) + \sum_{i=0}^{i^*} (w_m s_{i1} + \eta_{i1} s_{i1})}{\sum_{i=0}^{n} \sum_{k=0}^{1} s_{ik}^2}$$

rearranging terms:

$$(10)\quad \hat{\beta} = \frac{\sum_{i=0}^{n}\sum_{k=0}^{1} bs_{ik}^2 + \sum_{i=0}^{i*}(w_m - bs_{i1})s_{i1} + \sum_{i=0}^{n} E_{io}s_{io} + \sum_{i=i*}^{n} E_{i1}s_{i1} + \sum_{i=0}^{i*} \eta_{i1}s_{i1}}{\sum_{i=0}^{n}\sum_{k=0}^{1} s_{ik}^2}$$

Note that the expected value of the last three terms in the numerator is equal to zero,therefore we can write:

$$(11)\quad (E[\hat{\beta}] - b) = \frac{\sum_{i=0}^{i*}(w_m - bs_{i1})s_{i1}}{\sum_{i=0}^{n}\sum_{k=0}^{1} s_{ik}^2}$$

The right hand side of expression (11) represents the econometric bias in the estimation of b. The double sum in the denominator is always positive, therefore the sign of the bias depends entirely on the sign of the numerator, noting that

$$(12)\quad \overline{W} = \phi W_m + (1-\phi)\overline{W}^*$$

and

$$(13)\quad \overline{S} = \phi \overline{S}_{i*} + (1-\phi)\overline{S}^*$$

where ϕ is the number of workers earning the minimum wage in the protected sector as a percentage of total workers, $\overline{W}^*$, $\overline{S}^*$ is the mean wage and mean schooling of those workers not earning the minimum wage in the protected sector (this includes part of the protected sector and the totality of the unprotected sector) and $\overline{S}_{i*}$ is the mean schooling of those earning the minimum wage in the protected sector. Recalling the definitions of w_{ik} and s_{ik}, we can transform the numerator in (11) according to the following steps[1]

[1]For expositional purposes the word wage will be used for natural logarithm of wage.

$$(14)\quad \sum_{i=0}^{i^*} (w_m - bs_{i1}) s_{i1} = \sum_{i=0}^{i^*} [(W_m - \overline{W})(S_{i1} - \overline{S}) - b(S_{i1} - \overline{S})^2]$$

$$= \sum_{i=0}^{i^*} [(W_m - \overline{W})(S_{i1} - \overline{S}) - b((S_{i1} - \overline{S}_{i*}) + (\overline{S}_{i*} - \overline{S}))^2]$$

$$= \sum_{i=0}^{i^*} [(1-\phi)(W_m - \overline{W}^*)(S_{i1} - \phi\overline{S}_{i*} - (1-\phi)\overline{S}^*) - b(S_{i1} - \overline{S}_{i*}) + (1-\phi)(\overline{S}_{i*} - \overline{S}^*))^2]$$

$$= N_\phi (1-\phi)^2 b(\overline{S}_{i*} - \overline{S}^*)(S_{i*} - \overline{S}_{i*}) - b \sum_{i=0}^{i^*} (S_{i1} - \overline{S}_{i*})^2$$

$$= bN_\phi [(1-\phi)^2 (\overline{S}_{i*} - \overline{S}^*)(S_{i*} - \overline{S}_{i*}) - VAR(S_{i*1})]$$

Therefore the expression for the relative bias becomes

$$(15)\quad \frac{E[\hat{\beta}] - b}{b} = \phi \; \frac{(1-\phi)^2 (\overline{S}_{i*} - \overline{S}^*)(S_{i*} - \overline{S}_{i*}) - VAR(S_{i*1})}{VAR[S_{ik}]}$$

where VAR $[S_{i*1}]$ and VAR $[S_{ik}]$ are respectively the sample variance of the schooling level of those earning the minimum wage in the protected sector and the total sample variance; N_ϕ is the number of workers earning the minimum wage in the protected sector.

Expression (5) has the great advantage of expressing the relative bias in terms of more familar variables about whose magnitudes we can have a notion which does not require a perfect identification of the two sectors in question. These variables are the mean and variance of the schooling level of those benefiting from the minimum wage and the same measures for the overall labor force. In order to know the sign of the bias, we need to know the mean and variance of the schooling level of those earning the minimum wage in the protected sector as well as the overall mean schooling level. This will depend on the relative endowments of labor classified by schooling and on the behavior of employers in the protected sector toward "excess" education. However, we can derive some conclusions without the above information. If the average wage of the economy ($\overline{W}$), which is a weighted average of the minimum wage (W_m) and the average wage of those not earning the minimum wage in the protected sector ($\overline{W}^*$), is larger than the minimum wage, then:

$$(16) \quad \overline{W} = \phi W_m + (1-\phi)\overline{W}^* > W_m = a + bS_{i*}$$

given that

$$W^* = a + b\overline{S}^*$$

it follows that

$$(17) \quad \overline{S}^* > S_{i*} > \overline{S}_{i*}$$

given that S_{i*} is always larger or equal to $\overline{S}_{i*}$, this is a sufficient condition for the bias (expression (15)) to be negative which means that $\hat{\beta}$ underestimates the true coefficient b, and $\hat{\alpha}$ overestimates the true coefficient a.[1] If the average wage of the economy is smaller than the minimum wage, then we

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[1]We know that $\hat{\alpha} = \overline{W} - \hat{\beta}\overline{S}$ and $a = \overline{W}^* - b\overline{S}^*$ therefore,

$$\begin{aligned}(a-\hat{\alpha}) &= (\overline{W}^* - \overline{W}) - b\overline{S}^* + \hat{\beta}\overline{S} \\ &= \phi b(\overline{S}^* - S_{i*}) - b\overline{S}^* + \hat{\beta}\overline{S}^* - \phi\hat{\beta}\overline{S}^* + \phi\hat{\beta}\overline{S}_{i*} \\ &= (1-\phi)(\hat{\beta}-b)\overline{S}^* + \phi(\hat{\beta}\overline{S}_{i*} - bS_{i*})\end{aligned}$$

from this expression we see that if $\hat{\beta}$ underestimates b then $\hat{\alpha}$ overestimates a.

can prove that $S_i{}^* > \bar{S}^*$. We can distinguish two cases: i) $S_{i*} > \bar{S}^* > \bar{S}_{i*}$ in which case $\hat{\beta}$ continues underestimating b and $\hat{\alpha}$ overestimating a. ii) $S_{i*} > \bar{S}_{i*} > \bar{S}^*$ in which case the result is uncertain.

In general we can say that, ceteris paribus, the lower the educational level of those earning the minimum wage in the protected sector and the larger their schooling variance, the more likely that $\hat{\beta}$ will underestimate the true coefficient b and the larger the bias involved. We can illustrate this positive and negative bias by means of diagrams (2) and (3). In diagram (2), the level of schooling of those earning the minimum wage in the protected sector is relatively low, therefore $\hat{\beta}$ underestimates the true coefficient b. By contrast, in diagram (3), that level of schooling is relatively high and therefore $\hat{\beta}$ might overestimate the true coefficient b.

Note that the econometric bias analyzed in this section, is not exactly the standard problem originally formulated by Griliches (1957), of leaving out of the regression a variable with an independent impact on the regressand and correlated with the regressor. According to this "missing variable argument," the correct specification of the earnings function would be:

$$(18) \quad W_i = a + bS_i + CD_i + E_i$$

where D_i is a dummy variable that takes the value one if the observation comes from the protected sector and the value zero if it comes from the unprotected sector. However, this is not the correct specification, the true world is:

$$(19) \quad W_i = (1-D_i)(a+bS_i+e_i) + D_i(W_m+\eta_i)$$

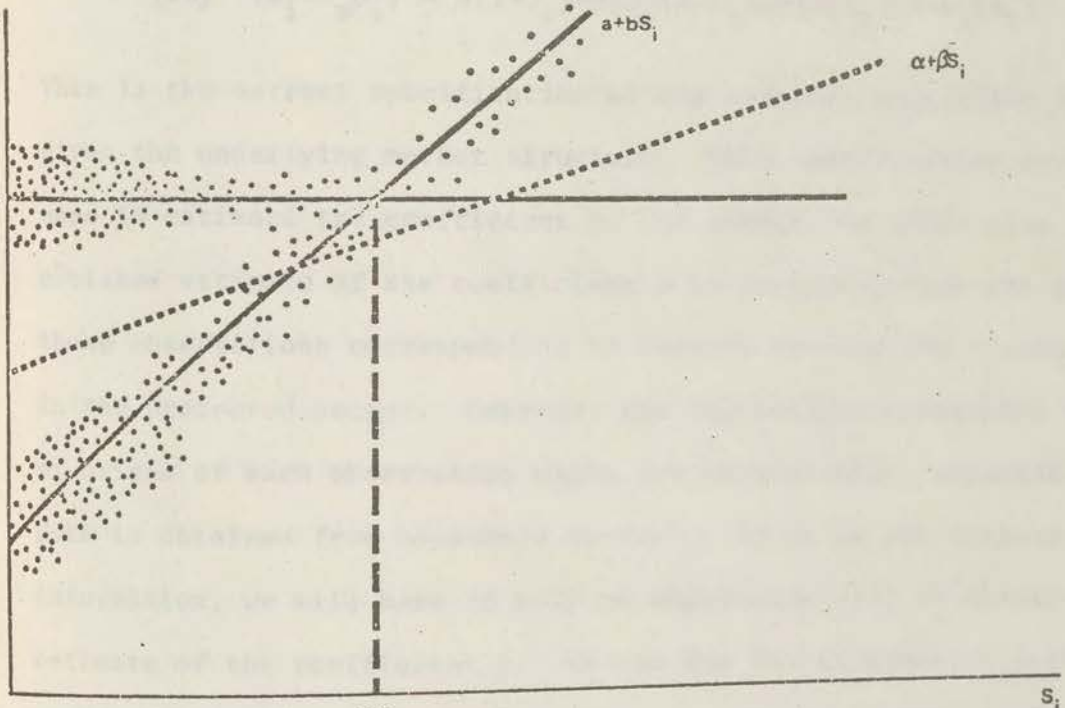
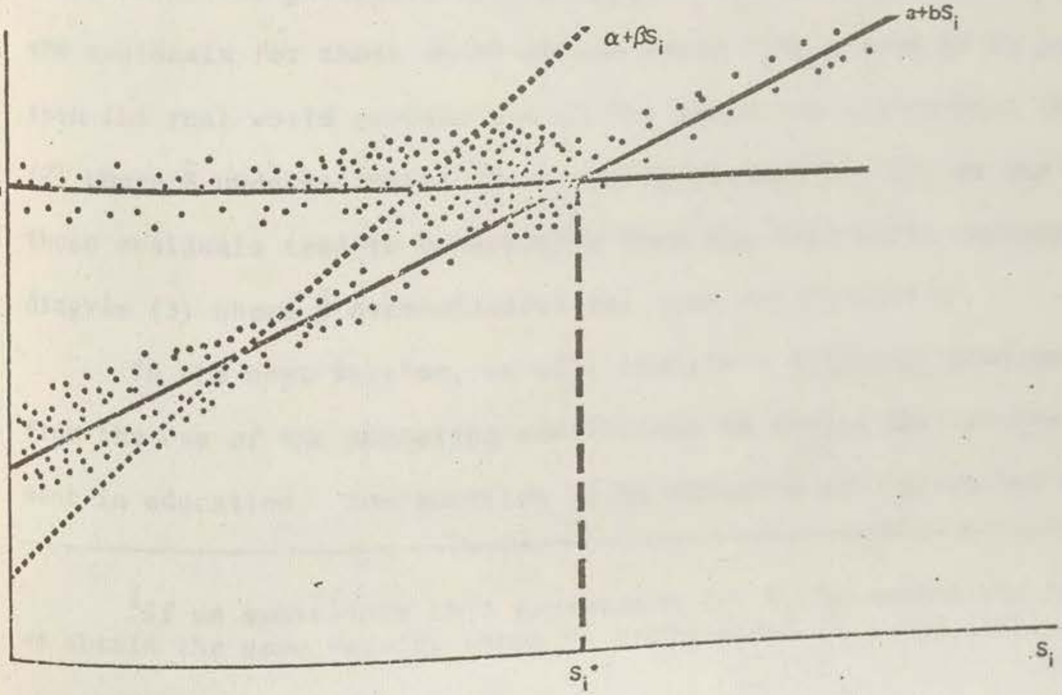


DIAGRAM (2)



where again D_i is a dummy variable that takes values according to the rule mentioned above. Expression (19) can be transformed into:

$$(20)\quad (W_i - W_m D_i) = a(1-D_i) + b[S_i(1-D_i)] + [D_i n_i + (1-D_i)e_i]^{1}$$

This is the correct specification of the earnings generating function given the underlying market structure. This specification should be used to estimate the coefficient b. Of course, we could also obtain an unbiased estimate of the coefficient b by excluding from the sample those observations corresponding to workers earning the minimum wage in the protected sector. However, the information concerning the sector of origin of each observation might not be available, especially if the data is obtained from household surveys. If we do not dispose of this information, we will have to rely on expression (15) to obtain an unbiased estimate of the coefficient b. We can use the information provided by the residuals of the regression (expressions (2) or (5)) to discriminate between the two possibilities illustrated in diagrams (2) and (3). If the residuals for those observations where $S_i > S_{i*}$ tend to be positive, then the real world corresponds to the situation illustrated in diagram (2) where $\hat{\beta}$ underestimates the true coefficient b. If, on the other hand, those residuals tend to be negative then the real world corresponds to diagram (3) where $\hat{\beta}$ overestimates the true coefficient b.

In the next section, we will analyze a <u>different</u> problem arising from the use of the schooling coefficient to assess the returns to investment in education. The question to be explored is: given the segmented

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[1]If we substitute this expression for W_i in expression (8), then we obtain the same results shown by expressions (11) and (15).

nature of the labor market, does the coefficient b, even if correctly measured, really reflect the true contribution of education to the economy? In section V we will return to the assessment of the possible bias in the estimate of b under different assumptions about employers' hiring practices.

IV. The True Contribution of Education and the Coefficient b.

If the person receiving the additional year of schooling has an educational level larger than S_{i*}, then, independently of the sector of origin or destination, the true contribution of education will be correctly reflected in the coefficient b. Therefore, we will analyze the impact of education when the receiver has an educational level smaller than S_{i*}. Given that the number of jobs under the minimum wage in the protected sector is fixed, any additional schooling will contribute to total output only through changes in the unprotected sector's output. Both the sector of origin and destination of the receiver of the additional schooling matter. If the receiver was and remains in the protected sector, the true contribution of education will be zero. If the receiver was and remains in the unprotected sector, then the coefficient b will correctly reflect the true contribution of education. If the receiver was in the unprotected sector, but after receiving the additional education "jumps" to the protected sector, then the true contribution of education will depend on who was displaced from that sector or was prevented from "jumping" to that sector.

Let us define the following variables for $i < i^*$

$\overline{N}_i$ = the number of workers in occupation i in the protected sector

Note that: $\sum_{i=0}^{i^*} \overline{N}_i = N_\phi$

$\tilde{N}_i$ = the number of workers with education i in the protected sector.

$\hat{N}_i$ = the number of workers with education i in the unprotected sector.

N_i = the total number of workers with education i

P_i^T = the probability of entering any occupation in the protected sector for a worker with a level of education i.

Therefore we can write:

$$(21) \quad \tilde{N}_i + \hat{N}_i = N_i$$

$$(22) \quad E[\tilde{N}_i] = P_i^T N_i \quad \underline{1/}$$

We can write the expected change in total output (Δy) which will be equal to the change in the output of the unprotected sector in terms of changes in this sector's employment:

$$(23) \quad \Delta y = \sum_{i=0}^{i*} \Delta \hat{N}_i W_i$$

given (21) and (22) we can write

$$(24) \quad \hat{N}_i = (1-P_i^T)N_i$$

therefore

$$(25) \quad \Delta\hat{N}_i = -\Delta P_i^T N_i + (1-P_i^T)\Delta N_i$$

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[1]Note that we are not assuming seniority in the protected sector. Workers with an educational level smaller than S_{i*} are competing for the whole stock of protected sector jobs covered under the minimum wage. If we assume seniority, then they would compete only for new vacancies or openings in the protected sector and the following analysis would have to be slightly modified to a simpler version.

substituting in (23)

$$(26)\quad \Delta Y = \sum_{i=0}^{i*} (-\Delta P_i^T N_i + (1-P_i^T)\Delta N_i) W_i$$

If the worker receiving the additional year of schooling has an educational level i_0 ($i_0<i*$) then $\Delta N_{i_o} = -1$, $\Delta N_{i_o+1} = 1$, and $\Delta N_i = 0$ for all others. Therefore expression (26) can be rewritten as follows:

$$(27)\quad \Delta Y = -(1-P_{i_o}^T)W_{i_o} + (1-P_{i_o+1}^T)W_{i_o+1} - \sum_{i=0}^{i*} \Delta P_i^T N_i W_i$$

To make this comparable to the coefficient b, we will rewrite expression (27) as a percentage change with respect to the initial wage W_{i_o}. Using expression (1) we obtain:

$$(28)\quad \frac{\Delta Y}{W_{i_o}} = (e^b-1) - [(P_{i_o+1}^T e^b - P_{i_o}^T) + \sum_{i=0}^{i*} \Delta P_i^T N_i e^{i-i_o}]$$

Expression (28) reflects the true expected percentage change in output due to an additional year of schooling. Now we have to compare this true change in output with the one predicted by the earnings generating function when the coefficient b is correctly measured (ΔY^P) according to this function, output should have increased by (e^b-1) percent of W_{i_o} (or approximately b percent of W_{i_o}).

$$(29)\quad \frac{\Delta Y^P b}{W_{i_o}} = (e^b-1)$$

Therefore, the difference between the predicted and the true change in output is given by:

$$(30)\quad \frac{\Delta Y^{P_b}}{W_{i_o}} - \frac{\Delta Y}{W_{i_o}} = (P^T_{i_o+1}e^{b} - P^T_{i_o}) + \sum_{i=0}^{i*} \Delta P^T_i N_i e^{(i-i_o)}$$

If this expression is positive, then the coefficient b, even if correctly measured, will overestimate the true contribution of education to the economy. If the expression is negative, then the coefficient b will underestimate that true contribution. See Appendix I for the derivation of the structure of probabilities by educational levels as well as the changes in these probabilities according to the educational level of the worker receiving the additional schooling.

V. Education and the Probability of Entering the Protected Sector.

Education might affect the probability of entering the protected sector for reasons related to supply and demand. The supply reasons are related to the fact that education might increase the "searching capacity" of workers by providing them with additional information about the nature of the labor market, the existence of differentiated sectors and the identification and location of the protected ones. The demand side reasons are related to the protected sector employers' behavior toward excess education in their hiring practices. There is some evidence in LDC's that employers do use educational attainment as a criterion for hiring and selecting the better educated in preference to those with a lower level of education.[1] According to Stiglitz, "the issue revolves around rules for hiring laborers when there is an excess of applicants

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[1]See for example Blaug, Layard, and Woodhall, (1969); Krueger, (1971); Skorov, (1969), Pang Eng Fong and Liu Pak Wai (1975).

over jobs. A common view is that employers hire the most qualified laborers so that if a skilled (educated) laborer applies for a job, then, even if he is no more productive at the given job than an unskilled laborer, he will be hired in preference to him" (Stiglitz, (1976) p. 18). This behavior might be particularly strong in the public sector because the educational level provides an objective and simple criteria to be followed by the bureaucrats in the selection process of new public employeees.

In this section we will describe two categories of behaviors and analyze their implications for the biases discussed in sections III and IV.

1. Lexicographic preferences or cascade model:[1]

Suppose the employers of the protected sector have a lexicographic preference for excess education. Given that this is a free good for them, they will hire for each occupation covered under the minimum wage those candidates with the highest level of excess education. Only when this group has been exhausted, will they proceed to hire workers with the second highest excess educational level and so on. Given this behavior, the probability and the change in probability of entering the protected sector for the lowest educational groups will be zero. Therefore, recalling expression (28) the coefficient b will correctly reflect the true contribution of education when the receiver belongs to one of those groups. However, if the receiver already had a positive or unitary probability, then the true contribution of education will be zero and the coefficient b

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[1]This has been referred to as the bumping model by Fields, (1974).

will overestimate it. Furthermore, this kind of behavior will, ceteris paribus, maximize the average level of education of those earning the minimum wage in the protected sector. The larger this average, the more likely that $\hat{\beta}$ will overestimate the true coefficient b. However, if the average educational level of those benefiting from the minimum wage legislation, fails to exceed the average level of those who do not ($\overline{S}_{i*} \leq \overline{S}*$), then, this lexicographic behavior will, ceteris paribus, minimize the absolute value of ($\overline{S}_{i*}-\overline{S}*$), ($S_{i*}-\overline{S}_{i*}$) and VAR[$S_{i*i}$]. Recalling expression (15), $\hat{\beta}$ will continue to underestimate the true coefficient b but the error involved will be minimized.

2. Non lexicographic preference or lottery model:

Suppose that workers entering a particular occupation in the protected sector covered under the minimum wage are selected randomly among those fulfilling the technological requirements. However, workers with difference educational levels need not have the same probability of entering those occupations. Employers might have a positive, but non lexicographic, preference for excess education. In this case, workers with higher educational levels will have a higher probability of entering the protected sector for two reasons:

1) Given the technological educational requirements, the higher the educational level, the larger the number of occupations to which they can apply.

2) The higher the educational level, the higher the probability of entering a particular occupation.

Employers might also be indifferent with respect to excess education. In this case again the higher the educational level, the higher the probability of entering the protected sector. However, this time only for the first reason given above. In both of these cases i.e., positive and neutral preference for excess education, P_{i_o+1} will exceed P_{i_o} and therefore, recalling expression (30), the coefficient b will tend to overestimate the true contribution of education to the economy when the receiver has a high educational level and will tend to underestimate it when the receiver has a low one. The stronger this positive preference, the larger the overestimation and underestimation involved.

Finally, employers might have a negative preference for excess education.[1] In this case, we do not know the relationship between the educational level and probability of entering the protected sector, because the two reasons mentioned above work in opposite directions. Therefore, we do not know whether the coefficient b overestimates or underestimates the true contribution of education to the economy. However, the stronger this negative preference, the more likely that b underestimates the true contribution of education to the economy.

With respect to the relationship between $\hat{\beta}$ and b:

$$(31) \quad \overline{S}_{i*} = \frac{\sum_{i=0}^{i*} \hat{N}_i S_i}{N_\phi} = \frac{\sum_{i=0}^{i*} P_i^T N_i S_i}{N_\phi} = \frac{\sum_{i=0}^{i*} P_i^T n_i S_i}{\phi}$$

where n_i is the number of workers with an educational level i as a percentage of the total labor force. We observe that $\overline{S}_{i*}$ will be larger the larger the probability and relative endowments of those workers with the highest

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[1]This case may be justified arguing that excess education may lower the morale and induce labor conflicts.

educational levels (subject to $i<i^*$). The stronger the positive preference for excess education, the more likely that $\overline{S}_{i*}$ exceeds $\overline{S}^*$ and therefore the more likely that $\hat{\beta}$ overestimates the true coefficient b. However, if $\overline{S}_{i*}$ fails to exceed $\overline{S}^*$, then $\hat{\beta}$ will underestimate the true b and the stronger the positive preference the smaller the bias involved. In the negative preference case, the stronger this negative preference, the more likely that $\hat{\beta}$ underestimates the true b and the larger the error involved. We can summarize part of these results in the following table.

TABLE 2

THE RELATIONSHIP BETWEEN $\hat{\beta}$, b AND THE TRUE CONTRIBUTION OF EDUCATION TO THE ECONOMY

Employers	$i < i^*$		$i > i^*$	
Behavior	$\overline{S}_{i*} > \overline{S}^*$	$\overline{S}_{i*} < \overline{S}^*$	$\overline{S}_{i*} > \overline{S}^*$	$\overline{S}_{i*} < \overline{S}^*$
lexicographic preference	$\hat{\beta} \gtrless b = \frac{\Delta Y}{W_i}$ for $i_o<i_c$	$\hat{\beta} < b = \frac{\Delta Y}{W_i}$ for $i_o<i_c$	$\hat{\beta} \gtrless b = \frac{\Delta Y}{W_i}$	$\hat{\beta}<b=\frac{\Delta Y}{W_i}$
	$\hat{\beta} \gtrless b > \frac{\Delta Y}{W_i} = 0$ for $i_o>i_c$	$\hat{\beta} < b > \frac{\Delta Y}{W_i} = 0$ for $i_o>i_c$		
Non-lexicographic positive, neutral, or negative preference	$\hat{\beta} \gtrless b \gtrless \frac{\Delta Y}{W_{i_o}}$	$\hat{\beta} < b \gtrless \frac{\Delta Y}{W_{i_o}}$	$\hat{\beta} \gtrless b = \frac{\Delta Y}{W_i}$	$\hat{\beta}<b=\frac{\Delta Y}{W_i}$

Where i_c, is the highest level of education sill with zero probability of entering the protected sector in the lexicographic preference case. For $i < i^*$, when $\overline{S}_{i^*} > S^*$, the stronger the positive preference (lexicographic, positive, neutral and negative) the more likely that $\hat{\beta}$ overestimates the coefficient b, and the larger the overestimation involved. However, if $\hat{\beta}$ fails to overesimtate b, the stronger the positive preference, the smaller the underestimation involved. When $\overline{S}_{i^*} < \overline{S}^*$, the stronger the positive preference the smaller the underestimation involved. As we will see from the empirical evaluation, when $i < i^*$, the relationship between the coefficient b and the true contribution of education depends critically on the initial level of schooling of the worker receiving the additional level of education. For $i > i^*$, when $\overline{S}_{i^*} > \overline{S}^*$, the stronger the positive preference, the more likely that $\hat{\beta}$ will overestimate the coefficient b, and therefore, the true contribution of education and the larger the error involved. However, if $\hat{\beta}$ fails to underestimate b, the stronger the positive preference, the smaller the discrepancy between $\hat{\beta}$ and b, and therefore, the smaller the underestimation by the coefficient $\hat{\beta}$ of the true contribution of education.

VI. Empirical Evaluation

We will undertake an empirical evaluation of the biases analyzed above for two Latin American countries: Chile and Mexico.

1. Chile: Table (3) presents the education distribution of the labor force and monthly earnings by years of schooling. Given the minimum wage,[1]

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[1]The minimum wage was obtained as an average of the salario minimo industrial (E°71) and the Sueldo Vital (E°150) this average was E°110.

TABLE 3

CHILE: EDUCATIONAL DISTRIBUTION OF THE LABOR FORCE AND MONTHLY EARNINGS BY YEARS OF SCHOOLING (1964)

Years of Schooling (1)	Monthly Earnings In Escados 1964 (2)	Number of Workers (in thousands) (3)	Percentage of Total Labor Force (4)
0	54.9	348.5[1]	13.67
1	61.2	47.2	1.85
2	68.7	130.5	5.12
3	74.0	299.2	11.73
4	88.1	348.0	13.65
5	87.0	171.8	6.74
6	101.4	513.8	20.15
7	110.6	111.1	4.36
8	141.1	104.5	4.10
9	148.8	122.1	4.78
10	151.7	96.6	3.79
11	194.0	58.0	2.27
12	268.4	125.7	4.93
13		10.5[1]	0.41
14	900.6	5.9	0.23
15		6.5	0.25
16		11.6	0.46
17 or more	1532.9	37.9	1.49
Total		2549.5	

SOURCES: Column (2) "Encuesta Nivel de Vida" centro de Planilicacion Economica. Universidad de Chile. As reported by Selowsky (1967). Column (3): based on 1960 Population Census assuming some hypothesis with respect to growth rates, as reported in Selowsky (1967).

[1] The relative weights of the 1960 Census were used to disaggregate the groups o-2 and 13-16 years of schooling.

the level of schooling for which the wage in the unprotected sector is equal to the minimum wage is between 6 and 7 years. Given the discontinuity of the schooling level, it is appropriate to take $S_{i*} = 6$ years. 72.9 percent of the labor force has 6 or less years of schooling. Given that the protected sector represents 36.5 percent of the urban labor force (see Table 1), the workers earning the minimum wage in the protected sector represent approximately 26.6 percent of the urban labor force ($\phi = 0.266$). From Table 3 we can obtain the mean and variance of the educational level of the labor force ($\overline{S} = 5.3$, $\sigma^2 = 13.8$). We will assume that these 26.6 percent of occupations covered under the minimum wage are equally distributed with respect to minimum technological educational requirements. Therefore the number of workers performing in each occupation under the minimum wage in the protected sector represents 3.8 percent of the total labor force. Furthermore, we will undertake this empirical evaluation under the assumption of employer neutral preferences toward excess education ($\alpha_i^h = 1$).[1] Using the probability expressions derived in Appendix I, we can obtain the probabilities by levels of schooling and the changes in these probabilities according to the educational level of the worker receiving the additional schooling. These probabilities and changes in probabilities are presented in Table (4). Using the probabilities shown in Table (4) we can obtain the educational distribution of workers earning the minimum wage in the protected sector.

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[1]The results obtained are stronger under any positive preference behavior on the part of employers.

TABLE 4

CHILE: PROBABILITIES BY EDUCATIONAL LEVEL: PROBABILITIES UNDER INITIAL CONDITIONS AND PROBABILITIES ACCORDING TO THE EDUCATIONAL LEVEL OF THE WORKER RECEIVING THE ADDITIONAL SCHOOLING. (FIGURES IN PARENTHESIS SHOW THE ABSOLUTE CHANGE WITH RESPECT TO THE INITIAL CONDITIONS)

Educational Level	Initial Conditions	Educational Level of the Receiver (In Years)					
		0 Years	1 Year	2 Years	3 Years	4 Years	5 Years
P^T_0	0.0758236976	0.0758236976 (0.0)	0.0758236976 (0.0)	0.0758236976 (0.0)	0.0758236976 (0.0)	0.0758236976 (0.0)	0.0758236976 (0.0)
P^T_1	0.1630818212	0.1630817361 ($-8.51\cdot10^{-8}$)	0.1630818212 (0.0)	0.1630818312 (0.0)	0.1630818212 (0.0)	0.1630818212 (0.0)	0.1630818212 (0.0)
P^T_2	0.2384520377	0.2384519603 ($-7.74\cdot10^{-8}$)	0.2384519676 ($-7.01\cdot10^{-8}$)	0.2384520377 (0.0)	0.2384520377 (0.0)	0.2384520377 (0.0)	0.2384520377 (0.0)
P^T_3	0.3092470601	0.3092469898 ($-7.03\cdot10^{-8}$)	0.3092469965 ($-6.36\cdot10^{-8}$)	0.309246992 ($-6.81\cdot10^{-8}$)	0.3092470601 (0.0)	0.3092470601 (0.0)	0.3092470601 (0.0)
P^T_4	0.3889300889	0.3889300268 ($-6.21\cdot10^{-8}$)	0.3889300326 ($-5.63\cdot10^{-8}$)	0.3889300287 ($-6.02\cdot10^{-8}$)	0.3889299939 ($-9.5\cdot10^{-8}$)	0.3889300889 (0.0)	0.3889300889 (0.0)
P^T_5	0.489489208	0.4894891562 ($-5.18\cdot10^{-8}$)	0.4894891611 ($-4.69\cdot10^{-8}$)	0.4894891578 ($-5.02\cdot10^{-8}$)	0.4894891287 ($-7.93\cdot10^{-8}$)	0.4894890372 ($-1.708\cdot10^{-7}$)	0.489489208 (0.0)
P^T_6	0.5857500022	0.5857499601 ($-4.21\cdot10^{-8}$)	0.5857499614 ($-3.81\cdot10^{-8}$)	0.5857499614 ($-4.08\cdot10^{-8}$)	0.5857499378 ($-6.44\cdot10^{-8}$)	0.5857498635 ($-1.387\cdot10^{-7}$)	0.5857498148 ($-1.874\cdot10^{-7}$)

TABLE 5

CHILE: EDUCATIONAL DISTRIBUTION OF THE LABOR FORCE BY SECTORS AS A PERCENTAGE OF THE TOTAL LABOR FORCE

Years of Schooling	Protected Sector (1)	Unprotected Sector (2)	Total (3)=(1)+(2)
0	1.036	12.630	13.670
1	0.301	1.550	1.850
2	1.221	3.900	5.120
3	3.627	8.103	11.730
4	5.308	8.342	13.650
5	3.299	3.441	6.740
6	11.804	8.346	20.150

From table (5), we can obtain the mean and variance of the educational level of those earning the minimum wage in the protected sector.

$(\bar{S}_{i*} = 4.59, \ \sigma^2_{i*} = 2.59)$

From tables (3) and (5) we can derive the mean educational level of those not earning the minimum wage ($\bar{S}* = 5.56$). Estimates of earnings generating functions undertaken in Chile have shown that the $\hat{\beta}$ coefficient, standardly estimated, is approximately 0.15[1] ($\hat{\beta} = 0.15$). With these parameters we can now evaluate the biases identified in expressions (15), (28), and (30).

[1]This value was taken from Sorkin, A. (1974). It is the coefficient of the schooling variable of the regression of earnings on schooling, age, occupation, and region for all workers evaluated at the sample mean value of the income variable. See also Corbo, M. (1974).

A. The relationship between $\hat{\beta}$ and b.

$$(32)\quad \frac{E[\hat{\beta}]-b}{b} = 0.266\ \frac{0.5388\ [4.59-5.56][6-4.59]-2.59}{13.8} = -0.0641$$

Therefore, $\hat{\beta}$ underestimates the coefficient b. Given a value of $\hat{\beta}$ of 0.15, the true coefficient b is 0.16. This implies a relative bias of 6.4 percent.

B. The relationship between b and the true contribution of education.

Recalling expression (29), the change in output as a percentage of the initial wage of the workers receiving the additional schooling predicted by the coefficient b is:

$$(33)\quad \frac{\Delta Y^{P_b}}{W_i} = (e^{b}-1) = 0.1935.$$

This same change, but predicted by the coefficient $\hat{\beta}$ is:

$$(34)\quad \frac{\Delta Y^{P\hat{\beta}}}{W_i} = (e^{\hat{\beta}}-1) = 0.1618$$

We can evaluate expression (28) to obtain the true expected change in output as a percentage of the initial wage of the worker receiving the additional education ($\frac{\Delta Y}{W_i}$). Table (6) presents these true contributions as well as the differences with respect to the predictions based on the coefficients b and $\hat{\beta}$.

Column (1) of table (6) shows the true contribution of education; column (2) and (3) show the absolute and relative biases involved in the predictions based on the coefficient b, columns (4) and (5) show the absolute and relative biases involved in the predictions based on the

TABLE 6

CHILE: TRUE EXPECTED PERCENTAGE CONTRIBUTION OF EDUCATION ACCORDING TO THE EDUCATIONAL LEVEL OF THE RECEIVER AND DIFFERENCES WITH RESPECT TO THE PREDICTIONS ($\hat{\beta}$=0.15, b=0.16)

Educational Level of the Receiver	$\frac{\Delta Y}{W_i}$ (1)	$\frac{\Delta Y^{P_b}}{W_i} - \frac{\Delta Y}{W_i}$ (2)	$\frac{\frac{\Delta Y^{P_b}}{W_i}}{\frac{Y}{W_i}} - 1$ (3)	$\frac{\Delta Y^{P\hat{\beta}}}{W_i} - \frac{\Delta Y}{W_i}$ (4)	$\frac{\frac{\Delta Y^{P\hat{\beta}}}{W_i}}{\frac{\Delta Y}{W_i}} - 1$ (5)
0	0.2278	-0.0543	-0.238	-0.0660	-0.290
1	0.1842	-0.0107	-0.058	-0.0224	-0.122
2	0.1555	0.0180	0.116	0.0063	0.041
3	0.1374	0.0361	0.263	0.0244	0.178
4	0.1206	0.0529	0.439	0.0412	0.342
5	0.0886	0.0849	0.958	0.0732	0.826
6 or more	0.1735	0.0	0.0	-0.0117	-0.067

coefficient $\hat{\beta}$. We observe that the true contribution of education varies widely with the educational level of the worker receiving the additional schooling. Both coefficients b and $\hat{\beta}$ underestimate the true contribution of education for workers with 0 or 1 years of schooling and overestimate it for workers with 2 to 5 years of schooling. For workers with 6 or more years of schooling, the coefficient b correctly reflects the true contribution of education. However, the coefficient $\hat{\beta}$ underestimates it. As we can see from column (5), the relative biases involved in the predictions based on the coefficient $\hat{\beta}$ are extremely significant for those workers who can potentially benefit from the minimum wage legislation.

It reaches a maximum of 82.6 percent for workers with 5 years of schooling. For workers for whom the minimum wage is not binding the coefficient $\hat{\beta}$ underestimates the true contribution of education by 6.7 percent.

2. Mexico

Table (7) presents the educational distribution of the labor force and monthly earnings by years of schooling. The minimum wage is 645 pesos.[1] Therefore, the level of schooling for which the wage in the unprotected sector is equal to the minimum wage is between 4 and 5 years. Given the discontinuity of the schooling variable it is appropriate to take $S_{i*} = 4$. From table (7) we can obtain the mean and variance of the educational level of the total labor force ($\overline{S} = 2.99$; $\sigma^2 = 10.2$). 73.7 percent of the labor force has 4 or less years of schooling. On the average, the protected sector in Latin America represents 30.1 percent of the urban labor force (see table 1). Since we do not have this information for Mexico, this regional average will be used. Therefore, the workers earning the minimum wage in the protected sector represent 22.2 percent of the urban labor force ($\phi = 0.222$). We assume that these 22.2 percent of occupations covered under the minimum wage are equally distributed with respect to minimum educational requirements. Therefore, the number of workers performing in each of these occupations represents 4.44 percent of the total labor force. We keep the assumption of neutral-preference-toward-excess education. Table (8) presents the probabilities

[1] See Memoria de los Trabajos 1972 y 1973. Comision Nacional de Salarios Minimos. Zona Economica Num. 74. Distrito Federal, Area Metropolitana. Salario Minimo General, 1964-1965. Mexico.

TABLE 7

MEXICO: EDUCATIONAL DISTRIBUTION OF THE LABOR FORCE

AND MONTHLY EARNINGS BY YEARS OF SCHOOLING

(1964)

Years of Schooling (1)	Monthly Earnings (in Pesos 1964) (2)	Number of Workers (in thousands) (3)	Percentage of Total Labor Force (4)
0	365	3612	33.17
1	365	531	4.88
2	451	1617	14.87
3	535	1426	13.09
4	632	841	7.72
5	692	360	3.30
6	854	1438	13.20
7	1202	128[1]	1.18
8	1202	208	1.91
9	1202	274	2.51
10	2390	74[1]	0.68
11	2390	93	0.85
12	1913	104[1]	0.96
13	1913	24	0.22
14	1913	24	0.22
15 or more	3861	136	1.25
Total		10890	100.00

SOURCE: Column (1) and (2): Secretaria de Industria y Comercio. Direccion de Muestreo. La Poblacion Economicamente Activa de Mexico, 1964-1965 as reported in Selowsky (1967).

[1]The weights from the 1960 estimted educational distribution of active population based on the 1960 Census were used to disaggregate the groups 0-1, 7-9, 10-14.

TABLE 8

MEXICO: PROBABILITIES BY EDUCATIONAL LEVELS: PROBABILITIES UNDER INITIAL CONDITIONS AND PROBABILITIES ACCORDING TO THE EDUCATIONAL LEVEL OF THE RECEIVER (FIGURES IN PARENTHESIS SHOW THE ABSOLUTE CHANGE WITH RESPECT TO THE INITIAL CONDITIONS)

Educational Level	Initial Conditions	Educational Level of the Receiver (In Years) 0	1	2	3
P_o^T	0.0793568158	0.0793568158 (0.0)	0.0793568158 (0.0)	0.0793568158 (0.0)	0.0793568158 (0.0)
P_1^T	0.2295180293	0.2295179787 ($-5.06\cdot10^{-8}$)	0.2295180293 (0.0)	0.2295180293 (0.0)	0.2295180293 (0.0)
P_2^T	0.3572329581	0.3572329159 ($-4.22\cdot10^{-8}$)	0.3572329144 ($-4.37\cdot10^{-8}$)	0.3572329581 (0.0)	0.3572329581 (0.0)
P_3^T	0.5314919641	0.5314919333 ($-3.08\cdot10^{-8}$)	0.5314919322 ($-3.19\cdot10^{-8}$)	0.5314918664 ($-9.77\cdot10^{-8}$)	0.5314919641 (0.0)
P_4^T	0.8008512168	0.8008512037 ($-1.31\cdot10^{-8}$)	0.8008512032 ($-1.36\cdot10^{-8}$)	0.8008511752 ($-4.16\cdot10^{-8}$)	0.8008508965 ($-3.203\cdot10^{-7}$)

and changes in probabilities according to the educational level of the receiver.

Using these probabilities we can obtain table (9).

TABLE 9

MEXICO: EDUCATIONAL DISTRIBUTION OF THE LABOR FORCE BY SECTORS AS A PERCENTAGE OF THE TOTAL LABOR FORCE

Years of Schooling	Protected Sector (1)	Unprotected Sector (2)	Total (3)=(1)+(2)
0	2.63	30.54	33.17
1	1.12	3.76	4.88
2	5.31	9.55	14.86
3	6.96	6.13	13.09
4	6.18	1.54	7.72

From table (9) we can obtain the mean and variance of the educational level of those earning the minimum wage in the protected sector.

$$(\overline{S}_{i*} = 2.58 \quad \sigma^2_{i*} = 1.61)$$

From table (7) and (9) we obtain the mean educational level of those workers not earning the minimum wage in the protected sector ($\overline{S}*=3.11$). In an empirical study for Mexico, Carnoy (1967) found a steady increase of log income with the increase in years of schooling. The average rise is 17 percent per year of schooling when log income is run on schooling alone; 15 percent when age is held constant and 12 percent when all other variables are held constant. (Age, father's occupation, industry and city.) Since we are interested on the contribution of schooling alone it is appropriate to use this last figure ($\hat{\beta}$ = 0.12). With these parameters we can evaluate the biases identified in expressions (15), (28), and (30).

A. <u>The Relationship between $\hat{\beta}$ and b.</u>

$$(35)\quad \frac{E[\hat{\beta}]-b}{b} = 0.222\ \frac{0.6053[2.58-3.11][4-2.58]-1.61}{10.2} = -0.045$$

Therefore, $\hat{\beta}$ underestimates the coefficient b. Given a value of $\hat{\beta}$ of 0.12, the true coefficient b is 0.1257. This implies a relative bias of 4.5 percent.

B. <u>The Relationship between b on the true contribution of education.</u>

Recalling expression (29), the change in output as a percentage of the initial wage of the receiver, predicted by the coefficient b is

$$(36)\quad \frac{\Delta Y^{Pb}}{W_i} = (e^b-1) = 0.1339$$

This same change but predicted by $\hat{\beta}$ is

$$(37)\quad \frac{\Delta Y^{P\hat{\beta}}}{W_i} = (e^{\hat{\beta}}-1) = 0.1275$$

We can evaluate expression (28) to obtain the true expected change in output as a percentage of the initial wage of the worker receiving the additional schooling. Table (10) presents these true contributions as well as the differences with respect to the predictions based on the coefficients b and $\hat{\beta}$. Column (1) of table (10) shows the true contribution of education; columns (2) and (3) show the absolute and relative biases involved in the predictions based on the coefficient b; columns

TABLE 10

MEXICO: TRUE EXPECTED PERCENTAGE CONTRIBUTION OF EDUCATION ACCORDING TO THE EDUCATIONAL LEVEL OF THE RECEIVER AND DIFFERENCES WITH RESPECT TO THE PREDICTIONS

($\hat{\beta}$=0.12; b=0.1257)

Educational Level of the Receiver	$\frac{\Delta Y}{W_i}$ (1)	$\frac{\Delta Y^{Pb}}{W_i} - \frac{\Delta Y}{W_i}$ (2)	$\frac{\frac{\Delta Y^{Pb}}{W_i} - 1}{\frac{\Delta Y}{W_i}}$ (3)	$\frac{\Delta Y^{P\hat{\beta}}}{W_i} - \frac{\Delta Y}{W_i}$ (4)	$\frac{\frac{\Delta Y^{P\hat{\beta}}}{W_i} - 1}{\frac{\Delta Y}{W_i}}$ (5)
0	0.1535	-0.0196	-0.128	-0.026	-0.169
1	0.1136	0.0203	0.179	0.0139	0.122
2	0.0914	0.0425	0.465	0.0361	0.395
3	0.0627	0.0712	1.14	0.0648	1.033
4 or more	0.1339	0.0	0.0	-0,0064	0.048

(4) and (5) show the absolute and relative biases involved in the predictions based on the coefficient $\hat{\beta}$. Once again, the true contribution of education varies widely with the educational level of the receiver. Both coefficients b and $\hat{\beta}$ underestimate the true contribution of education for workers with 0 years of education and overestimate for workers with 1 to 3 years of schooling. For workers with 4 or more years of schooling, the coefficient b correctly reflects the true contribution of education. However, the coefficient $\hat{\beta}$ underestimates it. As we can see from column (5) the relative biases orginated by the predictions based on $\hat{\beta}$ are quite significant, reaching a maximum of 103 percent for workers with three years of education. For workers with 4 or more years of education, the coefficient $\hat{\beta}$ underestimates the true contribution of

education by 4.8 percent.

VII. Conclusions

Given labor market segmentation, there are two distinct problems related to the use of the standard schooling coefficient to assess the social returns to investments in education.[1]

The first one is an econometric bias in the measurement of the schooling coefficient. The sign and magnitude of this econometric bias depend on a) the mean and variance of the educational level of those benefiting from the minimum wage legislation, b) the relative size of the protected sector, c) the level of the minimum wage rate relative to the wage structure of the economy, and d) the educational variance of the overall labor force.

A sufficient condition for a negative bias i.e., the true schooling coefficient is underestimated by the coefficient $\hat{\beta}$, is that the average of those not benefiting from the minimum wage legislation exceeds the minimum wage. This condition is fulfilled in both LDC's examined on our empirical analysis, Chile and Mexico. In both countries, this econometric bias turns out to be rather small, 6.4 percent in Chile and 4.5 percent in Mexico.

The second problem arises from a structural bias and refers to the relationship between the coefficient b, correctly measured, and the true marginal contribution of education to the economy. This structural

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[1]The use of earnings differentials by levels of schooling is subject to the same pitfalls analyzed in this paper in the context of the earnings generating function.

bias is due to a mis-specification of the underlying labor market and the impact that additional education has on the allocation of labor between the two sectors. The sign and magnitude of this bias depend on the initial educational level of the worker receiving the additional schooling, as well as, on factors determining the probabilities and changes in probabilities of entering the protected sector for workers with different levels of education. These factors are related to technological aspects as well as to the employer's behavior toward excess education.

For those workers for whom the minimum wage is not binding, this bias does not apply. For those workers for whom the minimum wage is binding, the higher the initial educational level of the worker receiving the additional education the more likely that the coefficient b will overestimate the true contribution of education. The intuitive reason for this is simple. The additional schooling increases the receiving worker's probability but decreases the probability of all workers with an educational level higher than his. Therefore, the higher the initial level of schooling of the receiver, the smaller the amount by which the expected educational level of the worker displaced from the protected sector (if any) will exceed the initial level of schooling of the receiver and therefore, the smaller the expected change in the unprotected sector's output as a percentage of the initial wage of the receiver. This structural bias is found to be extremely important in the two countries mentioned above. It reaches a maximum of 96 percent and 114 percent for Chile and Mexico respectively.

The net impact of these two biases is such that, the $\hat{\beta}$ coefficient underestimates the true contribution of education for very low and very high levels of education. However, for intermediate levels of education, the $\hat{\beta}$ coefficient overestimates the true contribution of education. The errors involved at the low and intermediate levels of education are significantly larger than the errors involved at higher levels of education. The policy implications arising from these results are that given the segmented nature of the labor market, the level and structure of educational expenditures should be severely revised in these two countries. The current allocation of expenditures by educational levels is highly concentrated at the upper tail. These expenditures should be reallocated to increase the share of total expenditures going to the lowest levels of the educational process.

APPENDIX I

THE STRUCTURE OF PROBABILITIES

Let us define $(i<i^*)$

P_i^h: The probability of an individual with i years of schooling, of entering the occupation in the protected sector for which he has h years of excess education i.e., occupation (i-h).

α_i^h: The number of times by which the probability of an individual with a level of schooling i, competing for a job for which he has h years of excess education, exceeds the probability of an individual with no excess education competing for the same job.

Note that α_i^h tends to infinity in the lexicographic preference case, is larger than one in the positive preference case, is equal to one in the no preference case and is smaller than one in the negative preference case.

$$(1) \quad P_i^h = \alpha_i^h P_{i-h}^0$$

$$(2) \quad P_i^T = P_i^0 + (1-P_i^0)P_i^1 + (1-P_i^0)(1-P_1^1)P_i^2 \ldots\ldots + (1-P_i^0)(1-P_1^1)\ldots(1-P_i^{m-1})P_i^m$$ [1]

given expression (1) we only need to define P_i^h for a given i to have the whole structure of P_i^h. Let us choose $i = i^*-1$.

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[1] Note that this specification assumes that there is no constraint on the number of occupations to which a worker can apply per unit of time. The only constraint is his educational status.

$$(3)\quad P^T_{i^*-1} = \overbrace{\frac{\alpha^0_{i^*-1}\bar{N}_{i^*-1}}{\alpha^0_{i^*-1}N_{i^*-1}}}^{P^0_{i^*-1}} + (1-P^0_{i^*-1})\overbrace{\frac{\alpha^1_{i^*-1}\bar{N}_{i^*-2}}{\alpha^1_{i^*-1}(1-P^0_{i^*-1})N_{i^*-1}+N_{i^*-2}}}^{P^1_{i^*-1}}$$

$$+(1-P^0_{i^*-1})(1-P^1_{i^*-1})\overbrace{\frac{\alpha^2_{i^*-1}\bar{N}_{i^*-3}}{\alpha^2_{i^*-1}(1-P^0_{i^*-1})(1-P^1_{i^*-1})N_{i^*-1}+\alpha^1_{i^*-2}(1-P^0_{i^*-2})N_{i^*-2}+N_{i^*-3}}}^{P^2_{i^*-1}}$$

$$+(1-P^0_{i^*-1})(1-P^1_{i^*-1})\cdot(1-P^2_{i^*-1})\overbrace{\frac{\alpha^3_{i^*-1}N_{i^*-4}}{\alpha^3_{i^*-1}(1-P^0_{i^*-1})(1-P^1_{i^*-1})(1-P^2_{i^*-1})N_{i^*-1}+\alpha^2_{i^*-2}(1-P^0_{i^*-2})(1-P^1_{i^*-2})N_{i^*-2}+\alpha^1_{i^*-3}(1-P^0_{i^*-3})N_{i\ldots}}}^{P^3_{i^*-1}}$$

$$+\ldots\ldots+(1-P^0_{i^*-1})(1-P^1_{i^*-1})(1-P^2_{i^*-1})\ldots(1-P^{m-1}_{i^*-1})P^m_{i^*-1}$$

we can rewrite expression (3) as follows

$$(4)\quad P^T_{i^*-1} = \sum_{i=0}^{i^*-1}\frac{\prod_{j=0}^{i-1}(1-P^j_{i^*-1})\alpha^i_{i^*-1}\bar{N}_{(i^*-1-i)}}{\sum_{j=0}^{i}\alpha^{i-j}_{i^*-1}\prod_{k=0}^{i-1-j}(1-P^k_{i^*-1-j})N_{i^*-1-j}}$$

Using expression (4) we can evaluate the probability of entering the protected sector given the educational level as a function of:

i) the behavior of employers toward excess education (α^h_i)

ii) the vector of occupations in the protected sector covered under the minimum wage ($\bar{N}_i$)

iii) the vector of labor endowments classified by schooling (N_i). As we proved in section III, IV and V, this structure of probabilities is crucial for the assessment of the relationships between the coefficient $\hat{\beta}$, the coefficient b and the true contribution of education to the economy. If the employers' preference function is such that $\alpha_i^h = \alpha_{i+1}^h$ then we can eliminate all the alpha coefficient's sub-indexes.

In the no preference case ($\alpha_i^h = 1$), expression (4) can be written as

$$(5)\quad P^T_{i^*-1} = \sum_{i=0}^{i^*-1} \frac{\prod_{j=0}^{i-1} (1-P^j_{i^*-1})\bar{N}_{i^*-1-j}}{\sum_{j=0}^{i} \prod_{k=0}^{i-1-j} (1-P^k_{i^*-1-j})N_{i^*-1-j}}$$

This is the basic expression being used in the text to evaluate the probabilities of workers with different educational levels. Note that in this case, the probability of entering a particular occupation is independent of the educational level of the candidate as long as he technologically qualifies for it. Therefore, expression (2) can be rewritten as

$$(6)\quad P^T_i = P_i + (1-P_i)P_{i-1} + (1-P_i)(1-P_{i-1})P_{i-2} + \dots (1-P_i)(1-P_{i-1})\dots(1-P_1)P_0$$

where P_i reflects the probability of entering occupation i for any qualified candidate independently of its educational level. These partial probabilities can be written as the ratio of job positions to qualified candidates:

$$(7)\quad P_{i^*-1} = \frac{\bar{N}_{i^*-1}}{N_{i^*-1}} \qquad (8)\quad P_{i^*-2} = \frac{\bar{N}_{i^*-2}}{N_{i^*-1}+N_{i^*-2}-\bar{N}_{i^*-1}}$$

$$(9)\quad P_{i^*-3} = \frac{\overline{N}_{i^*-3}}{N_{i^*-1}+N_{i^*-2}+N_{i^*-3}-\overline{N}_{i^*-1}-\overline{N}_{i^*-2}}$$

$$(10)\quad P_{i^*-4} = \frac{\overline{N}_{i^*-4}}{N_{i^*-1}+N_{i^*-2}+N_{i^*-3}+N_{i^*-4}-\overline{N}_{i^*-1}-\overline{N}_{i^*-2}-\overline{N}_{i^*-3}}$$

We can obtain a general expression for these partial probabilities:

$$(11)\quad P_{i^*-k} = \frac{\overline{N}_{i^*-k}}{\sum_{j=0}^{k-1} N_{i^*-1-j} - \sum_{j=0}^{k-2} \overline{N}_{i^*-1-j}}$$

From these last expressions, we observe that, if the worker receiving the additional schooling has a level of education i*-k-1, ($\Delta N_{i^*-k-1} = -1$; $\Delta N_{i^*-k} = 1$) the only partial probability that will be affected by this additional schooling is P_{i^*-k}. Therefore, the only workers whose total probabilities (P_i^T) will be affected are those applying to occupation i*-k. Given the educational technological requirement, these workers are those with an educational level higher than the educational level of the receiver. All those workers with an educational level smaller or equal to the educational level of the receiver, will not be affected in their probabilities of entering the protected sector.

We can get an expression for the change in P_{i^*-k}:

$$(12)\quad \Delta P_{i^*-k} = -\frac{1}{\left(\sum_{j=0}^{k-1} N_{i^*-1-j} - \sum_{j=0}^{k-2} \overline{N}_{i^*-1-j}\right)^2}$$

substituting the new value for P_{i^*-k} ($P_{i^*-k}+\Delta P_{i^*-k}$) in expression (6) we obtain the new total probabilities by schooling levels. Subtracting from these new probabilities the old ones we obtain the changes in probabilities according to educational levels due to one worker receiving one additional year of schooling. These changes in probabilities are used in expression (28) in the text to compute the true contribution of education.

REFERENCES

Arrow, K. (1973) "Higher Education as a Filter." Journal of Public Economics 2, No. 3: pp. 193-216.

Becker, G.S. (1964a) Human Capital. New York, Columbia Univerisity Press.

________. (1964b) Human Capital: A Theoretical and Empirical Analysis with Special Reference to Education. National Bureau of Economic Research. New York.

________., and Chiswick, B. (1966) "Education and the Distribution of Earnings." American Economic Review 56: pp. 358-369.

Berg, E. (1969) "Wage Structure in Less Developed Countries" in A.D. Smith (ed.) Wage Policy Issues in Economic Development. London, MacMillan.

________. (1970) "Wages, Policy and Employment in Less Developed Countries." Paper presented to the conference on prospects for employment opportunties in the nineteen seventies. University of Cambridge.

Berg, I. (1971) Education and Jobs: The Great Training Robbery. Boston, Beacon.

Blaugh, M. (1971) "The Rate of Return to Investment in Education in Thailand." A Report to the National Planning Committee on the Third Education Development Plan, Banghok: National Educational Council.

________., Layard, R., and Woodhall, M. (1969) The Causes of Graduate Unemployment in India. Penguin Books, London.

Calabi, A., Lima, R., Uthoff, A., and Zaghen, P. (1974) "Dual Labor Market in Latin America. An Empirical Test." Unpublished manuscript. Stanford, Berkeley.

Carnoy, M. (1967) "Earnings and Schooling in Mexico." Economic Development and Cultural Change 15, No. 4: pp. 408-420.

Corbo, M. (1974) "Educacion, Experiencia y Remuneraciones en Santiago de Chile." Cuadernos de Economia Universidad Catolica de Chile: pp. 47-77.

Duncan, O., Featherman, D., and Duncan, B. (1968) "Socioeconomic Background and Occupational Achievement: Extensions of a Basic Model." Washington: Department of Health, Education, and Welfare. Office of Education, Bureau of Research.

Fields, G. (1974) "The Private Demand for Education in Relation to Labor Market Conditions in Less Developed Countries." The Economic Journal 84, No. 336: pp. 906-926.

Frank, C. (1968) "Urban Unemployment and Economic Growth in Africa." Paper No. 120, Yale Economic Growth Center, New Haven,

Griliches, Z. (1957) "Specification Bias in Estimates of Production Functions." Journal of Farm Economics.

________. (1970) "Notes on the Role of Education in Production Functions and Growth Accounting." In Hansen, L. (ed.) Education and Income and Human Capital, Studies in Income and Wealth Vol. 35, National Bureau of Economic Research, New York: pp. 71-127.

________. (1975) "Estimating the Returns to Schooling: Some Econometric Problems." Discussion paper No. 433. Harvard Institute of Economic Research. Harvard University.

________., and Mason W. (1972) "Education, Income and Ability." The Journal of Political Economy 80, No. 3, Part II: pp. 74-103.

Hansen, W., Weisbrod, B., and Scanlon, W. (1970) "Determinant of Earnings: Does Schooling Really Count?" American Economic Review 60: pp. 409-418.

Hause, J. (1971) "Ability and Schooling as Determinants of Lifetime Earnings or If You are so Smart Why Aren't You Rich?" American Economic Review 61: pp. 289-298.

________. (1972) "Earnings Profile: Ability and Schooling." Journal of Political Economy 80, No. 3, suppl.: pp. 108-138.

Heckman, J. and Polachek, J. (1974) "Empirical Evidence on the Functional Form of the Earnings-Schooling Relationship." Journal of the American Statistical Association 69, No. 346: pp. 350-354.

Isbister, J. "Urban Wages and Employment in a Developing Economy." Economic Development and Cultural Change, October: pp. 24-46.

Krueger, A. (1971) "Turkisk Education and Manpower Development: Some Impressions." In Miller, D.R. (ed.) Essays on Labor Force and Employment in Turkey: pp. 225-256.

Layard, R., and Psacharopoulos, G. (1974) "The Screening Hypothesis and the Returns to Education." Journal of Political Economy 82, No. 5: pp. 985-998.

Mincer, J. (1957) "A Study of Personal Income Distribution." Unpublished Ph.D. dissertation. Columbia University, New York.

________. (1958) "Investment in Human Capital and Personal Income Distribution." Journal of Political Economy 66, No. 4.

________. (1970) "The Distribution of Labor Incomes: A Survey with Special Reference to the Human Capital Approach." Journal of Economic Literature 8: pp. 1-27.

________. (1975) "Education, Experience and the Distribution of Earnings and Employment: An Overview." In Fuster, S.T. (ed.) Education, Income and Human Behavior. A Report prepared for the Carnegie Commission on higher education and the National Bureau of Economic Research, McGraw-Hill.

Pan Eng Fong and Liu Pak Wai (1975) "Socioeconomic Status and Labor Market Success: A Case Study of Manufacturing Workers in Singapore." Working papers series of the research project on education and employment. No. 7. I.L.O.

Psacharopoulos, G. (1973) Returns to Education. Jossey-Bass, Inc. Washington.

________. (1975) Earnings and Education in OECD Countries, OECD, Paris.

Ramos, J. (1970) Labor and Development in Latin America. Columbia University Press, New York.

Rogers, D. (1969) "Private Rates of Return to Education in the U.S.: A Case Study." Yale Economic Essays (Spring) Yale University.

Schultz, T.P. (1968) "Return to Education in Bogota, Colombia." The Rand Corporation, Memorandum R.M. 5645-RC/AID.

Selowsky, M. (1967) "Education and Economic Growth: Some International Comparisons." Unpublished Ph.D. dissertation. University of Chicago.

Skorov, G. (1969) "Highlights of the Symposium in Manpower Aspects of Educational Planning (Unesco, Paris).

Sorkin, A. (1974) "Education and Income in Chile." Journal of Economic Studies 1, No. 1: pp. 45-55.

Taubman, P., and Wales T. (1973) "Higher Education, Mental Ability and Screening." Journal of Political Economy 81: pp. 28-55.

Thias, H., and Carnoy, M. (1969) "Cost Benefit Analysis in Education: A Case Study on Kenya." International Bank for Reconstruction and Development, Report EC-173.

Thurow, L. and Lucas, R. (1972) "The American Distribution of Income. A Structural Problem." Joint Economic Committee, U.S. Congress.

Tinbergen, J. (1973) "Labor with Different Types of Skills and Jobs as Production Factors." De Economist 121, No. 3: pp. 213-225.

Turner, H. and Jackson, D. (1970) "On the determination of the General Wage Level: A World Analysis; or Unlimited Labor Forever." Economic Journal (December): pp. 827-849.

Webb, R. (1974) "Wage Policy and Income Distribution in Developing Countries." Unpublished manuscript prepared for the Princeton-Brookings Income Distribution Study.

Weisbrod, B. and Karpoff, P. (1968) "Monetary Returns to College Education, Student Ability and College Quality." Review of Economics and Statistics (November).

Welch, F. (1971) "Black-White Differences in Returns to Schooling." Manuscript. The National Bureau of Economic Research.

Wiles, P. (1974) "The Correlation between Education and Earnings: The External-Test-Non-Content-Hypothesis (ETNC)." Higher Education 3, No. 1.

Wolfe, D. and Smith J. (1956) "Occupational Value of Education for Superior High School Graduates." Journal of Higher Education (April): pp. 201-213.

ESSAY III

THE ECONOMIC COST OF THE "INTERNAL" BRAIN DRAIN: ITS MAGNITUDE IN DEVELOPING COUNTRIES

ESSAY III

THE ECONOMIC COST OF THE "INTERNAL" BRAIN DRAIN: ITS MAGNITUDE IN DEVELOPING COUNTRIES*

I. INTRODUCTION

The welfare implications of the outflow of highly educated individuals from developing countries, i.e., the "external" brain drain, has received considerable attention in the development literature.[1] This paper calls attention to another type of brain drain that might prove to be of extreme importance in developing countries. By analogy, it might be called the "internal" brain drain, a drain taking place within a country.

The "internal" brain drain can be defined as the misallocation of preschool talents or abilities across educational categories of individuals or alternatively, as the misallocation of educational investment across individuals with different levels of preschool ability.

Two propositions are central in defining such misallocation: first, the hypothesis that preschool ability and education are complementary factors in the determination of the productivity of an individual. Second, the existence of an educational system that implicitly selects students according to factors other than ability, basically the socio-economic status of the family.

For a given degree of "factor complementarity" and "selection error," the extent to which the selection process fails to take into

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*This essay was prepared jointly with Marcelo Selowsky.

[1]See, for example, Johnson (1965, 1967), Grubel (1975), Bhagwati and Rodriguez (1975), McCulloch and Yellen (1975).

account that ability, the above misallocation will depend crucially on the "degree of openness" of the educational system, i.e., the fraction of students that presently proceed to further levels of schooling.

The economic cost of the "internal" brain drain can be thought of as the loss of value added in the existing educational system relative to an optimal system where students (at all schooling levels) are selected according to their preschool ability levels. The educational reform required to transform the present system to the optimal one (or the pure "meritocratic" system) is defined as "full reform."

This paper derives orders of magnitude for the gains in value added due to a "full reform" (or the total elimination of the cost of the internal brain drain) as well as for intermediate or partial reforms. Such reforms can be ranked according to the number of educational levels whose new selection criteria becomes the level of preschool ability. Throughout this evaluation the size or capacity of each educational level is held constant so as to isolate the pure qualitative effects of such reforms.

From the earlier considerations, it is clear that we are here emphasizing the economic or efficiency gains of alternative educational reforms. Some distributional effects are obviously present.

If the existing selection criteria is associated with family income, present educational rents flow towards high income groups. At the other extreme, under a fully reformed educational system (or the pure meritocratic case), these rents would flow toward the high ability groups. As long as these two groups are not identical, the educational reforms described before will have a positive distributive effect.

II. GENERAL FRAMEWORK

An optimal allocation of educational resources across individuals can be defined as the allocation that maximizes the net present value added by those resources. We are interested here in characterizing such optimal allocation under conditions of complementarity between the preschool ability of an individual and his educational level.

If ability and education are complementary factors in the earnings generating function, the productivity of a given amount of education will be larger if invested in individuals with higher abilities. Under this notion of complementarity, an optimal allocation of the existing educational resources among individuals with different abilities generates an optimal ability-education mix. Such a mix will be characterized by a positive and perfect correlation between ability and education, i.e., schooling will become a positive monotonic function of ability. In other words, under such a mix, we will not find a pair of individuals one of whom has higher ability and less schooling than the other.

Under this framework, any other allocation of given educational resources across individuals will be non-optimal in the sense that it will generate a lower net value added. Correspondingly, it will determine a non-optimal ability-education mix, i.e., we could find in such a mix pairs of individuals one of whom has a higher level of ability but less schooling than the other. The economic cost of such misallocation is the loss of value added relative to that previously under an optimal allocation.

The social cost of a suboptimal educational resources allocation depends on two factors. The first one is related to the "quantity" component of the misallocation, the discrepancy between the existing and the optimal ability-education mix. The second factor is related to the "price" component or valuation of a given "quantity" of misallocation. Such valuation will depend on the degree of complementarity between ability and education, the higher such complementarity the larger the cost of a given quantity of misallocation. The degree of complementarity will be basically determined by the functional form and parameter values of the earnings generating function.

The first part of this section analyzes the factors determining the "quantity" aspects of the existing misallocation. The second part discusses the "pricing" aspects as determined by the earnings generating function. The third section defines the concept of an educational reform whose aim is to narrow the gap between the existing and the optimal ability-education mix in order to reduce the "quantity" component of the misallocation.

1. The "Quantity" Component of the Misallocation: The Ability-Education Mix

This section analyzes the determinants of the "quantity" component of the misallocation of existing educational resources by a large fraction of LDC's. For this purpose, it is fundamental to understand the nature of the preschool ability relevant to the earnings function.

Under the existing educational system the amount of schooling an individual receives is positively correlated with his family income.[1]

[1] If we thought of education as a consumption good, and if individuals with high levels of ability have a stronger preference for education then under the existing system ability and schooling would be positively correlated.

To understand the ability-education mix generated by the system it is crucial to identify the factors determining the present distribution of (the relevant concept of) ability across individuals.

One concept of ability, which we denote A, could be conceived as being innate ability determined by genetic endowments. It is assumed to be a random variable normally distributed and independent of family income, with mean $\overline{A}$ and standard deviation σ_A.[1]

(1) $A \sim N(\overline{A}, \sigma_A)$

On the other hand the preschool ability concept could also be conceived as being "partically produced." In this case, the relevant concept of ability (which we denote A*) can be thought of as depending on innate ability or genetic endowments (which still might be assumed to be a random variable independent of family income) as well as on the quality of the environment to which the individual is exposed between birth and school age. The quality of the environment reflects the impact of variables such as nutrition, health, parental attitudes, psychological stimulation, etc. Since the quality of the environment is likely to be positively correlated with family income, we may write:

(2) $A^* = A^*[A, Q(Y)]$

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[1] If nutrition during pregnancy has an effect on such genetic endowment, this variable would be correlated with family income. To our knowledge, the relation between nutrition during pregnancy and the characteristics of the child at birth, although it has been advanced as an hypothesis in the medical field, has not been proved yet.

where A* is the "partly produced" level of ability, A the innate ability and Q the quality of the environment, itself a function of family income (Y).

The implications of choosing one of these two alternative concepts of ability in the definition of a non-optimal ability-education mix are not trivial. These implications are now discussed.

A. Innate Ability (A)

Accepting the innate ability concept implies that the relevant ability is independent of family income, which is the basic variable behind the selection criteria of the existing educational system.

In those levels of schooling where family income constitutes the only selection criterion the expected mean ability of students will be equal to the population mean. Therefore, within these levels, the amount of schooling an individual receives and his ability level are not correlated.[1] This non-correlation between ability and schooling violates the optimal ability-education mix condition and therefore, it implies a misallocation of educational resources.

A different situation characterizes the higher education level. For most countries we can assume that the selection criteria at this level is of a dual nature. First, family income matters because it determines who will apply for admission out of all potential candidates; given the absence of capital markets to invest in education, only those potential candidates who can finance the cost of education out of

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[1]For most developing countries we can think of these levels as being basically primary and secondary education.

family income will effectively apply for admission. Second, ability also matters to the extent to which an excess demand for admission exists (fewer students admitted than the number applying) and ability becomes part of the selection criteria in the process of admission.

This double nature of the selection criteria in higher education induces an expected positive correlation between ability and schooling. However, the existence of potential candidates (secondary graduates) who for economic reasons do not apply for admission implies that this correlation is not perfect. Therefore, there still exists a misallocation of resources at this level. The expected mean ability of students in higher education exceeds the population mean, the opposite being true for those who did apply but were not accepted.

B. "Partly Produced" Ability (A*)

Under the partly produced ability concept, ability is positively correlated with family income. Family income also determines the selection criterion of the existing educational system and therefore the amount of schooling an individual receives.

This dual role played by the income variable implies an expected positive correlation between schooling and ability at all levels of the educational system. This correlation is reinforced at the higher level given the dual nature of the selection process mentioned above.

However, the random element introduced by the innate ability component implies that the positive correlation is not a perfect one, i.e., we can still find two individuals one of whom has less schooling but more produced ability than the other, such an individual might have a low family income but a high level of innate ability. Therefore, even though there exists an expected positive correlation between ability and schooling, we would still expect a misallocation phenomenon. The more important the contribution of innate ability to produced ability, relatively to the contribution of the quality of environment, the larger the magnitude of the expected misallocation.

2. The "Price" Component of the Misallocation: The Earnings Generating Function

The human capital approach provides a theoretical framework within which the relationship between earnings, preschool ability and school can be justified. This approach assumes that wages are equal or proportional to marginal products which in turn are a function of the stock of human capital of each individual. Schooling, preschool ability, experience and other variables are considered as inputs in the production of human capital.[1]

Since we are basically interested in the relationship between schooling and preschool ability in their contribution to earnings we will discuss these two variables neglecting the others. Our emphasis is similar to the one present in the current work being undertaken to isolate the value added of schooling from the contribution of preschool ability.[2]

The most widely used functional form for the earnings function

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[1]See, for example, Mincer (1957, 1958); Ben Porath (1967); Becker (1967).

[2]See, for example, Griliches (1970, 1975); Hause (1971); Griliches and Mason (1972); Taubman and Wales (1973).

is a log linear one:

(3) $\log E = a + bS + cA$

where E represents earnings, S schooling and A some measure of preschool ability.

Mincer (1974) using a schooling investment model, provided a theoretical justification for this semi-log functional form. Heckman and Polachek (1974) empirically verified this hypothesis by using the Box and Cox (1964) transformation to test for the correct functional form. Working with several sets of data they concluded that, under the normality assumption, the semi-log form was the most appropriate simple transformation to be used in the specification of the earnings function.

Neither Mincer's theoretical argument, nor Heckman and Polachek's empirical test explicitly dealt with the preschool ability variable. However, Griliches (1970) using the Malmo data to regress earnings on schooling and preschool ability concluded that the semi-log form fitted the data best on the "standard error in comparable units criterion."[1]

Given these theoretical and empirical arguments, and following most of the literature on the subject, we will adopt the semi-log functional form for the purpose of our analysis. This form implies complementarity between schooling and ability; in other words, the absolute contribution of schooling to earnings is an increasing function of the level of preschool ability of the individual receiving the additional education.[2]

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[1] See Husen (1968) for a description of this data.

[2] From expression (3) $\log E = a + bS + cA$ we can obtain $\frac{\partial^2 E}{\partial S\, \partial A} = Ebc > 0$. Therefore, the larger the ability level the larger the contribution of schooling.

3. Educational Reforms and their Effects on the Ability-Education Mix

As we mentioned earlier, whether the relevant preschool ability (in the context of the earnings function as well as in the selection process) is innate or "partly produced" has important implications for the magnitude of the misallocation phenomena. For the same reasons, the effect of an educational reform on such misallocation will also depend on the relevant concept of ability.

An educational reform at any level of the schooling system implies a change in the selection criteria. A reformed system, rather than selecting students according to family income, will select them entirely on the basis of whichever ability notion is relevant in the context of the earnings function (Productivity).

It is obvious that, associated with each of these reforms, there must exist a program of loans, grants or other economic incentives which induce low income families to send their children to school as long as they are admitted.

The purpose of this section is to discuss the impact of an educational reform on the ability-education mix, and its corresponding misallocation, under the two notions of preschool ability described above.

A. Innate Ability (A)

Figure 1 illustrates the effect of a reform in an educational level previously selecting students exclusively according to family income. We assume the actual size of this level is equal to N_R, namely N_R students are presently enrolled in such level. In the existing system,

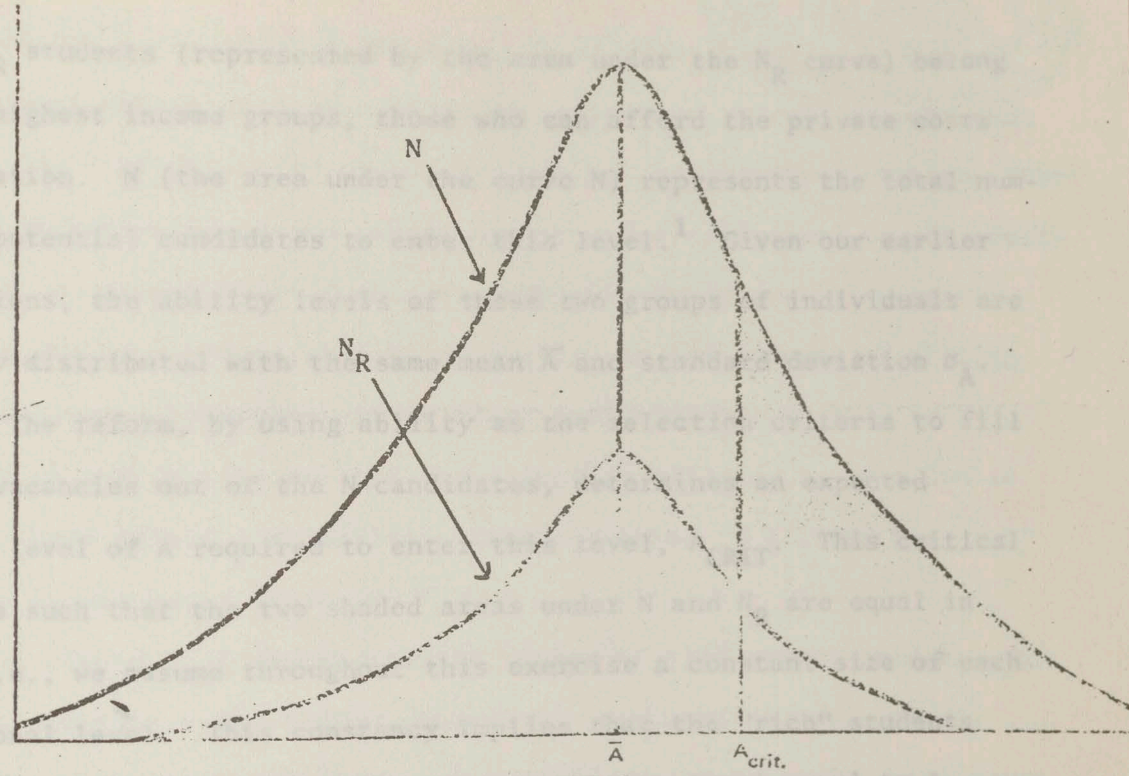
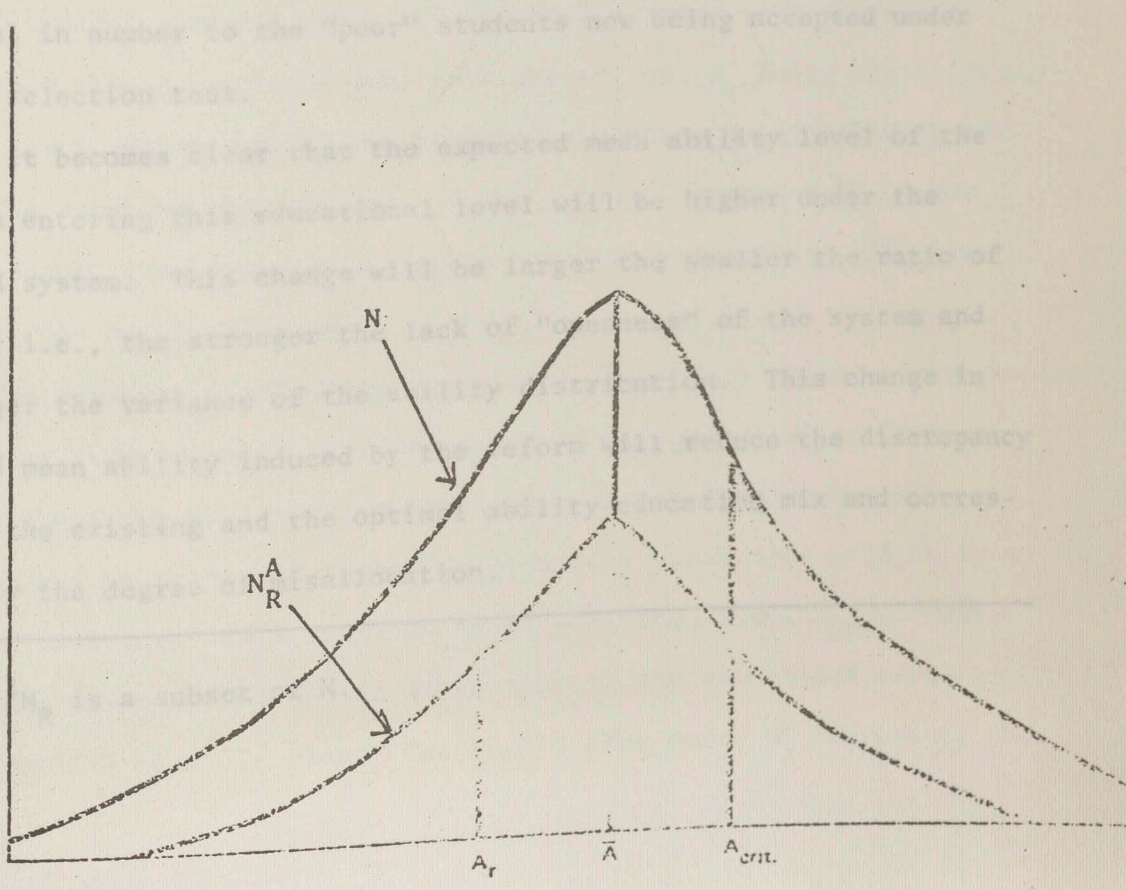


FIGURE 1



these N_R students (represented by the area under the N_R curve) belong to the highest income groups, those who can afford the private costs of education. N (the area under the curve N) represents the total number of potential candidates to enter this level.[1] Given our earlier assumptions, the ability levels of these two groups of individuals are normally distributed with the same mean $\overline{A}$ and standard deviation σ_A.

The reform, by using ability as the selection criteria to fill the N_R vacancies out of the N candidates, determines an expected minimum level of A required to enter this level, A_{CRIT}. This critical value is such that the two shaded areas under N and N_R are equal in size, i.e., we assume throughout this exercise a constant size of each educational level. This constancy implies that the "rich" students displaced by the reform by not having an ability level equal to A_{CRIT} are equal in number to the "poor" students now being accepted under the new selection test.

It becomes clear that the expected mean ability level of the students entering this educational level will be higher under the reformed system. This change will be larger the smaller the ratio of N^R to N, i.e., the stronger the lack of "openness" of the system and the larger the variance of the ability distribution. This change in expected mean ability induced by the reform will reduce the discrepancy between the existing and the optimal ability-education mix and correspondingly the degree of misallocation.

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[1] N_R is a subset of N.

Figure 2 illustrates the somewhat different case of a reform in the higher education system where the selection process is of a dual nature. Given the capacity of the system, not all students who can afford the cost of higher education (those applying for admission) can be admitted. What we assume here is that in most developing countries some selection device based on ability does exist in the process of filling these vacancies. From this, it is clear that higher education is different in the same sense that the selection criteria is of a double nature: There exists a selection criteria related to ability over and above the income based criteria.

In Figure 2, N represents the number of high school graduates or potential candidates for higher education. From this group, only N_R^A students have the minimum income required to become effective candidates. Under the present system, those effective candidates with an ability level higher than A_r are admitted into the system, A_r being the existing critical level determined by the ratio of vacancies to effective candidates. The expected mean ability of the students accepted is higher than the population mean, the opposite being true for those effective candidates not being admitted.

The purpose of reforming this level is to fill those same vacancies by selecting the most able candidates out of all potential candidates, including those who presently do not apply. A constant number of vacancies and an increased number of potential candidates will imply a higher critical level of A required to be admitted, i.e., A_{CRIT}. Once again, given the constant number of vacancies, the two shaded areas in Figure 2 will be equal in size. The shaded area under N_R^A represents the number of "rich" students that were accepted under the old system but are now rejected under the reform, i.e., the displaced "rich" students. The shaded area under N represents the number of students that presently do not apply but would be accepted under the reformed system. As before, the reform will increase the expected mean ability of the students in higher education, reducing the discrepancy between the existing and the optimal ability-education mix and its corresponding degree of misallocation.

If the reforms described above were simultaneously undertaken at all levels of the educational system, the resulting ability-education mix would approach the optimal one and the misallocation cost would disappear. Such a simultaneous implementation of these reforms at all levels constitutes what we call a "full" reform.

B. "Partly Produced" Ability (A*)

A different situation arises when the preschool ability variable has an innate as well as a produced component. Figure 3 shows the "isoquant" map of A* implicit in expression (2). Each iso-ability curve reflects the fact that there are several combinations of innate ability A and family income Y (operating via the quality of environment variable) generating a given level of produced ability A*.

Let us now define Y_{MIN} as the minimum level of family income necessary to enter a particular educational level under the existing system, i.e., the selection process is based entirely on income. The points above the Y_{MIN} line represent the number of "rich" students presently enrolled in that level, N_R. Holding constant the capacity of that level, (equal to N_R), what would be the composition of the admitted

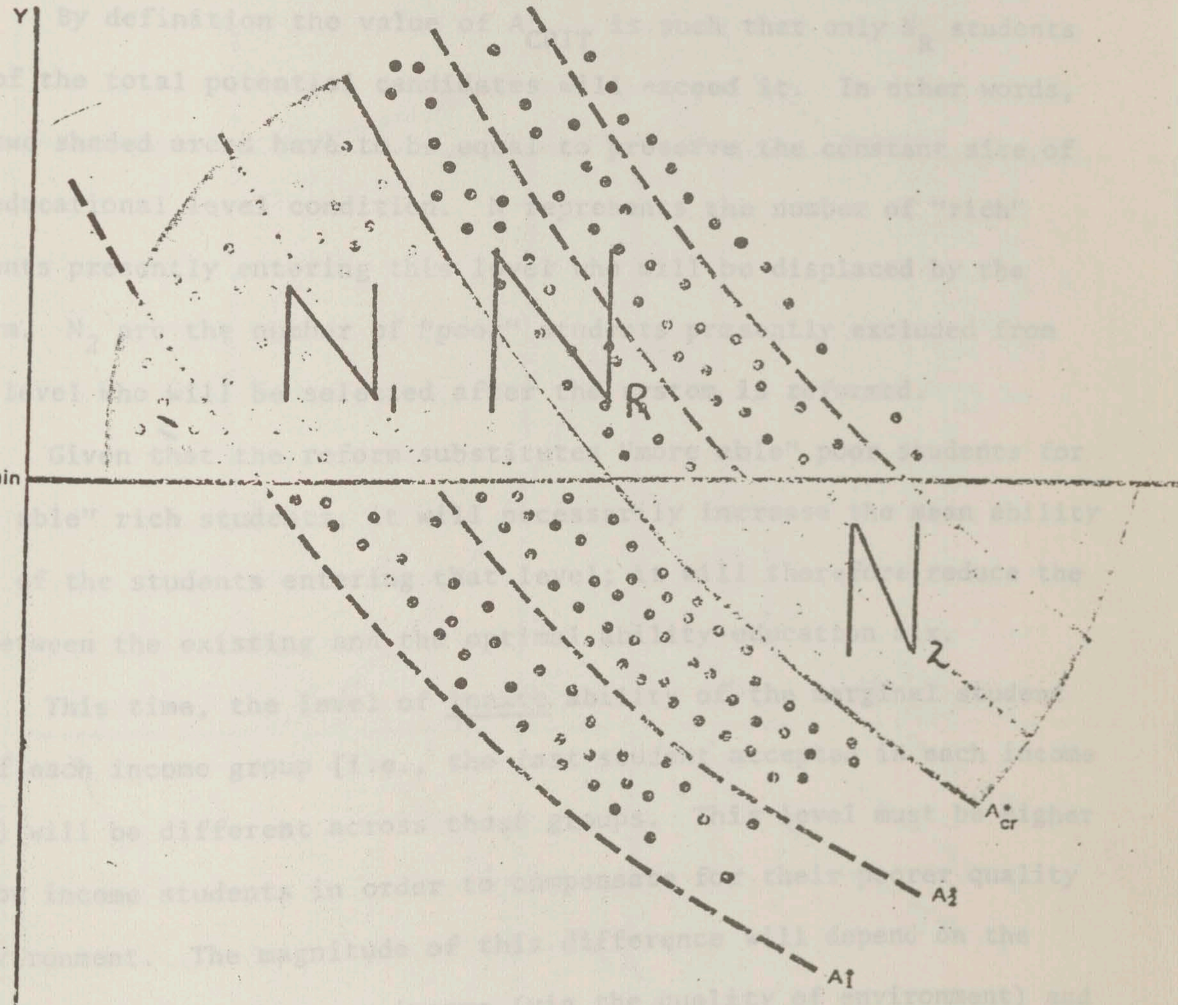


FIGURE 3

students if the selection process were to be based on A* rather than on family income? Such composition will be determined by requiring from the (last) marginal student selected from each income group a critical level of ability A_{CRIT}, equal for all groups.

By definition the value of A_{CRIT} is such that only N_R students out of the total potential candidates will exceed it. In other words, the two shaded areas have to be equal to preserve the constant size of the educational level condition. N represents the number of "rich" students presently entering this level who will be displaced by the reform. N_2 are the number of "poor" students presently excluded from this level who will be selected after the system is reformed.

Given that the reform substitutes "more able" poor students for "less able" rich students, it will necessarily increase the mean ability level of the students entering that level; it will therefore reduce the gap between the existing and the optimal ability-education mix.

This time, the level of <u>innate</u> ability of the marginal student out of each income group (i.e., the last student accepted in each income group) will be different across those groups. This level must be higher for low income students in order to compensate for their poorer quality of environment. The magnitude of this difference will depend on the rate of substitution between income (via the quality of environment) and innate ability in the generation of produced ability A*.

The case of a reform at the higher education level where, as mentioned before, the selection process is of a dual nature, is illustrated in Figure 4. Here we assume that, in the range relevant for higher education, the iso-ability curve becomes vertical at a given level of education, the iso-ability curve becomes vertical at a given level of

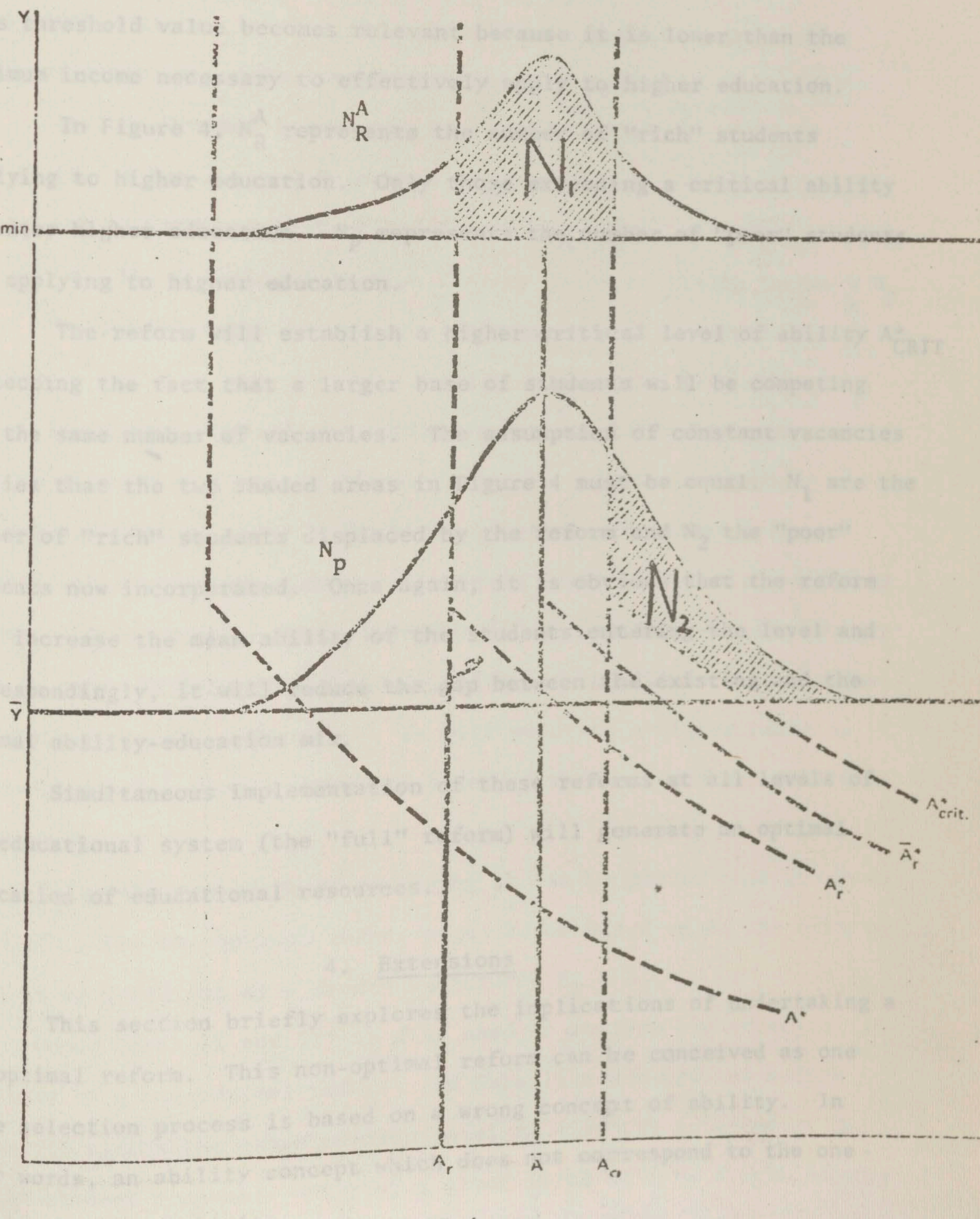


FIGURE 4

income. There exists a threshold value beyond which income (via the quality of the environment) has no effect on ability. In this case this threshold value becomes relevant because it is lower than the minimum income necessary to effectively apply to higher education.

In Figure 4, N_R^A represents the number of "rich" students applying to higher education. Only those exceeding a critical ability A_r^* enter higher education. N_P represents the number of "poor" students not applying to higher education.

The reform will establish a higher critical level of ability A^*_{CRIT} reflecting the fact that a larger base of students will be competing for the same number of vacancies. The assumption of constant vacancies implies that the two shaded areas in Figure 4 must be equal. N_1 are the number of "rich" students displaced by the reform and N_2 the "poor" students now incorporated. Once again, it is obvious that the reform will increase the mean ability of the students entering the level and correspondingly, it will reduce the gap between the existing and the optimal ability-education mix.

Simultaneous implementation of these reforms at all levels of the educational system (the "full" reform) will generate an optimal allocation of educational resources.

4. Extensions

This section briefly explores the implications of undertaking a non-optimal reform. This non-optimal reform can be conceived as one whose selection process is based on a wrong concept of ability. In other words, an ability concept which does not correspond to the one relevant for productivity.

One selection process is defined to be superior to another if it generates a larger net present value for a given capacity constrained educational system. In this conetext, Table I explores, under four different cases, the relationship between:

(a) An Optimal Reform = R_0

(b) A Non-Optimal Reform = R_{NO}

(c) A Random Selection Process = R_R

(d) The Existing Selection Process Based on Family Income = R_E

The relationship between the different selection processes is as follows:

In Cases I and III the optimum reform ought to be based on A* which is a positive function of both A and Y. Given our assumption of independence between A and Y, both the existing and random selection processes will yield the same expected mean level of A for the selected students. This expected level is equal to the population mean. However, the mean level of income of the selected students will be higher under the existing process. Therefore, it will generate a higher expected mean level of A*. We can therefore conclude that under these two cases $R_0 > R_E > R_R$.

Using the same type of reasoning it can be proved that in cases II and IV, where the optimum reform ought to be based on A, the existing system is as efficient as a random selection, $R_E = R_R$.

Under Cases II and III we also need to analyze the relative efficiency of a non-optimal reform. In Case II a non-optimal reform necessarily raises the expected mean level of A of the selected students. A "rich" student presently entering a given level will be displaced only

TABLE 1

THE RELATIONSHIP BETWEEN OPTIMAL AND NON-OPTIMAL REFORMS AND THE EXISTING SYSTEM

Ability Used As Selection Criteria	Ability Relevant for Productivity	
	A*[A, Q(Y)]	A
A*[A, Q(Y)]	(Case I) $R_0 > R_E > R_R$	(Case II) $R_0 > R_{NO} > R_E = R_R$
A	(Case III) $R_0 > R_{NO} \gtrless R_E > R_R$	(Case IV) $R_0 > R_E = R_R$

if a "poor" candidate has a larger value of A*; such a candidate will necessarily have a higher level of A.

In Case III this relationship is less clear. A "rich" student presently entering a particular level might be displaced by a "poor" student with a higher level of A. However, this does not necessarily imply a higher level of A* which is the relevant concept for productivity. In this case, the result of the comparison will depend on the rate of substitution between Y (via Q) and A in the generation of A*. The larger the relative importance of A in the production of A* the more likely that the non-optimal reform will be better than the existing selection process.

III. THE MEASUREMENT OF THE ECONOMIC COST: A METHODOLOGY FOR A SIMPLIFIED CASE

This section develops a methodology to appraise the magnitude of the economic cost of the misallocation phenomenon described earlier. For this purpose two basic simplifying assumptions are being used:

(i) Whatever is the relevant concept of ability in the context of productivity, we will assume it to be a random variable normally distributed and independent of family income.

(ii) The selection process to be used in the educational reforms will be based on that same concept of ability.

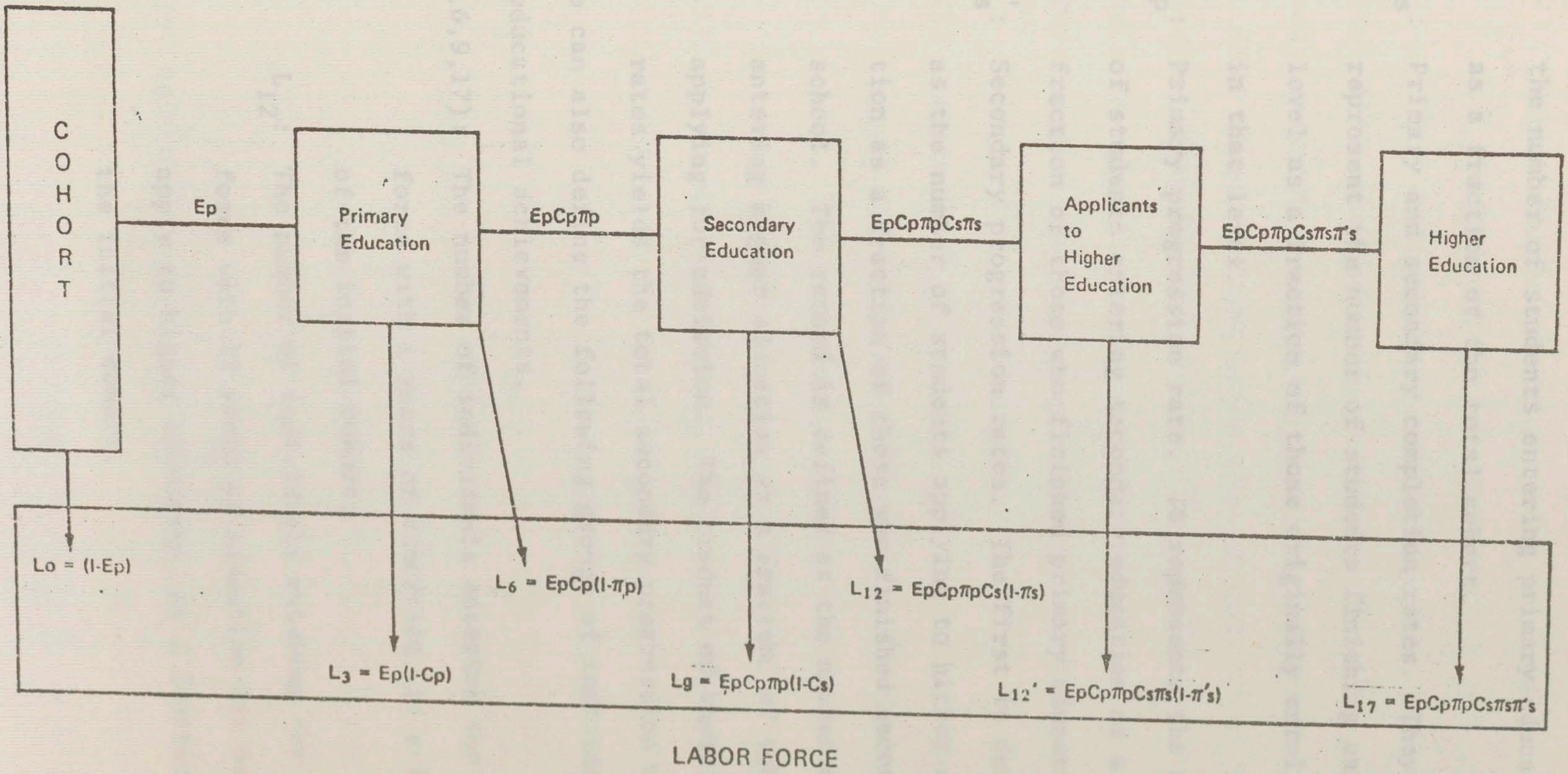
As we mentioned earlier, the economic cost of the misallocation phenomenon can be thought of as the incremental value added of an educational reform being simultaneously undertaken at all levels of the educational system. However, not all reforms need be of such an exhaustive nature. The first part of this section defines a set of alternative reforms ranging from very partial ones to what we have called a "full" reform. The second part provides a methodology to measure the impact of these reforms on the mean ability level of groups of individuals with different levels of schooling. The third part deals specifically with the measurement of the economic cost. The last part explores the impact of these reforms on the rate of return of different levels of the educational system.

1. The Structure of the Educational System and the Educational Reforms

Figure 5 presents the evolution of a given cohort of individuals through the educational system. It shows the flow of students remaining in the system as well as those leaving it at different levels to enter the labor force. If we follow this cohort of individuals, we can define the following parameters characterizing the "openness" of the educational system.

FIGURE 5

FLOW OF STUDENTS AS A FRACTION OF THE INITIAL COHORT



E_p: Primary school enrollment rate. It represents the number of students entering primary education as a fraction of the total cohort.

C_p, C_s: Primary and secondary completion rates. They represent the number of students finishing each level as a fraction of those originally enrolled in that level.

π_p: Primary progression rate. It represents the number of students entering secondary education as a fraction of those who finished primary education.

π_s, π_s': Secondary progression rates. The first is defined as the number of students applying to higher education as a fraction of those who finished secondary school. The second is defined as the number of students entering higher education as a fraction of those applying for admission. The product of these two rates yields the total secondary progression rate.

We can also define the following groups of individuals according to their educational achievements.

L_i (i=0,3,6,9,17): The number of individuals entering the labor force with i years of education, as a fraction of the initial cohort.

L_{12}: The number of individuals entering the labor force with 12 years of education who did not apply to higher education, as a fraction of the initial cohort.

L'_{12}: The number of individuals entering the labor force with 12 years of education who did apply to higher education but were not accepted, as a fraction of the initial cohort.

Five different reforms can be defined according to the number of educational levels whose selection process becomes entirely based on ability. They range from one where only the highest educational level is modified by the reform to one where all levels of the educational system are affected. This last one constitutes what we have called the "full reform" and defines and educational system of a pure meritocratic nature.

(i) Reform 1, (R_1): This reform induces all secondary school graduates (independently of family income) to apply for admission to higher education.

(ii) Reform 2, (R_2): In addition to undertaking Reform 1, it reforms part of the secondary school system. Dropouts from secondary schools (L_9) are now selected according to ability instead of family income. For this purpose, we can conceive secondary education as consisting of two sublevels, where the size of the second one is C_s times the first one.

(iii) Reform 3, (R_s): In addition to undertaking the previous reforms, it introduces further changes in secondary education. Students entering secondary schools are now selected among all primary school graduates according to their ability levels.

(iv) Reform 4, (R_4): In addition to undertaking the previous reforms, it introduces some changes in primary education. Dropouts from primary schools are selected according to their ability levels instead of family income. For this purpose we can again conceive this level as composed by two sublevels where the size of the second one is C_p times the first one.

(v) Reform 5, (R_5): In addition to undertaking the previous reforms, it introduces further changes in primary education. Students entering primary schools are now selected among all children of school age according to their ability levels.

Each of these five reforms defines a given educational state E_i. If we add to these five hypothetical states the existing state E_0 we can define six educational states (E_i, i = 0, ..., 5). The difference in value added between any educational state and the existing one represents the benefit of the reform defining each educational state.

2. The Mean Ability of Students Leaving the Educational System with Different Levels of Schooling: The Effect of the Reforms

In all educational levels where the selection process is based on family income, the expected mean ability of students will be equal to the population mean.

When ability is introduced into the selection process it imposes a critical (minimum) level of that ability that divides the cadidates into two groups: Those with abilities below that critical value and those with abilities above that value. If the mean ability of all candidates is equal to the population mean, the mean ability of the former group will be below the population mean. The opposite will be true for the later group.

The above conclusion will not be necessarily true for a given level of schooling if lower levels have already been "reformed," i.e., their selection criteria is now based on the ability variable. In such a case, the arriving candidates at each level would already have a mean ability above the population mean. Therefore, both the accepted candidates as well as the rejected ones might have mean abilities above the population mean.

It is important to realize that this result can only take place at the expense of generating, at low levels of schooling, a distribution of students with mean abilities substantially below the population mean. The reason is that the mean ability of the total cohort is unaffected by the reforms and is always equal to the population mean. The reforms as such do not "create" abilities but only redistributes them across educational groups or alternatively, they redistribute given educational resources across groups with different abilities.

Once we know the lower and upper ability bounds (A_L, A_U) of an educational level out of a given reform, we can compute the expected mean ability of the students in the level as:

$$(4) \quad \overline{A}_i = \frac{\int_{A_L}^{A_U} Af(A)dA}{\int_{A_L}^{A_U} f(A)dA}$$

where $\overline{A}_i$ is the expected mean ability of group L_i resulting from that particular reform and f(A) is the normal density function. Appendix I provides a detailed explanation of how these bounds are derived for each educational group under alternative reforms as well as the corresponding expected mean ability levels.

3. The Concept of Value Added by a Cohort and the Measurement of the Misallocation Cost

The educational process of a cohort of individuals going through the schooling system can be thought of as an investment project generating a stream of costs and benefits over time.

The costs associated with this kind of investment are of two types: A direct component, which we call K, including building rentals, teachers salaries and other elements required to perform schooling activities. Second, an indirect component represented by the foregone earnings (productivity) of students while they are enrolled in the system. It can be measured by the wages they would have otherwise earned had they entered the labor force. The benefits of such a project are the increased wages (productivity) of those students when they enter the labor force induced by the educational process.

Tables 2 and 3 illustrate these streams of positive and negative flows associated with such an investment. Both tables are equivalent except that Table 3 expresses the wage rate in terms of the schooling

TABLE 2.

NET PRESENT VALUE OF THE VALUE ADDED AT THE EDUCATIONAL SYSTEM. INITIAL CONDITIONS AND MARGINAL CONTRIBUTION OF THE LEARNERS

PERIOD	1	2	3	4	5	6	7	8	9	10	11	12
	$-\frac{E_p(K_p^1+W_o)}{e^{\rho}}$	$-\frac{E_p(K_p^2+W_1)}{e^{2\rho}}$	$-\frac{E_p(K_p^3+W_2)}{e^{3\rho}}$	$-\frac{E_pC_p(K_p^4+W_3)}{e^{4\rho}}$	$-\frac{E_pC_p(K_p^5+W_4)}{e^{5\rho}}$	$-\frac{E_pC_p(K_p^6+W_5)}{e^{6\rho}}$	$-\frac{E_pC_pH_p(K_s^1+W_6)}{e^{7\rho}}$	$-\frac{E_pC_pH_p(K_s^2+W_7)}{e^{8\rho}}$	$-\frac{E_pC_pH_p(K_s^3+W_8)}{e^{9\rho}}$	$-\frac{E_pC_pH_pC_s(K_s^4+W_9)}{e^{10\rho}}$	$-\frac{E_pC_pH_pC_s(K_s^5+W_{10})}{e^{11\rho}}$	$-\frac{E_pC_pH_pC_s(K_s^6+W_{11})}{e^{12\rho}}$
				$+\frac{E_p(1-C_p)(W_3-W_o)}{e^{\ln\rho}e^{3\rho}}$			$+\frac{E_pC_p(1-H_p)(W_6-W_o)}{e^{\ln\rho}e^{6\rho}}$			$+\frac{E_pC_pH_p(1-C_s)(W_9-W_o)}{e^{\ln\rho}e^{9\rho}}$		
	$+\frac{(1-E_p)(W_o'-W_o)}{e^{\ln\rho}}$			$+\frac{E_p(1-C_p)(W_3'-W_3)}{e^{\ln\rho}e^{3\rho}}$			$+\frac{E_pC_p(1-H_p)(W_6'-W_6)}{e^{\ln\rho}e^{6\rho}}+$			$+\frac{E_pC_pH_p(1-C_s)(W_9'-W_9)}{e^{\ln\rho}e^{9\rho}}$		

PERIOD	13	14	15	16	17	18
	$-\frac{E_pC_pH_pC_sH_sH_s'(K_h^1+W_{12})}{e^{13\rho}}$	$-\frac{E_pC_pH_pC_sH_sH_s'(K_h^2+W_{13})}{e^{14\rho}}$	$-\frac{E_pC_pH_pC_sH_sH_s'(K_h^3+W_{14})}{e^{15\rho}}$	$-\frac{E_pC_pH_pC_sH_sH_s'(K_h^4+W_{15})}{e^{16\rho}}$	$-\frac{E_pC_pH_pC_sH_sH_s'(K_h^5+W_{16})}{e^{17\rho}}$	
	$+\frac{E_pC_pH_pC_s(1-H_sH_s')(W_{12}-W_o)}{e^{\ln\rho}e^{12\rho}}$					$+\frac{E_pC_pH_pC_sH_sH_s'(W_{17}-W_o)}{e^{\ln\rho}e^{17\rho}}$
	$+\frac{E_pC_pH_pC_s(1-H_sH_s')(W_{12}'-W_{12})}{e^{\ln\rho}e^{12\rho}}$					$+\frac{E_pC_pH_pC_sH_sH_s'(W_{17}'-W_{17})}{e^{\ln\rho}e^{17\rho}}$

TABLE 3

NET PRESENT VALUE OF THE VALUE ADDED BY THE EDUCATIONAL SYSTEM. INITIAL CONDITIONS AND MARGINAL CONTRIBUTION OF THE REFORMS

PERIOD 1 2 3 4 5 6 7 8 9 10 11 12

$$C\Big[-\frac{E_p[K_p^1+W_o]}{e^{\rho}}-\frac{E_p[K_p^2+e^{b}W_o]}{e^{2\rho}}-\frac{E_p[K_p^3+e^{2b}W_o]}{e^{3\rho}}-\frac{E_pC_p[K_p^4+e^{3b}W_o]}{e^{4\rho}}-\frac{E_pC_p[K_p^5+e^{4b}W_o]}{e^{5\rho}}-\frac{E_pC_p[K_p^6+e^{5b}W_o]}{e^{6\rho}}-\frac{E_pC_pE_p[K_s^1+e^{6b}W_o]}{e^{7\rho}}-\frac{E_pC_pE_p[K_s^2+e^{7b}W_o]}{e^{8\rho}}-\frac{E_pC_pE_p[K_s^3+e^{8b}W_o]}{e^{9\rho}}=\frac{E_pC_pE_pC_s[K_s^4+e^{9b}W_o]}{e^{10\rho}}-\frac{E_pC_pE_pC_s[K_s^5+e^{10b}W_o]}{e^{11\rho}}-\frac{E_pC_pE_pC_s[K_s^6+e^{11b}W_o]}{e^{12\rho}}$$

$$+\frac{E_p(1-C_p)(e^{3b}-1)W_o}{e^{\ln\rho}\,e^{3\rho}}\qquad+\frac{E_pC_p(1-E_p)(e^{6b}-1)W_o}{e^{\ln\rho}\,e^{6\rho}}\qquad\frac{E_pC_pE_p(1-C_s)[e^{9b}-1]W_o}{e^{\ln\rho}\,e^{9\rho}}$$

$$C\Bigg[\boxed{\frac{(1-E_p)(e^{C\dot{A}_o}-1)W_o}{e^{\ln\rho}}}\qquad\boxed{E_p(1-C_p)e^{3b}(e^{C\dot{A}_3}-1)W_o}\qquad\boxed{+\frac{E_pC_p(1-E_p)\,e^{6b}(e^{C\dot{A}_6}-1)W_o}{e^{\ln\rho}\,e^{6\rho}}}\qquad\boxed{\frac{E_pC_pE_p(1-C_s)\,e^{9b}(e^{C\dot{A}_9}-1)W_o}{e^{\ln\rho}\,e^{9\rho}}}$$

PERIOD 13 14 15 16 17 18

$$-\frac{E_pC_pE_pC_sE_sE_h'[K_h^1+e^{12b+C[A_{17}-A_o]}W_o]}{e^{13\rho}}-\frac{E_pC_pE_pC_sE_sE_h'[K_h^2+e^{13b+C[A_{17}-A_o]}W_o]}{e^{14\rho}}-\frac{E_pC_pE_pC_sE_sE_h'[K_h^3+e^{14b+C[A_{17}-A_o]}W_o]}{e^{15\rho}}-\frac{E_pC_pE_pC_sE_sE_h'[K_h^3+e^{15b+C[A_{17}+A_o]}W_o]}{e^{16\rho}}-\frac{E_pC_pE_pC_sE_sE_h'[K_h^5+e^{16b+C[A_{17}-A_o]}W_o]}{e^{17\rho}}$$

$$\frac{E_pC_pE_pC_s(1-E_sE_h')[e^{12b+C[A_{12}-A_o]}-1)W_o]}{e^{\ln\rho}\,e^{12\rho}}\qquad+\frac{E_pC_pE_pC_sE_sE_h'[e^{17b+C[A_{17}-A_o]}-1]W_o}{e^{\ln\rho}\,e^{17\rho}}\Bigg]$$

$$\boxed{\frac{E_pC_pE_pC_s(1-E_sE_h')\,e^{12b+C[A_{12}-A_o]}(e^{C\dot{A}_{12}}-1)W_o}{e^{\ln\rho}\,e^{17\rho}}}\qquad\boxed{\frac{E_pC_pE_pC_sE_sE_h'\,e^{17b+C[A_{17}-A_o]}(e^{C\dot{A}_{17}}-1)W_o}{e^{\ln\rho}\,e^{17\rho}}}\Bigg]$$

and ability coefficients of the earnings function and a "numeraire wage" (W_0) for zero schooling and population mean ability.

The first row in both tables represent the streams of direct costs and foregone earnings. The second row shows the benefits of the educational system in terms of the increased productivity of students entering the labor force. The following symbols are used in the expressions for these streams:

C = size of the cohort of individuals.

K_P^i, K_S^i, K_h^i = direct cost associated with the i^{th} year of primary (P) secondary (S) and higher education (h) respectively.

w_i = yearly wage of an individual with i years of schooling given the present ability-education mix of individuals (leaving the educational system and) entering the labor force.

A_i = expected mean ability level of individuals entering the labor force with i years of schooling under the existing educational system.

b, c = schooling and preschool ability parameters of the earnings function specified in expression (3).

ρ = instantaneous rate of discount.

The algebraic sum of the first two rows in Tables 2 and 3 represent the net present value, NPV, of the value added by the existing educational system.

As mentioned earlier, the existing system determines a given structure of expected mean abilities (the ability-education mix) for individuals entering the labor force with different schooling levels. Each reform affects this structure and determines a new structure of mean abilities by educational groups. The mean ability of those groups with high educational levels will tend to increase and so their level of wages, the opposite being true for the groups with less education.[1]

Given the above considerations, it is clear that each reform will change the net present value of the lifetime production of the cohort. Since the reform has been undertaken holding constant the amount of real resources in the educational system, the entire change in such lifetime production can be attributed to the reform.

Each element of the third row of Table 2 or 3 (expressions in squares) represents the discounted value added of the change in the lifetime production of individuals entering the labor force with different amounts of schooling. The algebraic sum of these expressions represent the total net present value of the contribution of the reform, MPV.[1]

In defining the elements of the third row of Tables 2 and 3, w_i' represents the wage of an individual with i years of schooling given the the new structure of abilities introduced by the reform. $\dot{A}_i$ represents the difference in the mean ability of individuals entering the labor force with i years of schooling between the reformed and existing educational system.

At this stage it is important to point out that the magnitude of the contribution of the reforms are highly sensitive to the contribution of direct costs to the total costs of the educational system. This

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[1]Note that the full reform implies a lower level of ability for those individuals not entering at all the educational system. This negative effect is obviously part of the total effect of that reform.

[2]Note that the value added by the existing educational system plus the incremental value added by the reform i corresponds to the value added of the educational state i ($NPV + MPV_i = NPV_i$).

relationship will become clear in the next section.

4. Extensions: The Impact of the Reforms on the Rates of Returns of Different Levels of the Educational System

The purpose of the reforms is to increase the mean ability of the students remaining in the educational system at the expense of those who leave the system. Therefore, none of the reforms will ever reduce the mean ability of students in a particular level of schooling. Each educational reform will increase the mean ability of the levels being affected by the reform.

The expected mean ability of students at each educational level is a weighted average of the ability levels of the different types of students in that level. These types of students are defined according to the amount of time they will remain in the educational system. The weights are the number of students of each type relative to the total number of students in the level in question.[1] The rate of return to the i^{th} year of schooling can be written as:

$$(5)\quad r_i = \frac{W_i(A) - W_{i-1}(A)}{W_{i-1}(A) + K}$$

where r_i is the rate of return and $W_i(A)$ is the wage of an individual with i years of schooling and an ability level equal to A. K corresponds to the direct cost of that year of schooling. Using expression (5) we can rewrite (5) as:

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[1]See Appendix 3 for the derivation of these mean abilities by educational levels under different reforms.

$$(6)\quad r_i = \frac{b}{1 + \frac{K}{W_{i-1}(A)}} = \frac{b}{1 + \frac{K}{e^{a+b(i-1)+cA}}}$$

In order to assess the impact of changes in the mean ability of students perceiving the i^{th} year of schooling on the rate of return, we differentiate (6) with respect to A:

$$(7)\quad \frac{\frac{\partial r_i}{r_i}}{\partial A} = \frac{c}{1 + \frac{W_{i-1}(A)}{K}} > 0$$

From (7) it is clear that an increase in the mean ability will increase the rate of return, the effect being stronger the larger the coefficient C and the larger the value of K relatively to W_{i-1}. The fact that the ratio of direct cost to foregone income (K/W_{i-1}) conditions the effect of the change in A on the rate of return is of crucial importance.

The importance of the K/W_{i-1} ratio can be clearly seen by returning to expressions (5) and (6). The existence of K (which is independent of A) means that a reform, by increasing A, increases the benefit of education (the numerator of r_i) by a higher proportion than the increases in costs via increases in the foregone income (the denominator of r_i). Under an extreme situation where direct costs are absent (K=0) the rate of return becomes independent of the ability level of students, benefits and costs increase proportionally under increases in A.

From the above consideration we can also conclude that the contribution of the reforms will be larger the higher the ratio of direct costs to foregone income in the educational system. This condition is precisely the one that tends to characterize developing countries.

IV. EMPIRICAL EVALUATION

For the purpose of an empirical evaluation it is useful to divide the data requirements into two groups: Those determining the "quantity" component of the misallocation and those determing its "price" component.

1. Parameters Determing the "Quantity" Component of the Misallocation

As mentioned earlier, this "quantity" component depends on two types of parameters. First, the ones determining the degree of "openness" of the educational system, i.e., the enrollment, progression and completion rates. Second, it depends on the variance characterizing the distribution of preschool abilities in the population.

By looking at enrollment, progression and completion data for 62 countries, it was decided to group them according to regions and per capita income.[1] The resulting groups are the following.[2]

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[1] The selection of these countries was based on their availability of educational data.

[2] The groups are composed of the following countries:
Group I: El Salvador, Haiti, Honduras, Ecuador, and Paraquay.
Group II: Costa Rica, Dominican Republic, Guatemala, Mexico, Nicaragua, Brazil, Chile, Colombia, Peru, Venezuela.
Group III: Burundi, Chad, Ethiopia, Lesotho, Mali, Rwanda, Somalia, Upper Volta.
Group IV: Botswana, Cameroon, C.A.R. Dahomey, Kenya, Malwi, Mauritania,

	Region	Per Capita Income
Group I (La 1)	Latin America	Less than \$400
Group II (La 2)	Latin America	More than \$400
Group III (Af 1)	Africa	Less than \$100
Group IV (Af 2)	Africa	Between \$100 and \$300
Group V (Af 3)	Africa	More than \$300
Group VI (Me 1)	Middle East	
Group VII (As 1)	Asia	Less than \$200
Group VIII (As 2)	Asia	More than \$200

Table 4 shows the average value of the parameters of the educational system for each group of countries. These values represent simple unweighted averages of the corresponding parameters of the countries in the group.[1] Table 5 shows, for each group, the corresponding flow of students as a fraction of the initial cohort.

Regarding the variance of the distribution of ability, the findings tend to support a value of approximately 15 given a population mean of 100. This is based on IQ measurements as the proxy for ability. Therefore, for our purposes, we will assume the ability variable to be normally distributed with $\bar{A} = 100$ and $\sigma_A = 15$.

Morocco, Nigeria, Senegal, Sierra Leone, Sudan, Switzerland, Tanzania, Uganda, Zaire, Benin.
Group V: Algeria, Congo, Gabon, Ghana, Ivory Coast, Liberia, Tunisia, Zambia.
Group VI: Iran, Iraq, Jordan, Lebanon, Turkey.
Group VII: Bangladesh, India, Indonesia, Pakistan.
Group VIII: Taiwan, S. Korea, Malaysia, Philippines, Thailand.

[1] If a particular parameter of one country was not available, that country was not considered in the computation of the average value of that parameter.

Tables 2-A to 7-A in the Statistical Appendix present the structure of expected mean abilities for groups of individuals entering the labor force with different levels of schooling. These results are shown for the different groupings of countries and for the six educational states defined earlier. Table 6 shows the expected absolute changes in those mean abilities as induced by the different reforms. On the other hand, Table 7 presents values of the expected mean abilities of students in each educational level as well as the change in those means resulting from the reforms.

2. Parameters Determining the "Price" Component of the Misallocation

This component depends on three different parameters: the schooling and preschool ability coefficients of the earnings function and the ratio of direct costs of education to foregone income, $k = K/W$.

Significant empirical evidence tends to support the notion that the schooling coefficient is larger in developing countries than in more developed ones.[1] For developing countries this coefficient appears to be bounded by 0.15 and 0.25.[2] For the purpose of our analysis we will use two alternative values, namely 0.15 and 0.20.

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[1]This notion can also be rationalized from a theoretical angle if relative endowments of more to less educated people differ across these types of countries. The return to invest in education will be larger in countries with a lower endowment of relatively educated individuals.

[2]See, for example, Psacharopoulos (1973), Selowsky (1968), Carnoy (1967) and Sorkin (1974).

As mentioned before the rate of return to schooling can be written as:

$$r = \frac{b}{1+K/W}$$

Given the empirical findings concerning r and (K/W) the implicit values of b have usually tended to lie in the 0.20 range.

TABLE 4

PARAMETERS DETERMINING THE STRUCTURE OF FILTERS IN THE EDUCATIONAL SYSTEM. AVERAGE VALUES FOR SELECTED COUNTRY GROUPINGS

Group	E_p	C_p	E_p C_p	Π_p	C_s	Π_s Π'_s	Π_s	Π'_s	E_p C_p Π_p C_s Π_s Π'_s
	(1)	(2)	(3)=(1)x(2)	(4)	(5)	(6)	(7)	(8)=(6):(7)	(9)=(1)x(2)x(4)x(5)x(6)
Group I (La 1)	0.66	0.23	0.15	0.51	0.46	0.52	0.70	0.74	0.018
Group II (La 2)	0.80	0.40	0.32	0.56	0.63	0.63	0.70	0.90	0.07[illegible]
Group III (Af 1)	0.24	0.24	0.06	0.41	0.68	0.50	0.70	0.71	0.008
Group IV (Af 2)	0.47	0.48	0.22	0.31	0.45	0.53	0.70	0.76	0.017
Group V (Af 3)	0.65	0.62	0.40	0.24	0.33	0.45	0.70	0.64	0.015
Group VI (Me 1)	0.66	0.58	0.38	0.75	0.68	0.40	0.70	0.57	0.078
Group VII (As 1)	0.61	0.39	0.24	0.80	0.59	0.49	0.70	0.70	0.055
Group VIII (As 2)	0.93	0.93	0.86	0.82	0.89	0.50	0.70	0.71	0.312

SOURCE: Table 1-A, Statistical Appendix.

TABLE 5

FLOW OF STUDENTS AS A FRACTION OF THE INITIAL COHORT

Group	Cohort	Primary Entering	Primary Finishing	Secondary Entering	Secondary Finishing	Applying to Higher Education	Entering Higher Education
I (La 1)	100	66	15.2	7.8	3.6	2.5	1.8
II (La 2)	100	80	3.2	17.9	11.3	7.9	7.1
III (Af 1)	100	24	5.8	2.4	1.6	1.1	0.8
IV (Af 2)	100	47	22.6	7.0	3.1	2.2	1.7
V (Af 3)	100	65	40.3	9.7	3.2	2.2	1.4
VI (Me 1)	100	66	38.3	28.7	19.5	13.7	7.8
VII (As 1)	100	61	23.8	19.0	11.2	7.9	5.5
VIII (As 2)	100	93	85.6	70.2	62.4	43.7	31.0

Source: Table 4

TABLE 6

EXPECTED ABSOLUTE CHANGES IN MEAN ABILITY OF INDIVIDUALS LEAVING THE EDUCATIONAL SYSTEM CLASSIFIED BY SCHOOLING.

COUNTRY GROUPINGS

	I (La 1)	II (La 2)	III (Af 1)	IV (Af 2)	V (Af 3)	VI (Me 1)	VII (As 1)	VIII (As 2)
				Educational State 1				
L_0	0	0	0	0	0	0	0	0
L_3	0	0	0	0	0	0	0	0
L_6	0	0	0	0	0	0	0	0
L_9	0	0	0	0	0	0	0	0
L_{12}	-5.4	-10.3	-4.9	-5.7	-6.7	-2.8	-4.5	-4.9
L_{17}	5.0	6.1	4.8	5.1	4.5	4.2	4.8	4.8
				Educational State 2				
L_0	0	0	0	0	0	0	0	0
L_3	0	0	0	0	0	0	0	0
L_6	0	0	0	0	0	0	0	0
L_9	-11.0	-15.3	-6.8	-10.7	-8.1	-16.9	-14.2	-25.7
L_{12}	12.9	4.4	7.5	13.1	14.8	7.8	9.5	0.1
L_{17}	13.0	11.6	9.9	13.4	14.7	8.0	10.3	6.1
				Educational State 3				
L_0	0	0	0	0	0	0	0	0
L_3	0	0	0	0	0	0	0	0
L_6	-10.9	-13.4	-9.8	-7.6	-6.1	-19.0	-21.0	-21.9
L_9	5.0	1.8	6.3	11.5	14.0	-5.1	-5.4	-9.1
L_{12}	20.9	13.5	20.9	25.8	25.8	12.6	13.0	7.2
L_{17}	18.4	17.2	17.7	22.4	24.3	10.6	12.4	8.3
				Educational State 4				
L_0	0	0	0	0	0	0	0	0
L_3	-5.9	-9.7	-6.1	-11.5	-15.1	-13.9	-10.4	-27.9
L_6	14.9	7.4	14.6	7.5	4.7	-0.3	5.8	-15.1
L_9	21.6	13.7	20.9	18.7	19.6	5.2	10.3	-8.4
L_{12}	33.6	23.3	32.8	31.6	31.2	19.4	23.7	7.0
L_{17}	27.5	24.9	27.2	27.0	27.4	14.9	19.7	9.1
				Educational State 5				
L_0	-16.1	-21.0	- 6.1	-11.3	-15.9	-16.1	-14.8	-28.9
L_3	3.9	-2.4	23.7	6.0	-1.0	-0.8	3.0	-18.8
L_6	18.2	10.2	26.4	16.1	10.7	6.4	11.9	-11.6
L_9	24.0	15.9	30.9	24.8	23.2	10.6	15.6	-6.2
L_{12}	36.1	25.0	42.1	37.1	34.3	23.6	28.1	8.5
L_{17}	30.3	25.6	34.8	31.4	29.6	17.8	23.0	9.9

SOURCE: Tables 2-A - 7-A, Statistical Appendix

TABLE 7

EXPECTED MEAN ABILITY OF STUDENTS IN EACH LEVEL OF THE EDUCATIONAL SYSTEM

(figures in parenthesis show expected changes relatively to the initial conditions)

COUNTRY GROUPINGS

	Group I	Group II	Group III	Group IV	Group V	Group VI	Group VII	Group VIII
EDUCATIONAL STATE 0								
s_p^1	100	100	100	100	100	100	100	100
s_p^2	100	100	100	100	100	100	100	100
s_p^1	100	100	100	100	100	100	100	100
s_s^2	100	100	100	100	100	100	100	100
s_H	106.5	102.9	107.2	106.1	108.7	110.3	107.4	107.2
EDUCATIONAL STATE 1								
s_p^1	100	100	100	100	100	100	100	100
s_p^2	100	100	100	100	100	100	100	100
s_s^1	100	100	100	100	100	100	100	100
s_s^2	100	100	100	100	100	100	100	100
s_H	111.5 (5.0)	109.0 (6.1)	112.0 (4.8)	111.2 (5.1)	113.2 (4.5)	114.5 (4.2)	112.2 (4.8)	112.0 (4.8)

EDUCATIONAL STATE 2

	Group I	Group II	Group III	Group IV	Group V	Group VI	Group VII	Group VIII
s_p^1	100	100	100	100	100	100	100	100
s_p^2	100	100	100	100	100	100	100	100
s_s^1	100	100	100	100	100	100	100	100
s_s^2	113.1 (13.1)	108.9 (8.9)	108.8 (8.8)	43.2 (13.2)	116.8 (16.8)	107.9 (7.9)	109.8 (9.8)	103.1 (3.1)
s_H	119.5 (13.0)	114.5 (11.6)	117.1 (9.9)	119.5 (13.4)	123.4 (14.7)	118.3 (8.0)	117.7 (10.3)	113.3 (6.1)

TABLE 7 (Continued)

	Group I	Group II	Group III	Group IV	Group V	Group VI	Group VII	Group VIII
EDUCATIONAL STATE 3								
S_p^1	100	100	100	100	100	100	100	100
S_p^2	100	100	100	100	100	100	100	100
S_s^1	111.5 (11.5)	110.6 (10.6)	115.1 (15.1)	117.3 (17.3)	118.4 (18.4)	106.4 (6.4)	103.8 (3.8)	105.9 (5.9)
S_s^2	119.6 (19.6)	115.8 (15.8)	119.3 (19.3)	123.9 (23.9)	127.2 (27.2)	111.8 (11.8)	112.7 (12.7)	107.8 (7.8)
S_H	124.9 (18.4)	120.1 (17.2)	124.9 (17.7)	128.5 (22.4)	133.0 (24.3)	120.9 (10.6)	119.8 (12.4)	115.5 (8.3)
EDUCATIONAL STATE 4								
S_p^1	100	100	100	100	100	100	100	100
S_p^2	120.1 (20.1)	114.7 (14.7)	119.7 (19.7)	112.5 (12.5)	109.2 (9.2)	110.1 (10.1)	114.8 (14.8)	102.4 ((2.4)
S_s^1	125.7 (25.7)	120.4 (20.4)	127.1 (27.1)	123.6 (23.6)	123.6 (23.6)	113.6 (13.6)	117.0 (17.0)	106.3 (6.3)
S_s^2	130.4 (30.4)	124.3 (24.3)	130.1 (30.1)	129.1 (29.1)	131.6 (31.6)	117.6 (17.6)	121.7 (21.7)	108.1 (8.1)
S_H	134.0 (27.5)	127.8 (24.9)	134.4 (27.2)	133.1 (27.0)	136.1 (27.4)	125.2 (14.9)	127.1 (19.7)	116.3 (9.1)
EDUCATIONAL STATE 5								
S_p^1	108.3 (8.3)	105.3 (5.3)	125.3 (25.3)	112.8 (12.8)	108.7 (8.7)	108.4 (8.4)	109.5 (9.5)	102.5 (2.5)
S_p^2	123.0 (23.0)	116.8 (16.8)	130.4 (30.4)	120.1 (20.1)	114.6 (14.6)	115.0 (15.0)	119.6 (19.6)	104.1 (4.1)
S_s^1	128.2 (28.2)	121.9 (21.9)	136.0 (36.0)	129.1 (29.1)	126.9 (26.9)	117.8 (17.8)	121.5 (21.5)	107.6 (7.6)
S_s^2	133.1 (33.1)	125.5 (25.5)	138.5 (38.5)	134.0 (34.0)	134.3 (34.3)	121.3 (21.3)	125.6 (25.6)	109.3 (9.3)
S_H	136.8 (30.3)	128.7 (25.8)	142.0 (34.8)	137.5 (31.4)	138.3 (29.6)	128.1 (17.6)	130.4 (23.0)	117.1 (9.9)

Concerning the ability coefficient it is proper to quote Griliches:

> This is a very difficult topic with a large literature and very little data. (Griliches, 1970, p. 92)

Table 8 presents part of this scarce empirical evidence.

The first three columns of Table 8 present the results of regressing log earnings on ability for different educational levels and using different samples. Such results are reported in Hause (1972). The last two columns of Table 8 show the results of studies regressing earnings on ability and schooling (this last variable is explicitly introduced) reported in Griliches (1970) and Selowsky and Taylor (1973).

Of the first three columns, only the Husen sample provides estimates for low educational levels, the estimates of the columns four and five being relevant for all schooling levels. For the purpose of our empirical evaluations, we will use the estimates presented in columns two, four and five.

Regarding the cost structure of the schooling system, Table (9) presents the ratio of direct costs to foregone income as well as the ratio of direct costs to total costs for a group of selected countries. As can be seen from the table, the ratio of direct costs to foregone income (k) varies widely across educational levels and across countries. Nevertheless, most of the observations lie in the range of 0.5 to 1.0. In other words, direct costs represent from one third to one half of total costs. For the purpose of our analysis we will use two different values representing lower bounds for this parameter namely k = 0.5, 0.7.

TABLE 8

SURVEY OF ABILITY COEFFICIENTS BY SCHOOLING LEVEL.
(ABILITY MEASURED BY I.Q.)

Schooling Level	Rogers Sample	Husen Sample 1	NBER Thorndike	Husen Sample 2	Selowsky-Taylor
Elementary	(1)	(2)	(3)	(4) ↕	(5) ↕
Incomplete		0.0032[1/]			
Complete		0.0032			0.0076[2/]
High-School				0.0042	
Incomplete	0.00024	0.004			
Complete	0.0070	0.010	0.0032		
College					
Incomplete	0.0036		0.0026		
Graduate (One degree)	0.0092	0.011	0.0032		
Graduate (Two degrees)	0.0132		0.0086		
Doctors-Lawyers			0.0036		

TABLE 8 (Continued)

SOURCES: - Column (1)-(3) Results from Rogers Sample, Husen's Sample, NBER - Thorndike Sample respectively as reported in HAUSE (1972)

- Column (4) Results from Husen's sample as reported in Griliches (1970)

- Column (5) Results from Kardonsky, V., Undurraga, O. Seguir, T., Alvadado, L., and Manterola A. Sample "Efecto de la Desnutricion en el Desarrollo Intelectual Global" Santiago: Departamento de Psicologia, Universidad de Chile, Unidad de Nutricion. Hospital Roberto del Rio (1970) as reported in Selowsky and Taylor (1973).

1/ This figure was obtained from the regression of log earnings (1968) on TST-38 assuming that, in that range of schooling one standart deviation in either measure of ability (TST-38 or IQ measured 10 years later) has the same impact on earnings.

2/ Selowsky and Taylor used a doble log earnings function in their study. The above figure was derived evaluating that function at the mean level of the variables.

TABLE 9

RELATION BETWEEN FOREGONE INCOME (FI) AND DIRECT COSTS OF SCHOOLING (DC)

	$\left(\frac{DC}{DC+FI}\right)$			$\left(\frac{DC}{FI}\right)$		
COUNTRIES	Primary	Secondary	Higher	Primary	Secondary	Higher
United States	0.95	0.38	0.37	18.7	0.60	0.58
Great Britain		0.28	0.56		0.38	1.26
Norway		0.21	0.29		0.26	0.41
Denmark			0.39			0.63
Netherlands			0.69			2.19
Belgium						
Puerto Rico		0.60			1.5	
Mexico	0.43	0.39	0.35	0.76	0.61	0.54
Venezuela		0.19	0.30		0.24	0.42
Colombia	0.83	0.39	0.47	5.04	0.64	0.89
Chile		0.34	0.51		0.51	1.05
India	0.48	0.44	0.53	0.94	0.77	1.12
Malaysia		0.61	0.80		1.59	4.13
S. Korea		0.31	0.38		0.44	0.61
Nigeria	0.47	0.41	0.72	0.90	0.68	2.60
Ghana	0.69	0.37	0.75	2.25	0.59	3.10
Kenya		0.56	0.76		1.29	3.30
Uganda		0.57	0.66		1.34	1.91

Source: Psacharopolos (1973)

V. THE RESULTS

This section presents some empirical results in two different forms. First, and making use of the concept of a cohort, it derives values for the incremental value added--induced by different reforms--as a percentage of the value added of the existing educational system. Second, it shows the increase in the long run contribution of labor to GNP.

1. Changes in the Discounted Value Added of the Educational System

The parameters which have first order effects on the value added calculations are the ability coefficient (c) and the ratio of direct costs to foregone income (k). Therefore, the sensitivity analysis concentrates on these two parameters.

Tables 10, 11 and 12 present results of those changes--resulting from different reforms and for different country groupings--for alternative values of the coefficients c and k. The first two tables use a constant value of c, independent of the level of schooling. Table 12 presents results when that coefficient changes across educational levels.

The structure of the educational system or its relative "openness" at different levels, becomes extremely significant in assessing the impact of alternative reforms. The difference in the contribution of two consecutive reform measures the impact of extending the reform to one further level of schooling.[1] The stronger the lack of openness at

[1]It can be proved that NPV_2-NPV_1 reflects the contribution of extending the reform to the second phase of secondary education; NPV_3-NPV_2 measures the impact of extending the reform to the first phase of secondary education; NPV_4 - NPV_3 reflects the contribution of extending the reform to the second phase of primary education. Finally NPV_5-NPV_4 reflects the impact of extending the reform to the first phase of primary education.

that particular level the larger will be the difference in the contribution of the two reforms.

The effect of the structure (or relative openness at different levels) of the system can be illustrated by comparing two extreme types of country groupings, Af 1 and As 2. Af 1 is characterized by an extremely "strangled" primary education level relative to higher levels of schooling. The reverse is true for As 2.[1]

For Af 1, the first three reforms have a rather small contribution while the last two increase that contribution by a significant amount. The contribution of Reform V (which differs from Reform III by its inclusion of the elementary level of schooling) is approximately seven times larger than the contribution of Reform III (Tables 10 and 11).

For As 2, the situation is exactly the opposite. The first three reforms represent a large fraction of the total potential gains while the last two have a rather small marginal contribution. Reform V has a contribution only 1.2 times larger than Reform III in Tables 10 and 11.

In general, we can conclude that the contribution of the reforms are extremely significant. For a value of k = 0.5 --which represents a lower bound for this parameter--the contribution of a full reform ranges from 26 percent to 63 percent, from 50 percent to 124 percent and from 49 percent to 145 percent for Tables 10, 11, and 12. These contributions are significantly larger for k = 0.7.

The conclusion is that for a wide variety of cases the full reform will double the value added of the educational system.

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[1]See Table 4.

TABLE 10

INCREASE IN THE (discounted) VALUE ADDED OF THE EDUCATIONAL SYSTEM

($b = 0.20$; $\rho^* = 0.10$,[1/] $c = 0.0042$)

COUNTRY GROUPINGS

	Educational Reforms	I (La 1)	II (La 2)	III (Af 1)	IV (Af 2)	V (Af 3)	VI (Me)	VII (As 1)	VIII (As 2)
k=0.5	I	0.8%	3.2%	0.9%	0.9%	0.1%	2.9%	2.7%	7.7%
	II	3.6%	8.5%	5.1%	4.2%	2.5%	10.1%	9.4%	13.6%
	III	8.0%	17.3%	8.9%	11.0%	7.6%	18.4%	14.0%	33.0%
	IV	18.9%	34.3%	19.9%	20.0%	15.4%	35.7%	32.3%	34.5%
	V	27.8%	41.0%	63.3%	36.4%	25.8%	52.4%	49.7%	40.2%
k=0.7	I	1.8%	20.9%	2.1%	2.4%	0.1%	- 2/	35.7%	-
	II	7.8%	56.0%	11.3%	10.6%	5.9%	-	125.5%	-
	III	17.3%	113.7%	20.0%	27.8%	17.8%	-	189.2%	-
	IV	40.9%	225.6%	44.6%	50.6%	35.8%	-	432.1%	-
	V	60.2%	269.7%	141.4%	91.6%	59.8%	-	665.9%	-

1/ ρ^* is the discret discount rate. It is equivalent to an instantaneous rate of 0.095.

2/ Empty spaces reflect a negative initial value added of the educational system.

TABLE 11

INCREASE IN THE (Discounted) VALUE ADDED OF THE EDUCATIONAL SYSTEM

($b = 0.20$; $\rho^* = 0.10$; $c = 0.0076$)

COUNTRY GROUPINGS

Educational Reforms	I (La 1)	II (La 2)	III (Af 1)	IV (Af 2)	V (Af 3)	VI (Me)	VII (As 1)	VIII (As 2)
I	1.7%	6.2%	1.9%	1.9%	0.1%	5.7%	5.2%	15.0%
II	7.0%	16.3%	9.4%	8.1%	5.1%	19.1%	17.9%	25.6%
III	15.4%	32.9%	17.1%	21.5%	15.2%	34.3%	26.7%	59.4%
IV	36.9%	65.7%	38.9%	39.1%	30.3%	66.4%	61.2%	62.2%
V	54.4%	78.4%	124.1%	70.7%	50.0%	97.3%	94.1%	72.2%
I	3.5%	37.8%	4.1%	4.8%	0.3%	-	54.4%	--
II	15.0%	99.7%	20.7%	20.3%	11.6%	-	185.8%	-
III	32.9%	201.4%	37.8%	53.4%	35.0%	-	277.4%	-
IV	79.1%	402.2%	85.8%	97.5%	69.7%	-	635.9%	-
V	116.4%	480.2%	274.0%	176.0%	114.6%	-	976.4%	-

TABLE 12

INCREASE IN THE (discounted) VALUE ADDED OF THE EDUCATIONAL SYSTEM

$(b = 0.20;\ \rho^{*} = 0.10;\ c_0 = c_3 = c_6 = 0.0032;\ c_9 = 0.004;\ c_{12} = 0.01;\ c_{17} = 0.011)$

COUNTRY GROUPINGS

	Educational Reforms	I (La 1)	II (La 2)	III (Af 1)	IV (Af 2)	V (Af 3)	VI (Me)	VII (As 1)	VIII (As 2)
	I	2.8%	10.2%	3.1%	3.2%	0.5%	9.3%	8.6%	30.4%
	II	15.9%	34.3%	15.2%	18.3%	12.9%	42.6%	39.5%	61.4%
=0.5	III	27.9%	63.0%	32.6%	39.4%	28.3%	67.8%	53.5%	123.0%
	IV	50.9%	105.5%	58.0%	54.1%	38.4%	110.0%	102.4%	131.3%
	V	61.4%	114.5%	103.3%	73.8%	48.7%	141.7%	131.1%	145.1%
	I	5.8%	57.7%	6.8%	7.8%	1.3%	-	66.2%	-
	II	33.6%	193.4%	33.0%	44.7%	29.2%	-	302.8%	-
k=0.7	III	59.0%	355.1%	70.8%	96.2%	64.2%	-	410.8%	-
	IV	107.6%	595.0%	125.8%	132.3%	86.9%	-	785.7%	-
	V	129.7%	645.5%	224.1%	180.5%	110.2%	-	1005.7%	-

2. Changes in the Long Run Contributions of Labor

A second (and perhaps more illustrative) form of presenting the impact of the reforms is in terms of their effect on the contribuiton of labor to the economy. We can ask ourselves the following question: What will be the increase in the long run contribution of labor to the economy once all of the effects of a continuing full reform have taken place?

If enrollment, completion and progression rates remain constant over time, the educational structure of the labor force will tend to approach the educational distribution of the flows of students leaving the educational system. In this context, we can define the long run as that run where the educational distribution of the labor force becomes equal to the distribution of the streams of students leaving the schooling system.

The contribution of labor to output (Δ) under any educational system can, in the long run, be written as:

$$(8)\quad \Delta = LW_0[(1-E_p)e^{c\dot{A}_0} + E_p(1-C_p)e^{3b+c\dot{A}_3} + E_pC_p(1-\Pi_p)e^{6b+c\dot{A}_6} + E_pC_p\Pi_p(1-C_s)e^{9b+c\dot{A}_9} + E_pC_p\Pi_pC_s(1-\Pi_s\Pi'_s)e^{12b+c(A_{12}-A_0)+c\dot{A}_{12}} + E_pC_p\Pi_pC_s\Pi_s\Pi'_s\, e^{17b+c(A_{17}-A_0)+c\dot{A}_{17}}$$

where L represents the size of the labor force and W_0 the wage of a worker with no education and an ability level equal to the population mean.

Table 13 presents the change in the long run contribution of labor to the economy of a fully reformed system relative to the contribution that would have existed in the absence of such reform. Such changes are presented in column (1). Column (2) shows the long run effect on GNP. Except for the last country grouping, the results are fairly constant. This is despite the fact that we are comparing groups of countries with wide differences in their degree of "educational openness."

The constancy of this type of contribution across countries is the result of two forces working in opposite directions. The stronger the lack of openness of the system the larger are the induced changes in mean abilities and the larger the contribution of the reform. However, given the size of the educational system, the larger the lack of openness of the system the smaller will be the relative number of individuals with relatively high levels of schooling that are affected by the reforms.

The results of Table 13 show that the long run effects on GNP of having a fully reformed educational system are substantial, at least if compared with other misallocation estimates.[1] Harberger's (1959) estimates of the cost of the misallocation of capital and labor, under extremely large assumption concerning distortions in the Chilean economy, yield values between 9 percent and 15 percent of GNP. Balassa and Associates (1971) obtain values up to 2.4 percent of GNP for the welfare loss due to trade protection in selected developing countries. Dougherty and Selowsky's (1973) estimates of the welfare cost of the misallocation of labor across sectors in the urban economy of Colombia yielded values of less than 2 percent of the urban GNP. From the

[1]Notice however that the implementation of the reforms could imply important administrative costs. In those circumstances we can not conceive such reforms as completely costless.

above analysis we can conclude that in developing countries a more meritocratic educational system is not only desirable from an equity point of view but from an efficiency point as well.

TABLE 13

LONG RUN CHANGES INDUCED BY A FULLY REFORMED EDUCATIONAL SYSTEM

(b = 0.20; c = 0.0076)

Country Group	On the Wage Bill (1)	On GNP (Labor share = 0.5) (2)
La 1	11.2%	5.6%
La 2	13.4%	6.7%
Af 1	11.1%	5.5%
Af 2	11.8%	5.9%
Af 3	10.2%	5.1%
Me	11.5%	5.7%
As 1	12.9%	6.4%
As 2	6.0%	3.0%

APPENDIX 1

EXPECTED MEAN ABILITY OF STUDENTS LEAVING THE EDUCATIONAL SYSTEM WITH DIFFERENT DEGREES OF SCHOOLING

Let us assume that the ability level (A) of an individual is a random variable normally distributed with mean $\overline{A}$ and standard deviation σ_A.

(1) $A \simeq N[\overline{A}, \sigma_A]$

In order to obtain the expected mean levels of ability of the different groups under different educational states we need to define the expected upper and lower bound of the ability level for each group and then obtain the weighted average level of ability within the above interval.

If the criteria to select individuals for different educational groups is random or independent of the ability level then the expected mean ability of the different groups will be equal to the population mean. However, if the selection criteria is based on the ability level, different educational groups will have different expected ability levels. Since the reforms as such do not "create ability" but only redistribute ability across educational groups, the weighted average of the ability levels of the different groups will always be equal to the population mean (the weights being the percentage of people in each group).

1) EDUCATIONAL STATE 0: Initial Conditions

Up to the higher educational level, those students continuing in the educational system and those leaving the educational system to enter the labor force are selected according to income and not ability. Given that these two variables are supposed to be independently distributed, we can write:

2) $$\bar{A}^o_o = \bar{A}^o_3 = \bar{A}^o_6 = \bar{A}^o_9 = \bar{A}^o_{12} = \bar{A}$$

Applicants to higher education will be divided in two groups according to their ability levels. The best Π'_s % will enter higher education, the remaining $(1-\Pi'_s)$ % will enter the labor force.

Let f(A) be the normal density function. We define A^o_h as the minimum level of ability necessary to enter higher education such that

3) $$\int_{A^o_h}^{\infty} f(A)\, dA = \Pi'_s$$

using this lower ability bound we obtain the expected mean ability of the two groups defined above:

4) $$\bar{A}^o_{17} = \frac{\int_{A^o_h}^{\infty} Af(A)\, dA}{\int_{A^o_h}^{\infty} f(A)\, dA}$$

5) $$\bar{A}^o_{12'} = \frac{\int_{-\infty}^{A^o_h} Af(A)\, dA}{\int_{-\infty}^{A^o_h} f(A)\, dA}$$

2. EDUCATIONAL STATE I : Reform I

Up to the higher educational level ability does not enter the selection process, therefore

6) $$\bar{A}^1_o = \bar{A}^1_3 = \bar{A}^1_6 = A^1_9 = \bar{A}$$

We define A^1_h = the minimum level of ability to enter higher education such that

7) $$\int_{A^1_h}^{\infty} f(A)\, dA = \Pi_s \Pi'_s$$

using this ability limit we obtain

8) $$\bar{A}^1_{17} = \frac{\int_{A'_h}^{\infty} Af(A)\, dA}{\int_{A^1_h}^{\infty} A\, f(A) dA}$$

9) $$\bar{A}^1_{12} = - \frac{\int_{\infty}^{A^1_h} A\, f(A)\, dA}{\int_{-\infty}^{A^1_h} f(A)\, dA}$$

3. <u>EDUCATIONAL STATE II</u> : Reform II

Up to the second phase of secondary education the ability level does not enter the selection process, therefore

10) $$\bar{A}^2_o = \bar{A}^2_3 = \bar{A}^2_6 = \bar{A}$$

We define A^2_{s2}, A^2_h as the minimum level of ability necessary to enter the second phase of secondary education and higher education respectively such that:

$$(11) \qquad \int_{A^2_{s2}}^{A^2_h} f(A)\, dA = C_s\,(1-\Pi_s\Pi'_s)$$

$$(12) \qquad \int_{A^2_h}^{\infty} f(A)\, dA = C_s\;\Pi_s\Pi'_s$$

using these ability limits we obtain

$$(13) \qquad \bar{A}^2_{17} = \frac{\int_{A^2_h}^{\infty} Af(A)\, dA}{\int_{A^2_h}^{\infty} f(A)\, dA}$$

$$(14) \qquad \bar{A}^2_{12} = \frac{\int_{A^2_{s2}}^{A^2_h} Af(A)\, dA}{\int_{A^2_{s2}}^{A^2_h} f(A)\, dA}$$

$$(15) \qquad \bar{A}^2_{9} = \frac{\int_{-\infty}^{A^2_{s2}} Af(A)\, dA}{\int_{-\infty}^{A^2_{s2}} f(A)\, dA}$$

4. EDUCATIONAL STATE III : Reform III

Up to secondary education the selection process is independent of ability, therefore

$$\bar{A}_o^3 = \bar{A}_3^3 = \bar{A} \tag{16}$$

We define A_{s1}^3, A_{s2}^3, A_h^3 as the minimum level of ability necessary to enter secondary education, second phase of secondary education and higher education respectively such that

$$\int_{A_{s1}^3}^{A_{s2}^3} f(A)\, dA = \Pi_p (1-C_s) \tag{17}$$

$$\int_{A_{s2}^3}^{A_h^3} f(A)\, dA = \Pi_p\, C_s (1-\Pi_s \Pi_s') \tag{18}$$

$$\int_{A_h^3}^{\infty} f(A)\, dA = \Pi_p\, C_s\, \Pi_s \Pi_s' \tag{19}$$

using these ability levels we obtain:

$$\bar{A}_{17}^3 = \frac{\int_{A_h^3}^{\infty} Af(A)\, dA}{\int_{A_h^3}^{\infty} f(A)\, dA} \tag{20}$$

(21) $$\bar{A}^3_{12} = \frac{\int_{A^3_{s2}}^{A^3_h} Af(A)\, dA}{\int_{A^3_{s2}}^{A^3_h} f(A)\, dA}$$

(22) $$\bar{A}^3_9 = \frac{\int_{A^3_{s1}}^{A^3_{s2}} Af(A)\, dA}{\int_{A^3_{s1}}^{A^3_{s2}} f(A)\, dA}$$

(23) $$\bar{A}^3_6 = \frac{\int_{-\infty}^{A^3_{s1}} Af(A)\, dA}{\int_{-\infty}^{A^3_{s1}} f(A)\, dA}$$

5. EDUCATIONAL STATE IV : Reform IV

Up to the second part of primary education the selection process does not take into account the ability level, therefore

$$\bar{A}^4_o = \bar{A}$$

We define A^4_{p2}, A^4_{s1}, A^4_{s2}, A^4_h as the minimum level of ability necessary to enter the second part of primary education, secondary education, second part of secondary education and higher education respectively such that

(24) $$\int_{A^4_{p2}}^{A^4_{s1}} f(A)\, dA = C_p\,(1-\Pi_p)$$

(25) $$\int_{A^4_{s1}}^{A^4_{s2}} f(A)\, dA = C_p\Pi_p(1-C_s)$$

(26) $$\int_{A_{s2}}^{A^4_h} f(A)\, dA = C_p\Pi_pC_s(1-\Pi_s\Pi_s')$$

(27) $$\int_{A^4_h}^{\infty} f(A)\, dA = C_p\Pi_pC_s\Pi_s\Pi_s'$$

Using these ability levels we obtain:

(28) $$\bar{A}^4_{17} = \frac{\int_{A^4_h}^{\infty} Af(A)\, dA}{\int_{A^4_h}^{\infty} f(A)\, dA}$$

(29) $$\bar{A}^4_{12} = \frac{\int_{A^4_{s2}}^{A^4_h} Af(A)\, dA}{\int_{A^4_{s2}}^{A^4_h} f(A)\, dA}$$

(30) $$\bar{A}^4_9 = \frac{\int_{A^4_{s1}}^{A^4_{s2}} Af(A)\, dA}{\int_{A^4_{s1}}^{A^4_{s2}} f(A)\, dA}$$

(31) $$\bar{A}^4_6 = \frac{\int_{A^4_{p2}}^{A^4_{s1}} Af(A)\, dA}{\int_{A^4_{p2}}^{A^4_{s1}} f(A)\, dA}$$

(32) $$\bar{A}^4_3 = \frac{\int_{-\infty}^{A^4_{p2}} Af(A)\, dA}{\int_{-\infty}^{A^4_{p2}} f(A)\, dA}$$

5. EDUCATIONAL STATE V : Reform V

The selection process is entirely based on the ability level in all educational categories.

We define $A^5_{p1}, A^5_{p2}, A^5_{s1}, A^5_{s2}, A^5_h$

as the minimum level of ability necessary to enter primary education, second part of primary education, secondary education, second part of secondary education and higher education respectively such that

(33) $$\int_{A^5_{p1}}^{A^5_{p2}} f(A)\, dA = E_p(1-C_p)$$

(34) $$\int_{A^5_{p2}}^{A^5_{s1}} f(A)\, dA = E_p C_p (1-\Pi_p)$$

(35) $$\int_{A^5_{s1}}^{A^5_{s1}} f(A)\, dA = E_p C_p \Pi_p (1-C_s)$$

(36) $$\int_{A^5_{s2}}^{A^5_{h}} f(A)\, dA = E_p C_p \Pi_p C_s (1-\Pi_s \Pi_s')$$

(37) $$\int_{A^3_{h}}^{\infty} f(A)\, dA = E_p C_p \Pi_p C_s \Pi_s \Pi_s'$$

Using these ability limits we obtain

(38) $$\bar{A}^5_{17} = \frac{\int_{A^5_h}^{\infty} Af(A)\, dA}{\int_{A^5_h}^{\infty} f(A)\, dA}$$

(39) $$\bar{A}^5_{12} = \frac{\int_{A^5_{s2}}^{A^5_h} Af(A)\, dA}{\int_{A^5_{s2}}^{A^5_h} f(A)\, dA}$$

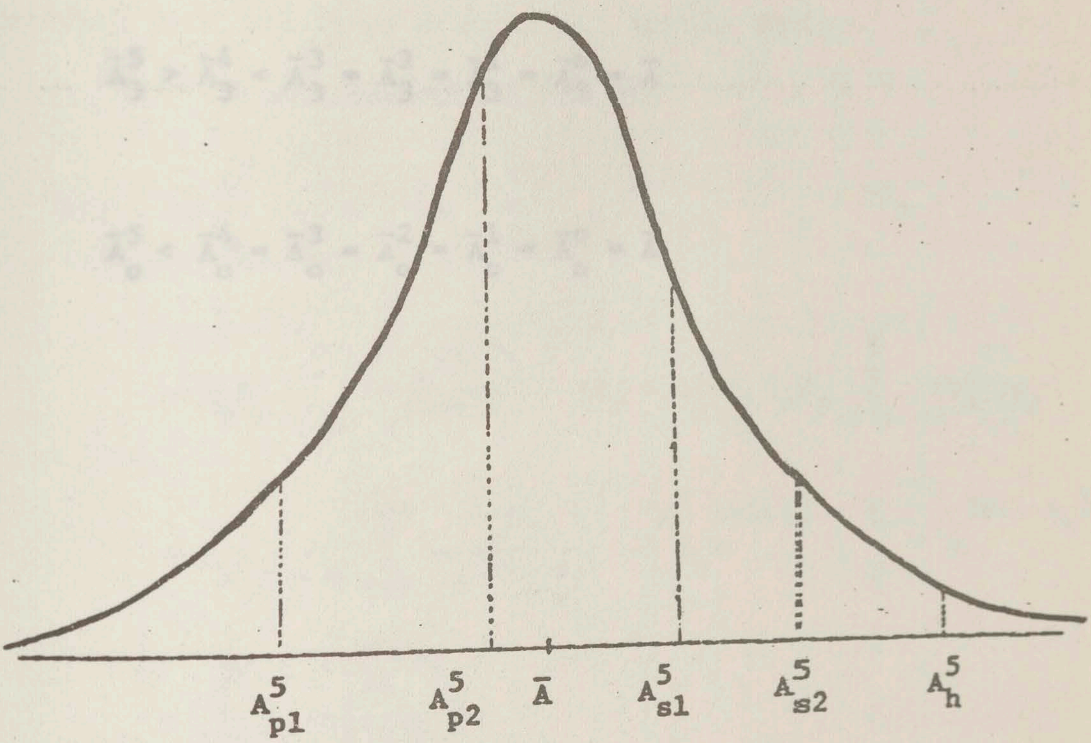
(40) $$\bar{A}_9^5 = \frac{\int_{A_{s1}^5}^{A_{s2}^5} Af(A)\, dA}{\int_{A_{s1}^5}^{A_{s2}^5} f(A)\, dA}$$

(41) $$\bar{A}_6^5 = \frac{\int_{A_{p2}^5}^{A_{s1}^5} Af(A)\, dA}{\int_{A_{p2}^5}^{A_{s1}^5} f(A)\, dA}$$

(42) $$\bar{A}_3^5 = \frac{\int_{A_{p1}^5}^{A_{p2}^5} Af(A)\, dA}{\int_{A_{p1}^5}^{A_{p2}^5} f(A)\, dA}$$

(43) $$\bar{A}_o^5 = \frac{\int_{-\infty}^{A_{p1}^5} Af(A)\, dA}{\int_{-\infty}^{A_{p1}^5} f(A)\, dA}$$

In other words, this last reform divides the population in 6 different groups according to their ability levels.



Given that

(44) $$A_h^5 > A_h^4 > A_h^3 > A_h^2 > A_h^1 > A_h^1$$

it can be shown that

(45) $$\bar{A}^5_{17} > \bar{A}^4_{17} > \bar{A}^3_{17} > \bar{A}^2_{17} > \bar{A}^1_{17} > \bar{A}^o_{17} > A$$

We can also prove that

(46) $$\bar{A}^5_{12} > \bar{A}^4_{12} > \bar{A}^3_{12} > \bar{A}^2_{12} > \bar{A}^1_{12} < \bar{A}^o_{12} < \bar{A}$$

(47) $$\bar{A}_9^5 > \bar{A}_9^4 > \bar{A}_9^3 > \bar{A}_9^2 < \bar{A}_9^1 = \bar{A}_9^o = \bar{A}$$

(48) $$\bar{A}_6^5 > \bar{A}_6^4 > \bar{A}_6^3 < \bar{A}_6^2 = \bar{A}_6^1 = \bar{A}_6^o = \bar{A}$$

(49) $$\bar{A}_3^5 > \bar{A}_3^4 < \bar{A}_3^3 = \bar{A}_3^2 = \bar{A}_3^1 = \bar{A}_3^o = \bar{A}$$

(50) $$\bar{A}_o^5 < \bar{A}_o^4 = \bar{A}_o^3 = \bar{A}_o^2 = \bar{A}_o^1 = \bar{A}_o^o = \bar{A}$$

APPENDIX 3

EXPECTED MEAN ABILITY OF STUDENTS IN EACH LEVEL OF THE EDUCATIONAL SYSTEM: INITIAL CONDITIONS AND EDUCATIONAL REFORMS

The expected mean ability level of student in each level of the educational system will be a weighted average of the ability levels of the different types of students in each level of the educational system. These different types of students are difined according to the lenght of time they will remain in the educational system. The weights are the percentage of each type of students in each level of the educational system.

let us define $\bar{A}^i_{p1}$, $\bar{A}^i_{p2}$, $\bar{A}^i_{s1}$, $\bar{A}^i_{s2}$ and $\bar{A}^i_h$

as the expected mean ability level of students in the first and second phase of primary education, the first and second phase of secondary education and higher education. The index i indicates the educational state.

Therefore we can write:

$$(1)\ \bar{A}^i_{p1}=(1-C_p)\bar{A}^i_3+C_p(1-\Pi_p)\bar{A}^i_6+C_p\Pi_p(1-C_s)\bar{A}^i_9+C_p\Pi_pC_s(1-\Pi_s\Pi'_s)\bar{A}^i_{12}+C_p\Pi_pC_s\Pi_s\Pi'_s\ \bar{A}^i_{17}$$

$$(2)\ \bar{A}^i_{p2}= (1-\Pi_p)\bar{A}^i_6+ \Pi_p(1-C_s)\bar{A}^i_9+ \Pi_pC_s(1-\Pi_s\Pi'_s)\bar{A}^i_{12}+ \Pi_pC_s\Pi_s\Pi'_s\ \bar{A}^i_{17}$$

$$(3)\ \bar{A}^i_{s1}= (1-C_s)\bar{A}^i_9+ C_s(1-\Pi_s\Pi'_s)\bar{A}^i_{12}+ C_s\Pi_s\Pi'_s\ \bar{A}^i_{12}+ C_s\Pi_s\Pi'_s\ \bar{A}^i_{17}$$

$$(4)\ \bar{A}^i_{s2}= (1-\Pi_s\Pi'_s)\bar{A}^i_{12}+ \Pi_s\Pi'_s\ \bar{A}^i_{17}$$

$$(5)\ \bar{A}^i_h = \bar{A}^i_{17}$$

$$+ \frac{E_p C_p \Pi_p C_s (1-\Pi_s \Pi'_s)(e^{17b+C[A_{17}-A_o]} - 1)}{e^{\ell n\rho}\, e^{17\rho}} \Bigg)\Bigg)$$

where $k_{p,\,s,\,h} = \dfrac{k^i_{p,\,s,\,h}}{W^{(A=100)}_{i-1}}$

The first parenthesis in expression (1) represents the direct costs and foregone incomes associated with the educational process while the second parenthesis represents the benefits due to the increased productivity generated by the educational system.

Assuming that $k_p = k_s = k_h = k$ we can transform (1) into

$$\text{(2)}\qquad NPV = CW_o \Bigg(-(k+1)e^{-\rho} \Bigg(E_p \sum_{i=0}^{2} e^{i(b-\rho)} + E_p C_p \sum_{i=3}^{5} e^{i(b-\rho)}$$

$$+ E_p C_p \Pi_p \sum_{i=6}^{8} e^{i(b-\rho)} + E_p C_p \Pi_p C_s \sum_{i=9}^{11} e^{i(b-\rho)} \Bigg)$$

$$+ E_p C_p \Pi_p C_s \Pi_s \Pi'_s \left(k e^{C[A_{12}-A_o]} + e^{C[A_{17}-A_o]} \right) \sum_{i=12}^{16} e^{i(b-\rho)}$$

$$+ e^{-\ell n\rho} \left(E_p (1-C_p)\, e^{3(b-\rho)} - e^{-3\rho} \right)$$

$$+ E_p C_p (1-\Pi_p) \left(e^{6(b-\rho)} - e^{-6\rho} \right) + E_p C_p \Pi_p (1-C_s) \left(e^{9(b-\rho)} - e^{-9\rho} \right)\Bigg)\Bigg)$$

$$+ E_pC_p\Pi_pC_s(1-\Pi_s\Pi_s') \left(e^{12(b-\rho) + C[A_{12}-A_o]} - e^{-12\rho}\right)$$

$$+ E_pC_p\Pi_pC_s\Pi_s\Pi_s' \left(e^{17(b-\rho) + C[A_{17}-A_o]} - e^{-17\rho}\right)\Bigg)\Bigg)\Bigg)$$

Note that equating this expression to zero and solving for ρ we could obtain the internal rate of return of the existing educational system.

We can also use the flows in squares shown in Tables (2) and (3) to derive an expression for the net present value of the incremental value added by the different educational reforms discussed in the text.

$$\text{(3)} \qquad MPV = CW_o\Bigg(e^{-\ell n\rho}\Bigg((1-E_p)(e^{C\dot{A}_o} - 1) + E_p(1-C_p)e^{3(b-\rho)}$$

$$(e^{C\dot{A}_3} - 1) + E_pC_p(1-\Pi_p)e^{6(b-\rho)}(e^{C\dot{A}_6} - 1) + E_pC_p\Pi_p(1-C_s)$$

$$e^{9(b-\rho)}(e^{C\dot{A}_9} - 1) + E_pC_p\Pi_pC_s(1-\Pi_s\Pi_s')\, e^{12(b-\rho)+C[A_{12}-A_o]}$$

$$(e^{C\dot{A}_{12}} - 1) + E_pC_p\Pi_pC_s\Pi_s\Pi_s' e^{17(b-\rho)+C[A_{17}-A_o]}$$

$$(e^{C\dot{A}_{17}} - 1)\Bigg)\Bigg)$$

Using expression (2) and (3) we can obtain an expression for the ratio

(4) $$R = \frac{MNPV}{NPV}$$

This ratio represents the incremental value added generated by the educational reforms as a fraction of the value added by the existing educational system. In other words, this ratio reflects the percentage by which the benefits of the existing educational system could be increased if the different educational reforms described in the text were undertaken.

APPENDIX 3

EXPECTED MEAN ABILITY OF STUDENTS IN EACH LEVEL OF THE EDUCATIONAL SYSTEM: INITIAL CONDITIONS AND EDUCATIONAL REFORMS

The expected mean ability level of student in each level of the educational system will be a weighted average of the ability levels of the different types of students in each level of the educational system. These different types of students are difined according to the lenght of time they will remain in the educational system. The weights are the percentage of each type of students in each level of the educational system.

let us define $\bar{A}^{i}_{p1}$, $\bar{A}^{i}_{p2}$, $\bar{A}^{i}_{s1}$, $\bar{A}^{i}_{s2}$ and $\bar{A}^{i}_{h}$

as the expected mean ability level of students in the first and second phase of primary education, the first and second phase of secondary education and higher education. The index i indicates the educational state.

Therefore we can write:

$$(1)\quad \bar{A}^{i}_{p1} = (1-C_p)\bar{A}^{i}_{3} + C_p(1-\Pi_p)\bar{A}^{i}_{6} + C_p\Pi_p(1-C_s)\bar{A}^{i}_{9} + C_p\Pi_pC_s(1-\Pi_s\Pi'_s)\bar{A}^{i}_{12} + C_p\Pi_pC_s\Pi_s\Pi'_s\,\bar{A}^{i}_{17}$$

$$(2)\quad \bar{A}^{i}_{p2} = (1-\Pi_p)\bar{A}^{i}_{6} + \Pi_p(1-C_s)\bar{A}^{i}_{9} + \Pi_pC_s(1-\Pi_s\Pi'_s)\bar{A}^{i}_{12} + \Pi_pC_s\Pi_s\Pi'_s\,\bar{A}^{i}_{17}$$

$$(3)\quad \bar{A}^{i}_{s1} = (1-C_s)\bar{A}^{i}_{9} + C_s(1-\Pi_s\Pi'_s)\bar{A}^{i}_{12} + C_s\Pi_s\Pi'_s\,\bar{A}^{i}_{12} + C_s\Pi_s\Pi'_s\,\bar{A}^{i}_{17}$$

$$(4)\quad \bar{A}^{i}_{s2} = (1-\Pi_s\Pi'_s)\bar{A}^{i}_{12} + \Pi_s\Pi'_s\,\bar{A}^{i}_{17}$$

APPENDIX 4

STATISTICAL APPENDIX

TABLE 1-A

PARAMETERS DETERMINING THE STRUCTURE OF FILTERS IN THE EDUCATIONAL SYSTEM. VALUES FOR SELECTED COUNTRIES. (GROUPS ACCORDING TO GEOGRAPHICAL AREAS AND PER CAPITA INCOME)

Country	E_p (1)	C_p (2)	$E_p\ C_p$ (3)=(1)x(2)	Π_p (4)	C_s (5)	$\Pi_s\ \Pi'_s$ (6)
Group I						
(La 1)						
El Salvador	0.71	-*	-	-	-	-
Haiti	0.22	0.25	0.05	0.50	-	-
Honduras	0.81	0.18	0.15	0.75	0.53	0.52
Ecuador	0.72	-	-	0.14	-	-
Paraguay	0.88	0.26	0.23	0.65	0.40	0.53
MEAN**	0.66	0.23	-	0.51	0.46	0.52
Group II						
(La 2)						
Costa Rica	0.86	0.65	0.56	0.58	0.47	0.58
Dom.Rep.	0.80	0.17	0.14	0.63	0.71	0.90
Guatemala	0.64	0.26	0.17	0.69	0.62	0.99
Mexico	0.71	0.31	0.22	0.63	0.65	0.75
Nicaragua	0.88	-	-	-	0.71	0.38
Trin. Tobago	0.95	0.87	0.83	0.15	0.89	0.50
Brazil	0.80	-	-	-	-	-
Chile	-	-	-	-	-	-
Colombia	0.67	0.20	0.13	0.90	0.40	0.64
Guayana	0.92	0.39	0.36	0.19	-	0.10
Peru	0.80	0.38	0.30	0.70	-	0.80
Venezuela	0.81	-	-	-	-	-
MEAN	0.80	0.40	-	0.56	0.63	0.63

TABLE 1-A (Continued)

Country	E_p (1)	C_p (2)	$E_p C_p$ (3)=(1)x(2)	Π_p (4)	C_s (5)	Π_s Π'_s (6)
Group III						
(Af 1)						
Burundi	0.27	–	–	–	–	–
Chad	0.29	–	–	–	–	–
Ethiopia	0.17	0.42	0.07	0.63	0.70	0.17
Mali	0.18	0.22	0.04	0.37	0.57	0.70
Rwanda	0.52	–	–	–	–	–
Somalia	0.13	–	–	0.45	0.95	0.25
Upper Volta	0.10	0.09	0.009	0.20	0.30	0.90
MEAN	0.24	0.24	–	0.41	0.68	0.50
Group IV						
(Af 2)						
Botswana	0.60	–	–	–	–	—
Cameroon	0.74	–	–	–	–	–
C.A.R.	0.64	0.25	0.16	0.18	0.13	0.65
Dahomey	0.32	0.70	0.22	0.43	0.70	0.89
Kenya	–	–	–	0.14	–	–
Malawi	0.56	0.60	0.34	0.40	–	–
Mauritania	0.15	–	–	–	–	–
Morocco	0.54	0.21	0.11	0.31	0.60	0.36
Nigeria	0.39	–	–	–	–	–
Senegal	0.38	–	–	..	–	–
Sierra Leone	0.34	0.45	0.15	0.68	0.59	0.14
Sudan	0.38	0.75	0.28	0.25	0.80	0.37
Swaziland	0.66	0.28	0.18	–	0.25	–
Tanzania	0.44	–	–	0.07	–	–
Uganda	0.48	–	–	0.14	–	–
Zaire	0.63	0.38	0.24	0.43	0.11	0.75
Benin	0.32	0.70	0.22	0.43	–	–
MEAN	0.47	0.48	–	0.31	0.45	0.53

TABLE 1-A (Continued)

Country	E_p (1)	C_p (2)	$E_p\ C_p$ (3)=(1)x(2)	Π_p (4)	C_s (5)	$\Pi_s\ \Pi'_s$ (6)
Group V						
(Af 3)						
Algeria	0.67	0.86	0.58	0.37	0.61	0.56
Congo (B)	–	–	–	–	–	–
Gabon	–	0.25	–	0.18	–	–
Ghana	0.56	0.62	0.35	0.14	0.16	–
Ivory Coast	0.52	0.57	0.30	–	–	–
Liberia	0.59	–	–	–	–	–
Tunisia	0.70	0.81	0.57	0.31	0.22	0.34
Zambia	0.95	–	–	0.20	–	–
MEAN	0.65	0.62	–	0.24	0.33	0.45
Group VI						
(Me 1)						
Iran	0.77	0.74	0.57	0.80	–	–
Iraq	0.61	–	–	–	–	–
Jordan	0.91	0.76	0.69	0.84	0.70	0.21
Lebanon	0.86	0.65	0.56	0.63	0.58	0.90
Yemen	0.15	0.18	0.03	0.75	0.76	0.09
MEAN	0.66	0.58	–	0.75	0.68	0.40

TABLE 1-A(Continued)

Country	E_p (1)	C_p (2)	E_p C_p (3)=(1)x(2)	Π_p (4)	C_s (5)	Π_s Π'_s (6)
Group VII						
(As 1)						
Bangladesh	0.56	0.26	0.15	0.74	0.58	0.45
India	0.79	-	-	-	-	-
Indonesia	0.63	0.40	0.25	0.91	0.69	0.52
Pakistan	0.47	0.50	0.24	0.75	0.49	0.50
MEAN	0.61	0.39	-	0.80	0.59	0.49
Group VIII						
(As 2)						
China(T)	0.98	0.94	0.92	0.84	0.86	0.75
Korea	0.97	0.90	0.87	0.71	0.93	0.25
Malaysia	0.90	-	-	-	-	-
Philippines	-	-	-	-	-	-
Thailand	0.87	0.93	0.81	0.91	-	-
MEAN	0.93	0.92	-	0.82	0.89	0.50

SOURCE: Education Projects Department.
Comparative Education Indicators, January 1976
International Bank for Reconstruction and Development.
(The data has been collected largely by the Bank missions from Government Sources. The Remainder are staff estimates or data from UNESCO Statistical Year Book)

* - : Datum Unavailable

** MEAN: Unweighted average of the available observations.

TABLE 2-A

INITIAL CONDITIONS. EDUCATIONAL STATE 0 ($\mu = 100$)

STRUCTURE OF EXPECTED MEAN ABILITIES ($\sigma = 15$)

Type of Labor	Group I (La 1)	Group II (La 2)	Group III (Af 1)	Group IV (Af 2)	Group V (Af 3)	Group VI (Me 1)	Group VII (As 1)	Group VIII (As 2)
L_0	100	100	100	100	100	100	100	100
L_3	100	100	100	100	100	100	100	100
L_6	100	100	100	100	100	100	100	100
L_9	100	100	100	100	100	100	100	100
L_{12}	93.0	95.0	92.9	93.0	96.0	93.1	92.8	92.9
L_{17}	106.5	102.9	107.2	106.1	108.7	110.3	107.4	107.2

TABLE 3-A

EDUCATIONAL STATE 1 ($\mu = 100$)

STRUCTURE OF EXPECTED MEAN ABILITIES ($\sigma = 15$)

(Figures in parenthesis show the absolute change relatively to the initial conditions)

Type of Labor	Group I (La 1)	Group II (La 2)	Group III (Af 1)	Group IV (Af 2)	Group V (Af 3)	Group VI (Me 1)	Group VII (As 1)	Group VIII (As 2)
L_0	100	100	100	100	100	100	100	100
L_3	100	100	100	100	100	100	100	100
L_6	100	100	100	100	100	100	100	100
L_9	100	100	100	100	100	100	100	100
L_{12}	87.6 (-5.4)	84.7 (-10.3)	88.0 (-4.9)	87.3 (-5.7)	89.3 (-6.7)	90.3 (-2.8)	83.3 (-4.5)	88.0 (-4.9)
L_{17}	111.5 (5.0)	109.0 (6.1)	112.0 (4.8)	111.2 (5.1)	113.2 (4.5)	114.5 (4.2)	112.2 (4.8)	112.0 (4.8)

TABLE 4-A

EDUCATIONAL STATE 2 ($\mu = 100$)

STRUCTURE OF EXPECTED MEAN ABILITIES ($\sigma = 15$)

(Figures in parenthesis show the absolute change relatively to the initial conditions)

Type of Labor	Group I (La 1)	Group II (La 2)	Group III (Af 1)	Group IV (Af 2)	Group V (Af 3)	Group VI (Me 1)	Group VII (As 1))	Group VIII (As 2)
L_0	100	100	100	100	100	100	100	100
L_3	100	100	100	100	100	100	100	100
L_6	100	100	100	100	100	100	100	100
L_9	89.0 (-11.0)	84.7 (-15.3)	83.2 (-6.8)	89.3 (-10.7)	91.9 (-8.1)	83.2 (-16.9)	85.8 (-14.2)	74.3 (-25.7)
L_{12}	105.9 (12.9)	99.4 (4.4)	100.4 (7.5)	106.1 (13.1)	110.8 (14.8)	100.9 (7.8)	102.3 (9.5)	93.0 (0.1)
L_{17}	119.5 (13.0)	114.5 (11.6)	117.1 (9.9)	119.5 (13.4)	123.4 (14.7)	118.3 (8.0)	117.7 (10.3)	113.3 (6.1)

EDUCATIONAL STATE 3 (μ = 100)

STRUCTURE OF EXPECTED MEAN ABILITIES (σ = 15)

(Figures in parenthesis show the absolute change relatively to the initial conditions)

Type of Labor	Group I (La 1)	Group II (La 2)	Group III (Af 1)	Group IV (Af 2)	Group V (Af 3)	Group VI (Me 1)	Group VII (As 1)	Group VIII (As 2)
L_0	100	100	100	100	100	100	100	100
L_3	100	100	100	100	100	100	100	100
L_6	89.1 (-10.9)	86.6 (-13.4)	90.2 (-9.8)	92.4 (-7.6)	93.9 (-6.1)	81.0 (-19.0)	79.0 (-21.0)	78.1 (-21.9)
L_9	105.0 (5.0)	101.8 (1.8)	106.3 (6.3)	111.5 (11.5)	114.0 (14.0)	94.9 (-5.1)	94.6 (-5.4)	90.9 (-9.1)
L_{12}	113.9 (20.9)	108.5 (13.5)	113.8 (20.9)	118.8 (25.8)	121.8 (25.8)	105.7 (12.6)	105.8 (13.0)	100.1 (7.2)
L_{17}	124.9 (18.4)	120.1 (17.2)	124.9 (17.7)	128.5 (22.4)	133.0 (24.3)	120.9 (10.6)	119.8 (12.4)	115.5 (8.3)

TABLE 6-A

EDUCATIONAL STATE 4 (μ = 100)

STRUCTURE OF EXPECTED MEAN ABILITIES (σ = 15)

(Figures in parenthesis show the absolute change relatively to the initial conditions)

Type of Labor	Group I (La 1)	Group II (La 2)	Group III (Af 1)	Group IV (Af 2)	Group V (Af 3)	Group VI (Me 1)	Group VII (As 1)	Group VIII (As 2)
L_0	100	100	1-0	100	100	100	100	100
L_3	94.1 (-5.9)	90.3 (-9.7)	93.9 (-6.1)	88.5 (-11.5)	84.9 (-15.1)	86.1 (-13.9)	99.6 (-10.4)	72.1 (-27.9)
L_6	114.9 (14.9)	107.4 (7.4)	114.6 (14.6)	107.5 (7.5)	104.7 (4.7)	99.7 (-0.3)	105.8 (5.8)	84.9 (-15.1)
L_9	121.6 (21.6)	113.7 (13.7)	120.9 (20.9)	118.7 (18.7)	119.6 (19.6)	105.2 (5.2)	110.3 (10.3)	91.6 (-8.4)
L_{12}	126.6 (33.6)	118.3 (23.3)	125.7 (32.8)	124.6 (31.6)	127.2 (31.2)	112.5 (19.4)	116.5 (23.7)	99.9 (7.0)
L_{17}	134.0 (27.5)	127.8 (24.9)	134.4 (27.2)	133.1 (27.0)	136.1 (27.4)	125.2 (14.9(	127.1 (19.7)	116.3 (9.1)

TABLE 7-A

EDUCATIONAL STATE 5 (μ = 100)

STRUCTURE OF EXPECTED MEAN ABILITIES (σ = 15)

(Figures in parenthesis show the absolute change relatively to the initial conditions)

Type of labor	Group I (La 1)	Group II (La 2)	Group III (Af 1)	Group IV (Af 2)	Group V (Af 3)	Group VI (Me 1)	Group VII (As 1)	Group VIII (As 2)
L_0	83.9 (-16.1)	79.0 (-21.0)	93.9 (- 6.1)	88.7 (-11.3)	84.1 (-15.9)	83.9 (-16.1)	85.2 (-14.8)	71.1 (-28.9)
L_3	103.9 ((3.9)	97.6 (-2.4)	123.7 (23.7)	106.0 (6.0)	99.0 (-1.0)	99.2 (-0.8)	103.0 (3.0)	81.2 (-18.8)
L_6	118.2 (18.2)	110.2 (10.2)	126.4 (26.4)	116.1 (16.1)	110.7 (10.7)	106.4 (6.4)	111.9 (11.9)	88.4 (-11.6)
L_9	124.0 (24.0)	115.9 (15.9)	130.9 (30.9)	124.8 (24.8)	123.2 (23.2)	110.6 (10.6)	115.6 (15.6)	93.8 (-6.2)
L_{12}	129.1 (36.1)	120.0 (25.0)	135.0 (42.1)	130.1 (37.1)	130.3 (34.3)	116.7 (23.6)	120.9 (28.1)	101.4 (8.5)
L_{17}	136.8 (30.3)	128.7 (25.8)	142.0 (34.8)	137.5 (31.4)	138.3 (29.6)	128.1 (17.8)	130.4 (23.0)	117.1 (9.9)

REFERENCES

Balassa, B. et al. (1971) The Structure of Protection in Developing Countries (Baltimore: Johns Hopkins Press).

Becker, G. (1967) "Human Capital and the Personal Distribution of Income" Woytinsky lecture No. 1; Ann Arbor: University of Michigan.

Ben Porath, Y. (1967) "The Production of Human Capital and the Life Cycle of Earnings." Journal of Policial Economy, Vo. 75, pp. 352-365.

Bhagwati, J. and Rodriguez (1975) "Welfare-Theoretical Analysis of the Brain Drain." Journal of Development Economics, Vol. 2, No. 3, pp. 195-221.

Box, G. and Cox, D. (1964) "An Analysis of Transformations." Journal of the Royal Statistical Society, Series B, Vol. 26, pp. 211-243.

Carnoy, M. (1967) "Earnings and Schooling in Mexico." Economic Development and Cultural Change (July 1967).

Dougherty, C. and Selowsky, M. (1973) "Measuring the Effects of the Misallocation of Labor." Review of Economics and Statistics, Vol. LV, No. 3.

Griliches, Z. (1970) "Notes on the Role of Education in Productions Functions and Growth Accounting." In Lee Hansen, ed. Education and Income, Studies in Income and Wealth, Vol. 35, National Bureau of Economic Research, New York.

________. (1975) "Estimating the Returns to Schooling: Some Econometric Problems." Discussion paper No. 433 (September 1975) Harvard Institute of Economic Research, Harvard University.

________., and Mason, W.M. (1972) "Education, Income and Ability." Journal of Political Economy, Part II (May/June 1972).

Grubel, H. (1975) "Evaluating the Welfare Effects of the Brain Drain from Developing Countries." Paper presented at the Bellagio Conference on Brain Drain and Income Taxation. Bellagio, Italy.

Harberger, A. (1959) "Using the Resources at Hand More Effectively." American Economic Review, May 1959.

Hause, J.C. (1971) "Ability and Schooling as Determinants of Earnings or if You are so Smart Why Aren't you Rich?" American Economic Review, (May 1971).

________. (1972) "Earnings Profile: Ability and Schooling." Journal of Political Economy (May/June, Part II).

Heckman, J. and Polachek, S. (1974) "Empirical Evidence on the Functional Form of the Earnings Schooling Relationship." Journal of the American Statistical Association. Vol. 69, pp. 350-354.

Husen, T. (1968) "Talent, Opportunity and Career: A 26 Year Follow Up." School Review, 76 (4) University of Chicago.

Johnson, H. (1965) "The Economics of the Brain Drain: The Canadian Case." Minerva.

________. (1957) "Some Economics Aspects of Brain Drain." Pakistan Development Review, 3.

McCulloch, R. and Yellen, J. (1975) "Consequences of a Tax on a Brain Drain for Unemployment and Income Inequality in LDC's. Journal of Development Economics, Vol. 2, No. 3, pp. 249-264.

Mincer, J. (1957) "A Study of Personal Income Distribution." Unpublished Ph.D. Dissertation. Columbia University, New York.

________. (1958) "Investments in Human Capital and Personal Income Distribution." Journal of Policital Economy, LXVI, No. 4.

________. (1974) "Schooling Experience and Earnings." National Bureau of Economic Research, New York.

Psacharopoulos, G. (1973) Returns to Education. Jossey-Bass Inc. Washington, 1973.

Selowsky, M. (1967) "Education and Economic Growth: Some International Comparisons." Unpublished Ph.D. dissertation, University of Chicago.

________., and Taylor L. (1973) "The Economics of Malnourished Children: An Example of Disinvestment in Human Capital." Economic Development and Cultural Change, Vol. 22, No. 1.

Sorkin, A. (1974) "Education and Income in Chile." Journal of Economic Studies (May 1974).

Taubman, P.J. and Wales, T. J. "Higher Education, Mental Ability, and Screening." Journal of Political Economy 81 (Jan/Feb 1973) pp. 28-55.