PRINCIPLES IN THE VALUATION OF HUMAN CAPITAL

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Human capital concepts and measures have been applied and misapplied to an increasing variety of economic problem areas, two of which are examined.

One of these is measurement of human capital gains and losses through migration. First requirements here are specification of the gaining or losing entities and of the relevant welfare functions. Alternatives in these respects are outlined. It is then argued that an appropriately adapted Fisherian present-value assessment of human capital is normally the correct measure. Replacement costs are a legitimate substitute only for young migrants with little cumulated learning through experience and even then they have usually been fallaciously applied. Probability adjustments for migration and re-migration are required in both cost and present-value assessments of human capital effects of migration–relevant policy alternatives, but the nature of those adjustments differs with the measurement approach used.

For longitudinal analysis of contributions of human capital to economic growth, all measures of human capital stocks are inappropriate. A first principle of such analysis is measurement of resource inputs as flows. A coordinate principle requires that disaggregation be carried as far as necessary to distinguish essentially homogeneous categories of labor inputs. Though a way of separating out the schooling versus on-the-job-experience components of human capital is illustrated, it requires some strong assumptions. Splitting men into abstracted human capital components is better avoided in growth analysis. Furthermore, categorization of labor-force sub-groups could equally well provide the basis for rate-of-return assessments of marginal changes in the pace of investments in humans. Such assessments would incorporate the main elements of capital theory *except* valuation of the capital asset itself.

Ultimately, human resource measurements for use in major public policy decisions relating to either growth or migration (or both) must incorporate modifications or error components that allow for development phenomena that elude marginal assessments. Among developing countries especially, a consideration of educational diffusion processes and dynamic productivity scale effects, for example, could have critical measurement and policy implications.

Prefatory Remarks

The first tenet in any attempt at valuation or measurement must be: suit your measures to the purposes for which they are made. That tenet, underlying the remainder of this paper, dictated also that I begin with identification of the major problem areas with which the notion of human capital and its measurement has been associated. In addition, the context of the conference and the session for which the paper was written led me to emphasize aggregative measurement and development questions, excluding both applications of human-capital concepts in the analysis (and making) of decisions at the individual or micro level, and their use in the explanation of earnings or income distributions. Partly because I did not want to go back over the controversies about opportunity costing,[1] and partly for other reasons (some of which will become evident shortly) I have omitted any discussion of methods of valuation oriented to analysis of the aggregate levels of investment of resources in human-capital

[1]This topic was discussed at some length in my paper for the International Economic Association meeting in 1963, "The Costing of Human Resource Development" (See Bowman, 1966b).

formation, and hence of methods of measurement of aggregate human capital in cost terms.[2] This left two major topics for consideration: human-capital valuation as applied to studies of the contributions of human capital (and, more narrowly, of education) to economic growth, and the valuation of gains and losses in human capital through migration. These constitute respectively Parts II and III of this paper. Although capital theory, and hence its application to human beings, comes fully into play only in the elaboration and application of decision theory, I have not treated this under a separate heading. There are two reasons. In the first place, we must ask: decisions of what kind about what investments? Having elected to focus upon contributions of human capital to growth in national income and upon human-capital gains and losses through migration, it is evident that the associated human-investment decision problems will be planners' decisions closely linked to one or both of these areas of concern. Valuation of human capital for such decisions is therefore discussed in each of the two main parts of the paper already specified. However, human-investment decisions receive explicit attention only toward or at the end of each of these main sections. This is a paper on human-capital valuation and measurement, not on the even larger topic of benefit/cost accounting and social decision making with respect to investments in the formation, retention, or attraction of human capital.

The lay-out of the paper is as follows:

I. *Capital Is What Capital Does*

A brief discussion of the concept of human capital and some of its kin.

II. *Human Capital in Aggregate Input-Output Analysis*

1. The Identification and Measurement of Neglected Inputs

Three principles of valuation for purposes of assessing human-capital contributions to economic growth are presented. The first of these specifies that we must measure not human capital proper but its current inputs of services into production.

2. The Linking of Human-Capital Service Measurements to Particular Investments in Human-Capital Formation

This introduces valuation problems associated more explicitly with human-investment decisions. Special attention is given to some empirical possibilities and limitations in measurements that would separate out schooling and on-the-job components of human capital.

[2]Dudley Seers and Richard Jolly (1966) make a strong plea for revision of national accounts to treat educational costs as investments, for the maintenance of systematic educational statistics in physical units as part of demographic accounting, and for use of replacement-cost estimates in the valuation of human-capital stock. Despite my rather critical treatment of replacement costs in the particular context of Part III, section 4, of this paper, I am very much in sympathy with their position so far as national accounting systems are concerned, and strongly urge full demographic accounts. (On human-investment accounting see also Kendrick, 1966.)

III. *The Valuation of Human-Capital Gains and Losses Through Migration*

1. Specification of the Gaining or Losing Entities

This is a brief discussion of alternative orientations with respect to whose gain or loss is being measured.

2. Selective Human-Capital Counts and a Welfare Function

Taking the nation-collectivity orientation, this section examines alternative specifications concerning which components of human capital are to be counted (including the alternative of counting all the human capital embodied in all migrants or in a selected group thereof, as, for example, engineers). It goes on to develop a reasonable and flexible welfare function that can be applied to correct preliminary measures that incorporate the totality of human capital embodied in the migrants under consideration.

3. Single-Dated, Marginal Assessments of Human-Capital Gains and Losses: Present Values

A fairly extended discussion and empirical illustration of the importance of correct empirical specification of present values puts special emphasis on locational differences in learning through experience.

4. Replacement-Cost Valuations and Migration-Probability Adjustments

Some awkward twists and common fallacies in replacement-cost valuation are pointed out and the particular conditions under which replacement-cost valuation would be logically preferred to present-value assessments, not merely a pragmatically available but weak substitute, are laid out.

5. Marginal Decisions and Human-Capital Flows

Remigration as well as permanent migration and probabilities of return or non-return are taken into account in a brief summary of a long paper in which methods of measurement and some illustrative applications to public decision-making are developed.

6. Copper-Age Assessments and Human-Capital Epidemiology

A brief flight into growth dynamics (applicable to both Parts II and III) winds up with a somewhat fanciful but nevertheless serious suggestion for one among many possible orientations of research into interrelationships between cumulative growth of human capital and economic development.

IV. *On the Importance of Knowing Your Question; or What is Appropriate When*

This brief conclusion pulls together the main principles and guides to valuation developed throughout the paper, adding a few thoughts not explicitly noted in the previous discussions.

I. Capital Is What Capital Does

There is one, and only one, generalized definition of the concept of capital, and hence of human capital, that can stand up logically. Be it human or physical, embodied or not, capital is a resource capable of yielding a stream of future services. Capital is what capital will (or can) do, and when; it is not what capital costs, and only under special conditions can it be measured by the costs of producing it. Capital so defined is a stock, and its measurement is at a specific date in time. This Fisherian definition[3] implies the measurement of capital as the present value of a stream of future yields appropriately discounted. It does not, of course, specify what the "appropriate" discount rate should be—a topic on which there is a considerable technical literature, but one that I shall evade here. Fortunately, a yield-based definition of capital has some particular advantages for human-capital assessments that I shall come back to in a moment. I shall use it throughout Part III.

Capital as such is not an input into production processes, despite conventions that so treated it in most aggregative econometric analysis of national income growth until recently. Thus what I once called "effective current stock" (of human capital) and what Solow has more recently called "effective stock" (of physical capital) is not properly speaking capital at all.[4] Rather, it is a summation of inputs of services of capital into production processes (over a given period—say a year). But analyses of these inputs and attempts to measure their role in the economic growth of the more advanced nations have been closely interwoven in the recent literature with the so-called "human-capital approach," just as recent attempts to assess service inputs of physical capital have grown out of capital theory. No discussion of capital valuation can neglect this important shift towards emphasis on the streams of services that capital yields as against capital itself. Thus in the analysis of valuation problems relating to national income growth, in Part II, I will in fact depart from the capital concept proper.

Returning to the Fisherian concept, and yield-based measurement, I promised further comments on why this approach has some special advantages in the valuation of human capital. First of all, we can thereby at least partially evade the recalcitrant and frequently bemoaned problem of distinguishing the consumer from the producer capital associated with investments in education (or schooling). For some (many) purposes we can also evade assessing the important but often elusive non-market components of human-resource formation. The foregone earnings of students are the easy part of this. The difficult parts, which have in fact a major impact on formation of production potential, are in such things as contributions of families, general community life, and job experience to human learning.

On the returns side, we are often in a better position to identify rental-value streams for services of human than of material capital, even though we have difficulty in showing just what the human capital cost was and how it was formed. The fact that new physical capital is frequently sold helps bring costs

[3]Just how broad the Fisherian concept of capital can become is well stated in Johnson, 1964. Kendrick took a similar position in his comments in the same symposium. He carries this further in a later paper on national income accounts (Kendrick, 1966).

[4]Bowman 1961, Solow 1963.

and expected values of this new capital into line. However, thereafter most physical capital never appears in rental markets; we have no readily observed material-capital earnings streams.

A major problem in assessing human capital inheres in the fact that human-capital formation has no clear cut-off point when it is completed, whereas material capital comes much closer to discreteness and identifiability in this respect. Appreciation of human productive capacity, not merely its depreciation rate, is affected by the way in which human capital is used. Moreover, over the life-cycle, observed earnings lag behind true productivity and total earnings, because they do not include current increments to human capital.[5] Among the distinctive characteristics of human capital, this especially will call for further attention.

A curious result of these characteristics of human capital formation, taken together with the durability of men, is that human capital is easier to measure when it is old than when it is new, whereas values of material capital are easier to approximate empirically when it is quite pristine.

II. Human Capital in Aggregate Input-Output Analysis

1. *The Identification and Measurement of Neglected Inputs*

It is now a decade since econometricians on both sides of the Atlantic found that conventionally measured inputs into production left unexplained a very large fraction of measured growth in national products.[6] That decade has seen a variety of attempts to explain or to reduce "the Residual"—which has also been variously labeled "technical change," the "human factor," and "the measure of our ignorance."

Some have laid special stress on reassessments of the extent and effects of inputs of physical capital. Thus, Solow increases the estimates of growth in physical-capital inputs by use of a model that assumes all "technical change" must be "embodied." He derives a rate of growth in the quality of successive physical-capital "vintages" by imputation from observed trend coefficients in the unexplained "residual."[7] Arrow's quite different learning-by-doing thesis also argues for the importance of levels of gross investment.[8] Meanwhile, Schultz was of course busily engaged in expounding quite another kind of embodiment than Solow's—the embodiment of learning in human-capital agents and the importance of this sort of embodiment for economic development.[9] The contrast between Schultz and Solow was not only in their respective emphases on human and material capital. It was also methodological in a critical respect: Solow started with an aggregate production function that included technical change (T) as a latent variable and derived rates of change in the

[5]See Becker 1962, Mincer 1962, and Ben-Porath 1967.

[6]See Aukrust 1959, Fabricant 1959, Solow 1957. These studies and the use of a Cobb-Douglas aggregate production function in the analysis of change in total productivity were anticipated 15 years earlier by Tinbergen, who used the phrase "increase in efficiency" (see Tinbergen, 1942).

[7]See Solow 1960, 1962.

[8]See Arrow 1962.

[9]See especially Schultz 1961.

quality of capital, his vintage model. Schultz, on the other hand, started with direct measurement of human-capital and asked how much of the growth in national income the increases in human capital could explain. More recently Denison[10] and Griliches[11] have also taken the direct-measurement approach but on a broader front, seeking to identify all kinds of heretofore neglected inputs (or quality changes in them) and to identify aggregation errors that have led to under-estimation of factor inputs.

If these direct sallies into a more inclusive and refined measurement of inputs can be said to incorporate a theory of growth at all, it is a very modest one. It says either that if we could measure all the inputs fully and accurately, the measure of change in total factor productivity would shrink to a negligible value (or zero)—or that this would be the case except for increasing returns to scale. The social accounting problem is to measure real-factor inputs against real outputs as these move through time, hopefully learning thereby more about the growth process itself. Just what one finally labels as "technical change" (neutral or otherwise) matters very little so long as we are getting a better idea of what it is that has been going on. In most of these attempts, equilibrium is assumed for at least the base year establishment of measures and weights, and private are assumed to match social marginal costs and returns. For the present I shall go along with these base year assumptions in order to simplify presentation, but whether we adhere to them or not, we must give heed to three principles of valuation.

Principle 1. *Measurements should be of input flows, not of stocks*

A first requirement is evidently the correct specification of the factor inputs. The problem posed for research—identification and allocation of the sources of national income growth—automatically gives us this first principle: i.e., identification of service inputs per unit of time. A fifty-year old man will normally not have as high an implicit asset value as his twenty-year-old son and it may have cost less to "produce him," but he may nevertheless have a higher current productivity. It is the latter, rental or service value (or proxies thereof), not asset values, that are relevant in the construction of indices of factor inputs. Asset valuations, whether based on cost or yield data, are inappropriate.[12]

Principle 2. *Disaggregation should be carried as far as possible to distinguish internally homogeneous categories of labor input*

Adequate disaggregation and specification of classificatory principles in the identification and measurement of human (as of other) factor inputs must go hand in hand with measurement of service flows. Indeed, implementation of the first principle of valuation depends upon the second. Ideally, what is wanted

[10]Denison 1962, 1964.

[11]Griliches 1963 and 1967. Also Griliches and Jorgenson, 1967.

[12]For discussion of some of the complex issues that lie back of this assertion, see my "Schultz, Denison, and the Contribution of Eds to National Income Growth" (1964), and my examination of cost and yield approaches to estimation of aggregate net human capital formation and human capital service inputs in "Human Capital: Concepts and Measures" (1961, 1962).

is a break-down such that within each group there will be essential homogeneity of service values, and of any "quality" changes in them. For human capital this might mean, for example, disaggregation into occupation-schooling-age-sex categories. Notice, however, that I have said nothing about distinguishing education from other components of human capital embodied in the *same* individuals. This brings me to a third principle.

Principle 3. *Avoid reliance on assumptions that are not essential to the problem under investigation*

Though less essential than principles 1 and 2, this principle must be kept in mind. In the present context it may be translated: subject to principle 2, disaggregation should stay as close to empirically identifiable input entities as possible, with minimal abstracting out of components of human resources that can be measured only as we make strong theoretical or empirical assumptions. Thus, where the problem in hand does not require the splitting up of the total human capital embodied in an individual into components of different sorts, such splitting is better avoided. Rather, we would be well advised to concentrate on refining the categories of men along the lines that are relevant under principle 2. This is the best statistical starting point even when the splitting into conceptually distinguished components of a man is also desired. It is also the more generally practicable in that cross-classifications by income are not required.[13]

So long as we wish only to measure amounts and qualities of human-resource inputs into production processes, and provided quality changes *within* the labor-force categories identified are negligible, it does not matter how human-capital formulation takes place, or what in a man's productive capacities may be traced to one or another investment in him. We need not worry about Denison's figure of 60% for the proportion of observed income differentials attributable to schooling. If classification by schooling classifies automatically (and with reasonable stability) on other factors associated with a man's productivity, so much the better. Moreover, so-called "raw labor" is by no means raw and was not costlessly formed: the capacity for such labor too is part of human capital, whether or not it is accompanied in the individual by embodied school learning.[14] Unfortunately, this does not end the matter of when to split men into components versus when to refine their categorization, however. The catch is in the phrase "what may be called for by the problem at hand" when that problem goes beyond the kind of aggregate input-output measurement considered to this point.

[13]We could go a long way with no more than age-schooling cross-classifications of the labor force and changes in its age-schooling composition over time. Even though such data are lacking in many countries, they are becoming increasingly available. Moreover, they can sometimes be estimated from historical school enrollment data and data on the age composition of the labor force; the difficulty in this is primarily correction for educational selectivity of migration and mortality, which will be a major difficulty in some countries but a minor one in others. Adequate identification and measurement of non-labor inputs may be the more serious stumbling block.

[14]In this connection see Kendrick, 1966. Kendrick presents a strong argument in favor of detailed and full accounting of human-investment costs, including rearing costs. The changed perspective on investment that he argues (and the revolution in accounting systems that it implies) is in my judgement not only sound but critically important, even though I have reservations about "rearing cost" estimations.

2. *The Linking of Human-Capital Service Measurements to Particular Investments in Human-Capital Formation*

If he accepts the argument presented thus far, the reader may well ask, just where does a concept or theory of capital come into all this? Why not just talk about different kinds and qualities of labor services? Unless we push our problem deeper it would seem that the capital concept and capital theory come into it not at all; the notion of human capital is redundant. In fact we could get along very well without it so long as we posed no questions about how growth in the various factor inputs came about—in other words, so long as we raised no issues about human-investment decisions.[15] But once we ask the planners' investment questions it becomes evident that however well we may manage to explain measured growth in aggregate output by improved specification and measurement of growths in inputs (including all kinds of labor services), the critical question of just how these human productive capacities came into being, at what costs, also comes to the fore. Furthermore, since we are dealing with people, not machines, we must ask which of the processes that contributed to formation of human capital are strategic or manipulable variables? Which, on the other hand, may be treated better as final consumption products even though they may nourish human capital or fuel the human machine? The answers to such questions cannot be once-and-for-all matters, independent of levels of economic development, relative resource availabilities, and scope for manoeuver. An economic model that treats food as investment in human resources that produce food and so forth, laying out a spiral path that has no final products, may be a helpful way of thinking in some contexts—even though it does not fit at all with conventional social accounting.[16] We may get further, on the other hand, by a more selective focus upon key manoeuverable components in the formation (and obsolescing) of human capital, limiting our measures of "human capital" to those parts of the total that can be attributed to particular types of investment in human beings. This is of course what Schultz did in selecting out schooling embodied in the labor force as the most critical component of human capital. A more intensive scrutiny of the critical ranges in effects of nutrition (and sanitation) on human productive potentials is clearly in order, not only for less developed countries but also for disadvantaged groups in wealthy nations.

Once we determine to distinguish certain components of human productive capacities not merely by homogeneous categorizations of labor units but by the particular kinds of investments in formation of human capital to which different kinds and quantities of services are causally linked (schooling, versus health measures, versus books and conversations in the home, etc.), the question of how to value these several human-capital inputs into production must be taken up once again. Should we then attempt to value them separately by splitting individuals into component human capital parts instead of dividing the labor

[15]Essentially this position is argued in Bowman, 1964; see also Bowman, 1966a.

[16]For an interesting theoretical analysis of a closed theoretical system in which consumption becomes in turn investment in human resources, see Bonner and Lees, 1963. A less formal but related analysis is included in my "The Consumer and the History of Economic Doctrine," *American Economic Review*, Vol. XLI, No. 2, May 1951, pp. 1–18.

force into categories of individuals who make up a homogeneous population with respect to the bundles of productive capacities embodied in them? And if the former, how should the splitting be done? A simplified delineation of alternatives will help here.

(a) We might count a college man in his forties as part of three different input indexes: a simple man-hour (or man-year) of conventional labor input, a cumulative package of embodied schooling through the college level, and an index of "quality" attributable to age. In this case the man of age 40 but with only eight years of schooling will count exactly as the college man in the simple raw labor index and in that for age, but will have a lower valuation on the index for the educational component.

This was the procedure used by Denison in his study for the United States (1962). While the age composition of the labor force is taken into account, the interaction between age and schooling (in their effects on productivity potentials) is disregarded. The distortion of measurement could be considerable where shapes of age-earnings streams differ substantially as among schooling-attainment categories and especially where the latter have very different incidence among the various age categories.

(b) We could simply group all college men aged 50 together, all eighth-grade graduates age 40 together, and so forth, counting each of these as a separate factor input.

This alternative could bring us right back to where we started when we were "merely" seeking bases for classification of the labor force into homogeneous groups with respect to their human-capital rental values. The important difference is that we are asking more critically of our assessments that they contribute to the illumination of human-investment questions; it is not enough to contribute only to more adequate measurement of factor inputs in an aggregate input-output description of national income growth. Classifications of components of the labor force by occupation, industry, and so forth (even if they gave us the within-group homogeneity needed for index number construction and weighting) would help only to the extent that they were good proxies for categorizations linked to the human investments in which we are interested. In fact in most parts of the world occupations and industry of employment are quite loosely correlated with schooling.

(c) We might overcome the interaction problem by specifying it. This would require separate estimates of the age or post-school-experience components of human capital for each schooling-attainment category.

Just how this should be done, even when we have refined data, is another matter. To get some idea of what might be involved, let us look at just one critical problem: separation of the schooling from the experience or on-the-job-training component. In order to simplify presentation I shall retain the assumption of a competitive equilibrium economy or, alternatively, a planned state that allocates and prices resources in Pareto-optimal fashion. Also, in order not to encumber

the analysis unduly, let us suppose that the awkward problems of controlling for effects of family background, health, and native ability on the differentials in incomes of lesser and better educated people of the same age and sex have been solved (by further fine disaggregations, if need be). This leaves the two major components of investment in human capital formation that we wanted especially to assess: schooling and post-school training and learning on the job. It will be helpful in analyzing this problem if we set up three extreme models:

Model 1. Productivity differentials are determined by schooling differentials only, these are realized immediately, and productive capacity is sustained intact until its complete demise, one-hoss-shay style.

Model 2. Productivity differentials are determined by schooling differentials only, in that all subsequent appreciation of productive capacity is costless. Nevertheless, productivity has an age pattern similar to that observed in cross-section earnings. This is attributed to differential automatic learning with experience that follows from having had one versus another level (or type) of schooling. All returns are thus again returns to schooling.

Model 3. The potential productivity differentials determined by schooling take effect immediately and are sustained intact throughout working life, but in addition there are opportunity-cost investments in on-the-job training or learning which account for the non-horizontal shapes of earnings streams. The internal rate to the schooling differential equals the average internal rate on all post-schooling investments (over and above those made by men with the next-lower level of schooling). This model can have two variants, the choice between which will not affect the analysis that follows.

3.1. Internal rates of return to all incremental post-school investments are the same. This is the Mincer model.[17]

3.2. Provided their average equals that to schooling, internal rates of return to incremental post-school investments can vary freely.

If the world were like Model 1 we would have no problem; in fact there would be no reason for taking age into account in any way. The only reason for listing Model 1 is to help us envisage the others. The second model is also a simple one, differing from the first only in requiring that we distinguish by age in measuring human-capital services. In Model 2 complementary post-school learning from experience is fixed by the initial schooling, no matter what the individual may do subsequently.[18]

In Model 3 all deviations from a horizontal post-school path of earnings are attributed to post-school investments by the individual in himself. Each such investment takes the form of foregoing higher earnings in a job that would

[17]See Mincer 1962.

[18]This model is compared and contrasted with the Mincer model in my paper on "The Costing of Human Resource Development" (Bowman, 1966b).

not add to his future productive potential, in favor of taking lower than maximum potential pay in a job that adds to his productive capacity. In Mincer's empirical estimates it is assumed further that every such investment over and above the post-school investments made by men at the next lower schooling attainment level will yield the same internal rate of return as the average internal rate for the associated schooling increment and post-school investment increments taken together. And finally, each post-school investment produces an increment to human productive power that neither rises nor declines thereafter up to the end of the working life, when all of them cease completely. How, under these assumptions, might we separate the schooling from the nonschooling component in human-capital inputs for any one time interval (say a year)? Or to pose this same question in another way, what rental values would we arrive at, and how, for each of these components separately? And how would each of the average rental/cost ratios compare with the "average internal rate of return?" How, in turn, would they compare with the average rental/cost ratio for Model 2?

Whichever of the models we start with, we have the same formula for derivation of the average internal rate of return to investments in the *i*th increment of schooling and subsequent investments (if any) in on-the-job learning, taken together.

Y_{it} = earnings in year t of men who go through the *i*th increment of schooling. (These earnings are not necessarily zero while attending school.)

$Y_{i-1,t}$ = earnings in the year t of men who stop just prior to the *i*th increment of schooling.

D_t = direct costs of schooling incurred in the year t. In a social evaluation these will include all the real resources devoted to an individual's schooling other than his own time.

r = the average internal rate of return.

We then have:

$$(1) \qquad \sum_{t=-s}^{0} \frac{(Y_{it} - Y_{i-1,t} - D_t)}{(1+r)^t} + \sum_{t=1}^{n} \frac{(Y_{it} - Y_{i-1,t})}{(1+r)^t} = 0$$

where the years $t = -s$ to $t = 0$ are those spent in the *i*th schooling stage, $t = 1$ is the first post-school year, and $t = n$ is the last year of working life. The first term of the equation is an expression of total costs of schooling, hereafter designated C_i. The second term is the present value of the ensuing incremental life-earnings stream discounted at the average internal rate, hereafter designated V_i. The data are the two earnings streams and the direct costs. The internal rate of return, which is the rate at which $C_i = V_i$, is determined by iteration.

If we let S_i^3 stand for the (constant) annual incremental earnings potential (rental potential) attributable to schooling in the Mincer model, we can then write:

$$(2) \qquad C_i = S_i^3/r - (S_i^3/r)(1+r)^{-n}.$$

The second term on the right is a correction for the finiteness of the earning life.

Let us designate the schooling rental to cost ratio S_i^3/C_i by R_i^3. We then have

$$R_i^3 = S_i^3/C_i = r\left[\frac{1}{1 - 1/(1+r)^n}\right]. \tag{3}$$

Letting a represent the term in brackets, we may write $R_i^3 = ra$, and $S_i^3 = raC_i$. Since the total number of years of post-school working life for men who have completed the ith year of schooling (n) will be 40 years or more, a is very close to 1, and R_i^3 is very close to r. This means that under the Mincer assumptions the annual incremental rental values attributable to schooling could be approximated by the value rC_i, which will be very close to S_i^3. However, there is a national accounting problem that was not encountered under Model 1.

In taking S_i^3 as the measure of the annual contributions of schooling to national income under the Mincer assumptions we have done two things. First we have "purified" our income data to exclude all effects, both positive and negative, of post-school opportunity-cost investments (though this does not of course mean that we have succeeded in securing a measure that is independent of market demand and structure). But in doing this we have taken the estimated potential marginal products associated with the ith increment of schooling as the measure of education's contributions, counting in those contributions some foregone earnings in post-school investments that are not measured in the estimates of the national product. If we do this we must make an adjustment in the estimate of national output, to add to gross investment the amount of the foregone earnings wherever rC_i exceeds $(Y_{it} - Y_{i-1,t})$. This will be the case for the early post-school years, so that we cannot entirely escape an age adjustment even when concentrating on S_i^3 alone. If we are to be consistent, we should also count the full costs of schooling, including foregone incomes, as part of the gross investment component of national income in the years $t = -s$ through $t = 0$, whereas in fact national accounts include only the D component, which is treated as consumption. This latter omission, by the way, is an accounting gap that is relevant whatever our assumptions concerning post-school investments in human resource formation.[19]

Before considering the post-school investment components in human capital and in its services, let us turn back to Model 2. In that model we assumed that earnings streams were as observed in the same empirical data we are looking at in Model 3, but that all post-school increases in earnings were attributable to prior schooling and that alone. The year t rental value increment attributable to schooling in Model 2 is simply $(Y_{it} - Y_{i-1,t})$, which we may designate as S_{it}^2. Its mean value, S_i^2, will be simply $\Sigma(Y_{it} - Y_{i-1,t})/n$. If the age income stream rises at all steeply this value will be considerably in excess of rC_i, or S_i^3.

What do we have under the Mincer assumption when we use observed incremental earnings streams to estimate the rental values of human-capital services? Evidently in this case the difference $(Y_{it} - Y_{i-1,t})$ is compounded of returns to schooling, returns to post-school investments, and deductions from

[19]In effect national accounting practice depreciates all foregone income investments immediately. For arguments favoring revision of national income accounts in this respect see Kendrick, 1966, and Seers and Jolly, 1966—also discussions of Bowman and rejoinder, 1966b.

these of the foregone income "invested" in on-the-job training or learning.[20] The lifetime net returns to investments in on-the-job training (after deductions of the foregone incomes entailed) will be:

$$(4) \qquad \sum_{t=1}^{n} J_{it} = \sum_{t=1}^{n} (Y_{it} - Y_{i-1,t}) - nS_i^3 = n(S_i^2 - S_i^3),$$

and hence we have for the mean rental value of the post-school investment component:

$$(5) \qquad J_i = S_i^2 - S_i^3 = S_i^2 - raC_i.$$

Some idea of the magnitudes of J_i and of S_i^2 relative to raC_i (or S_i^3) in concrete cases is given by the summary in Table 1 for the 4-year college increments to schooling with associated on-the-job training in the United States as of 1939, 1949 and 1958 (based on Mincer's data) and for three sets of Japanese data for 1961. The mean Japanese income streams are roughly comparable with the U.S. 1939 figures.

TABLE 1

MEAN INCREMENTAL RENTAL VALUES[a]

Ratios for Model 2 Schooling (S_i^2) and for Model 3 On-the-Job Training (J_i) to Model 3 Schooling (S_i^3)

(College Compared with Senior-Secondary Earnings Streams)

	S_i^2/S_i^3	J_i/S_i^3
U.S. 1939		
White Urban Males in Wage and Salaried Employment	1.68	0.68
U.S. 1949		
All Males	2.18	1.18
U.S. 1958		
All Males	1.80	0.80
Japan 1961		
Males in Wage and Salaried Employment except Government Civil Servants and Service Industries		
Mean Streams	2.50	1.50
Maximum Seniority Streams	5.64	4.64
Zero Seniority Streams	2.12	1.12

[a]The estimates for the United States were computed on the basis of data and rate-of-return computations in Jacob Mincer, "On-the-Job Training: Costs, Returns, and Implications," *Journal of Political Economy*, Vol. LXX, No. 5, Part 2, October 1962 Supplement, pp. 50–79.

For Japan, wage data were adjusted to incorporate annual bonuses. The "zero seniority streams" were constructed from data referring to men with less than one year's seniority in the firm at every age. The "maximum seniority streams" were from data referring at each age to men with maximum seniority compatible with their age and schooling. These are preliminary estimates, prepared by the author under a research grant from the Carnegie Corporation in New York.

[20]And immediately depreciated.

The late stage at which incomes of university graduates in Japan rise above those of senior-secondary graduates is evidenced by the high ratios for the mean-income streams. Even in the extreme case (in which the zero seniority streams are compared) J_i exceeds S_i[3].

What have we learned from this exercise in the estimation of rental values associated with schooling and on-the-job learning? First, we have evidence of marked shifts in age-income patterns among secondary school graduates within the United States and as between the United States and Japan; no matter how these data are interpreted, the ratios shown in Table 1 stand as descriptions of the shapes of those earnings paths. We have very strong hints, well supported by other kinds of evidence, that realization of productive potentials and the life patterns of human resource development are sensitive to both underlying labor market institutions and shorter term labor market conditions. We have a valuable starting point, if no more, for further analysis of relationships among schooling, on-the-job learning, and labor market characteristics. This is an important problem, or cluster of problems, but it is not the one with which we started.

So far as the valuation of human-capital services as inputs in aggregate input-output growth econometrics is concerned, the main results are to cast further doubt upon what I have called the "splitting of individuals" methods in such applications. This concluson must be all the stronger when we remember that in all of this I have simply waived the problem of filtering out such elements as native ability and family background in differential income streams.

On the other hand, we may add significantly to our understanding of growth processes if we keep men intact as individuals but group them in relevant (and sufficiently disaggregated) categories. From this point on a variety of statistical and econometric experiments can be undertaken, whether with alternative aggregate production functions, distributed lag models, linear programming, or other devices.[21] The first requirement is so to design our collection of data as to permit the testing of well chosen hypotheses concerning investment in human beings and the conditions for payoff to such investments in economic development. In this human investment orientation, human capital proper, measured as a stock, is an ephemeral marker between investment flows into human capital formation and ensuing (overlapping) income streams.[22] It has little aggregative meaning despite its importance in micro-decisions.

III. The Valuation of Gains and Losses in Human Capital Through Migration

A second major area for the application of human-capital and/or human-investment concepts to development analysis and planning is in the effects of migration. Here the capital concept proper, in a Fisherian definition, comes more

[21]Both theoretical considerations and recent research on production functions by industry or sector clearly indicate the desirability of separate analyses of developments in distinctive sectors of the economy, characterized by different physical and human capital mixes, labor market structures, and associated on-the-job training patterns. Griliches has done this taking education explicitly into account in his analysis of aggregate production functions in agriculture and in manufacturing in the United States. See Griliches, 1963 and 1967.

[22]This position is very close to that taken by Solow, 1963.

fully into play in that we are seeking to measure gain or loss in an asset or stock rather than a current input into production. Whether we will want to include the totality of human capital or only certain parts of it is another matter, to which I shall return. First it is necessary to consider who or what is to be taken as the gaining or losing entity or entities.

1. Specification of the Gaining or Losing Entities

Evidently any attempt to delineate the relevant principles for evaluation of human capital gains and losses through migration (whether international or intra-national) must begin with consideration of *whose* gains or losses are to be counted. Or, proceeding from a Fisherian definition of capital, whose future income streams are we going to value in estimating human capital gains or losses?

At one time or another, each of the following gaining (or losing) entities has been the focus of attention in professional writings:

1. *The world at large*, or the aggregate of all individuals, migrant or not and regardless of their particular origins or destinations.

2. *The pre-migration population of country A*. This includes gains (or losses) to emigrants as well as to the original inhabitants who remain.[23] The problem may be defined to exclude consideration of immigrants altogether, or to include their impact on the human capital values of the original and remaining population of country A, but the gains to the immigrants themselves are not counted. (They would appear as emigrants from country B.)

3. *The permanent residents of country A*. This is a subcategory of 2., consisting of the remaining pre-migration population; both immigrants and emigrants are excluded from the group whose gains or losses are assessed. (This is a common lay orientation with a distinct in-group or "belonging" coloration in that those who leave quickly become "them," not "us." In this sense it has a nationalist flavor. Nevertheless, it is a legitimate focus for analysis.)

4. *The nation-collectivity.* Here the pre- and post-migration residents of a nation or area are taken as the relevant collectivities though their membership changes, whereas in the first three cases the gaining or losing groups retained their pre-migration membership lists.

Setting aside the vituperative charges of militarist nationalism and the counter-charges of inhuman atomism or static myopia, the two extremes represented by 1 and 4 can have more in common so far as measurement problems are concerned than the intermediate cases. At either extreme we can start with the simplifying assumption of zero spill-over or scale effects; everything that is added or substracted is then embodied in or accrues to the migrants. On the other hand, not even a first step can be taken toward assessment of effects of migration on the permanent-resident population or the permanent-resident component of the pre-migration population without consideration of how the departure of emigrants or the arrival of immigrants affects the future earnings

[23] This orientation is used in Grubel and Scott, 1966a.

streams of *other* people.[24] Nevertheless, there is a bit of a paradox in the mathematical relations between alternatives 1 and 4. So long as gains to the nation-collectivity are counted in terms of total human-capital aggregates, regardless of local per capita income effects, the answer to 1 will be the algebraic sum of all the 4's; but as soon as per capita earnings cut-off contraints are introduced into nation-collectivity valuations, this equation is upset.

Given the extreme difficulties of measuring spill-over and scale effects, I shall concentrate most (not all) of the following discussion on the more limited task of valuing human-capital gains and losses exclusive of such considerations. This means that the effects of migration on the human capital of permanent-resident populations receives short shrift. Furthermore, in view of the widespread interest in national development and the prevelance of such concerns among the participants in this conference, most of what follows takes the nation-collectivity orientation. This is not to deny the fundamental importance of analysis in the other perspectives, however. Neither is it to take the position that what counts even from a nation-collectivity point of view is what is added to or subtracted from a resident human-capital aggregate, regardless of *per capita* incomes or *per capita* human-capital values.

2. *Selective Human Capital Counts and a Welfare Function*

The second requirement in any discussion of the valuation of human-capital gains and losses through migration is specification of just what part of human capital we are counting. Are we interested in the present values of earnings streams in their totality or only in part? If the latter, is it certain components of human capital, say the education or schooling component, that is of concern? Are we interested only in gains or losses above some criterion per capita level? These questions are of special importance in a nation-collectivity perspective. The four following alternatives immediately suggest themselves.

1. Simply count the gross human-capital values with and without migration and take the difference as gain or loss.

2. Select out, to be counted, only those components of human-capital values that can be attributed to particular kinds of investments in human-resource formation.

3. Deduct from 1 a correction for maintenance costs.

4. Apply a per capita value constraint on the maximization function implicit in 1.

The first alternative is straight-forward enough, and it is the approach used by Rashi Fein[25] in his assessments of human capital flows into and out of the U.S. South. It is also the starting point for present-value measures of human-capital gains and losses that incorporate adjustments such as those involved in alternatives 3 and 4. Moreover, this comparatively simple approach can serve

[24]See the debate concerning externalities and market distortions in articles by Grubel and Scott, 1966a, Harry Johnson, 1965, 1966, 1967 and 1968, Brinley Thomas, 1967.

[25]See Fein, 1965.

us very well in considering the complications that enter into other types of assessments. I shall therefore make considerable use of it despite cogent criticisms of it by Grubel and others.

Alternative 2 should not be confused with focus upon particular categories of migrants (say doctors, engineers, college graduates). Selection of particular categories of people would still leave unsettled the question as to which of the four alternatives listed should be used to evaluate human-capital gains and losses associated with their migration. By alternative 2 I refer, rather, to the splitting off of a part of the human capital embodied in a man, to count that part only (by definition) as the "human capital" in which we are interested. In practice the component selected for attention has usually been schooling, and the measurements of migration gains or losses in this segment of human capital have been in terms of costs rather than present values.

Alternative 3 derives from a contrast between human and physical capital that is particularly awkward, both conceptually and empirically, when attempting to measure gains and losses through migration. When physical capital moves across frontiers there will be little ambiguity about the answer to the question: Should this be counted as a capital accession? But note that the present value of the future income stream that is expected from this unit of physical capital has already been estimated net of the costs of its maintenance. Thus where gasoline prices are extremely high the demand price for small trucks that conserve on gasoline will be higher relative to that for trucks that use much gasoline. Yet no one has even suggested that we differentiate according to whether migrants are little men who don't eat much or big ones with robust appetites. Logically, to deduct maintenance costs before valuing the human capital embodied in migrants is to extend to human capital the standard adjustments for maintenance that would be applied in an expected income stream valuation of physical capital. The chief trouble with this alternative is the very wobbly peg on which the "maintenance" measures would stand. (Note that the logic of this procedure in the nation-collectivity perspective implies maintenance deductions on human capital valuations of migrant and non-migrant populations alike.)

Although alternative 4 is formally similar to 3, it stands on a very different ground. Alternative 4 is of interest primarily because it represents a kind of valuation that seems to be implicit in much of the informed but less technical thinking about human capital gains and losses. It specifies application of some sort of welfare function in the assessment of human capital gains and losses that will take both scale and per capita level considerations into account. In fact I am willing to go further, to suggest the form and values that this implicit popular function may approximate. To do this we need some elementary mathematical notation.

H = gain or loss in human capital

V_0 = the present value of the mean *per capita* earnings stream for all residents of country X in the absence of the migration increments under consideration

V_a = the present value of the mean *per capita* earnings stream for all residents of country X after such migration

V_b = The present value of a reference standard *per capita* income stream. $V_b \geq V_0$

P_0 = population resident in country X in the absence of migration.

P_a = population resident in country X after migration occurs.

All values of V and of P carry the same date. Also, I take the "appropriate" discount rates for deriving V to be given; this is not the place to discuss arguments over social interest rates or the treatment of discount rates in moving from one country (or set of individuals) to another. Because we are dealing with human capital, I have specified earnings streams, not total per capita income streams. The latter, however, would give us a more generalized welfare function. Using the above notation, the measure of human capital gains or losses takes the form:

$$H = P_a(V_a - V_b) - P_0(V_0 - V_b) \tag{6}$$

or, rearranging,

$$H = (P_a V_a - P_0 V_0) - V_b(P_a - P_0). \tag{6.1}$$

The first term on the right in the second form of this equation defines the gain or loss in a nationalist gross-aggregate perspective, and the second term is the deduction against this on account of the per capita earnings constraint. The term $V_b(P_a - P_0)$ will always be positive for net immigration, when it is deducted from the estimate of gain; for emigration it reduces the estimate of loss. Note that $(P_a V_a - P_0 V_0)$ can be either positive or negative for either immigration or emigration, depending upon factor substitution elasticities and scale effects as well as the quality of migrants relative to non-migrants.

Where $V_b = V_0$ we can substitute V_0 for V_b in equation (6.1). This gives us the simple truncated form:

$$H = P_a(V_a - V_0) \tag{7}$$

with the implied welfare criterion of maximizing the aggregate value of earnings streams differentials over and above the mean original value V_0. Above the level V_0, but not below it, there can be a trade-off between numbers and per capita returns.

I introduced the specification $V_b \geq V_0$ to allow generalization of the equation to situations in which there is a massive low income population pressing against limited physical resources. If we set V_b high enough relative to V_0 the deduction term on the right can be extremely powerful in filtering out what will be included in measures of human-capital gains and losses through migration. Evidently, neither this nor any other welfare function can claim ultimate validity, but specification of the effects of taking different levels for V_b within this essentially simple construct can be an illuminating enterprise for the would-be social engineer.[26] Furthermore, making such estimates in practice is no more (and no less) difficult than the estimation of gains and losses using the simple gross

[26]This formula can be readily adapted for measurement in line with alternative 3. Defining V_m as the present value of a per capita maintenance or subsistence stream all that is required is to substitute V_m for V_b in equation (6.1). This formal identity conceals the underlying conceptual contrast, however.

aggregates of the first alternative. Once we have the latter it is a simple matter to convert them to measurements in line with whatever V_b value the planner may prefer.

3. *Single Dated, Marginal Assessments of Human-Capital Gains and Losses; Present Values*

Two characteristics of the simple formulas presented above are that they relate to specific dates and that they evade specification of production functions. By dating them we treat the migration assessments as quasi-market transactions in the exchange of assets, even though no one directly "buys" or "sells" the human capital as such. Also, we have implicitly set up both a single-period frame of reference and an assumption of permanent one-way migration as at least a starting point.

In the nation-collectivity orientation the specification of production functions was evaded by tacitly assuming that this problem had been solved in arriving at values for $(P_a V_a - P_0 V_0)$. Such evasion need not worry us so long as we are concerned only with small relative movements.[27] We can then legitimately take a marginal product (assuming we can find the right one) for the measure of assessment of human-capital gains and losses through migration.[28] As soon as the magnitude of a movement becomes larger relative to comparable population bases at origin or destination, consideration of substitutabilities, complementarities, and scale effects becomes essential, however. Unfortunately it is also difficult to arrive at valid estimates under these circumstances. In any case, it will help to examine the simpler case, which I shall proceed to do.

To begin with, let us take a practical look at the present-value estimation of gains and losses through migration when data are comparatively good. I retain the simplifying assumption that all the migration is one-way and terminal; there is no re-migration. Since Robert Myers and I have discussed both this and the re-migration case at some length in a recent article,[29] I can be brief here. We were concerned with how the mix of schooling and post-school learning may affect (among other things) the valuation of human-capital flows. However, we did not recommend measuring these components of human capital separately from each other or from the total human-capital values of those in whom the schooling and experience were embodied. Moreover, experience components in human learning that accrue prior to school completion were equally included in our concerns. The thrust of the relevant part of our article was to underline the importance of contrasts between one and another country or region in the kinds and extent of effects of experience on human capital values.[30]

This being the case, the measurement of gains and losses in human capital must take account of differences in experiences and in school quality between the areas of origin and destination. Assume, for example, that 30-year-old male college-educated migrants from country A to country B will not move voluntarily

[27]At any given distinct category of the labor force and the human capital embodied in it.

[28]Alternatively, but less plausibly, we can assume infinite elasticities of substitution.

[29]Bowman and Myers, 1967.

[30]Differences in quality of schooling come in too, though perhaps less potently than out-of-school experience (both early and later in life).

unless as individuals they anticipate life-earnings opportunities in B *at least* as high as those in A. We can then set as a minimum estimated per capita value of these migrants their capital value in the country of origin. Not only is this the best approximation of the gross human capital loss to country A; in the absence of data referring explicitly to the life earnings of migrants into country B from A, this figure may also be our best approximation to the gain in human capital experienced by country B. It will of course normally understate that gain.

Just how important the choice of valuation base may be in estimating aggregate capital gains or losses to a nation or region is illustrated by our adjustments of Fein's estimates for white male migration into and out of the South over the decade 1950–1960. Fein valued all migrants, both in and out, on the basis of life-earnings data for the South. Following our argument, we drew upon life-earnings data from the North to value white male migrants (of each age and educational attainment level) who originated in the North. The resulting estimates of human-capital gains to the South contrast sharply with those using the southern base for valuing the in- as well as the out-migrants (Table 2).

TABLE 2

ALTERNATIVE VALUATIONS OF SOUTHERN HUMAN CAPITAL GAINS BY INTER-REGIONAL MIGRATION; U.S., 1950–1960

	Mean Present Value per Migrant	Total Value (millions)	Net Gain (millions)
	$	$	$
554,900 Out-Migrants, Southern Value Basis	40,000	22,196	
579,100 In-Migrants			
Southern Value Basis	40,000	23,164	968
Northern Value Basis (1)	50,000	28,955	6,759
Northern Value Basis (2), adjusted for major re-migration	44,000	25,480	3,284

SOURCE: Adapted from M. J. Bowman and R. G. Myers, 1967.

The present value per migrant figures are weighted averages, multiplying the estimate for each age-education category by the number in that category. The $50,000 figure for in-migrants is estimated on the assumption of one-way migration.[31] The very conservative figure of $44,000 might be taken as a minimum after making an extreme adjustment for the fact that the census estimates of gross in-migration include some remigration of southerners back again from North to South. Using the $50,000 estimate, the net southern gain on human capital account becomes $6,759 million instead of the $968 million estimate using the southern present-value estimates throughout. The difference of $5.8 billion is almost a seven-fold increase in the estimate of gain. Even with our more conservative valuations of in-migrants, the estimated southern aggregate net

[31]Following Fein, we used a 5% discount rate. However, we also biased our figures (*both* North and South) downward, which has the effect of raising the implicit discount rate.

human-capital gain is 3.4 times that obtained when all migrants in both directions were valued on the basis of southern life-earnings data; the absolute difference is still well over $2.2 billion.[32]

4. *Replacement Cost Valuations and Migration Probability Adjustments*

In their "Cost of U.S. College Student Exchange Programs," Grubel and Scott[33] used replacement-cost assessments for the valuation of human-capital gains and losses through migration. Among other things, alternative estimates were given: one incorporates only the schooling-cost component, while the other incorporates also the total "maintenance costs" of raising a man to the age at which the schooling-cost estimates begin.[34] Given their careful work, I can concentrate on a few conceptual considerations in the utilization of a replacement-cost method of assessing human-capital flows.

I shall again take the nation-collectivity orientations (as did Grubel and Scott in this case) and assume that migration is on a small relative scale, allowing us to neglect the limitations of deriving aggregated valuations from marginal ones. Furthermore, I shall again begin with the single-dated migration event.

Evidently in a perfect equilibrium world with only marginal migration, and a world in which all educational or even maintenance costs are incurred with solely investment motives, the measurement of human-capital gains and losses at replacement costs would give us the same results as measuring in present values; the internal rate of return and the externally determined appropriate discount rate would coincide. Or such would be the case provided the replacement costs were properly specified. But we run into difficulties here from the very start.

One pervasive difficulty is the neglect of all post-school learning and investments in it, whichever of their replacement measures Grubel and Scott use; but let us set this problem aside for the moment, making the extreme assumption that all post-school learning is a function of schooling regardless of later experience and of where that experience is obtained. Assuming the intent is to measure total human capital, the relevant Grubel and Scott replacement costs would be their cumulated "maintenance" alternative. However, they apparently made no allowance for cumulated interest over the long period of formation of the human capital they are measuring. This might be ignored on the ground that even the staunchest adherent of the equilibrium assumption as a useful working hypothesis must flinch at the notion that what is spent on children is determined by rationalistic investment motives alone, or that the maintenance component of such expenditures is so determined. If we simply take total replacement costs, without considering interest, they are no longer really replacement costs;

[32]These estimates would be increased if the cross-section life-earnings data had been adjusted for a growth factor. In fact, anything that raises the southern and northern origin-values by the same absolute amount will raise the estimated net aggregate human capital gain, and vice versa.

[33]See Grubel and Scott, 1966b. A replacement cost method of valuation has been used by Bruce Williamson also (1965).

[34]Actually in their total human-capital version they take maintenance instead of foregone earnings estimates of costs even during the school years to which the latter would be relevant. It is not clear to me why they did this unless they in fact measured "maintenance" costs for the schooling period at the same value that they set on foregone earnings.

in that case we must regard them as an indicator of present values, but without any very clear rationale as to just what the relation is. I fear that this total replacement cost method of assessing gains and losses in human capital through migration gets us into a conceptual morass.

What of the other alternative, of counting only the schooling component in costs? In this case too we must take the time lag into account, but for the *student* population to which Grubel and Scott were applying their measures that lag will not be so long. There are now two ways in which we may look at the schooling replacement-cost. First, we might view it as an approximation to present values of the schooling component of human capital, confining our attention and our definition of human-capital gains and losses to that component. If so, the replacement-cost measure is a pragmatic compromise, justified by the difficulty of arriving at present values. It is subject to all the difficulties that have led me to reject the split-person method in aggregative assessments, even while insisting upon its usefulness for decision theory and for empirical studies related directly thereto. However, there is another way of looking at the replacement-cost alternative that is confined to schooling. We might specify to start with that we are uninterested in any human capital that does not embody schooling above some stated level and, further, that we have an ample supply of human raw material that could be processed further. This is what the Grubel and Scott schooling-cost approach seems really to be. It is a little awkward to compute foregone incomes as costs when we counted the human assets that provided them at a value of zero, but we might set something like this as a constraint in defining a welfare function analogous to that set up earlier. In effect we are specifying that the value of V_b refers to whatever people with less than the indicated schooling increments are worth, and in using a schooling-cost measure as our value proxy we are automatically deducting $V_b(P_a - P_0)$ without ever measuring either it or the gross human capital.

Once this has been specified as a constraint, we may then ask under what circumstances, if any, we might choose a schooling replacement-cost measure in preference to a present-value indicator of gains and losses in human capital *even* if we could sort out the schooling components in income streams and assess present values with precision? Since the two measures would coincide in equilibrium, some degree of disequilibrium must be involved if we are to set a preference.

In seeking to answer this question, let us consider first the valuation of human-capital losses through emigration. If the present value of the human-capital replacement cost, including an allowance for the loss involved in deferring the earnings stream, is less than the correctly assessed present value of the emigrant human capital had it instead been used in the country of origin, the present-value measure would overstate loss to that country. On the other hand, if the human-capital replacement cost exceeds its home-country present value, the latter is the appropriate figure: to use replacement cost under such circumstances is clearly erroneous. Looking at the gains to the country of immigration, the valuation rule would be similar except that both the present-value and the replacement-cost estimates are for that country, not the country of origin. One of the most common uses of replacement-cost thinking is unfortunately the wrong one, the valuing of poorly equipped out-migrants who are not economically

"worth what they cost" at either a historic or a replacement cost figure. This naiveté has plagued thinking about migration out of Appalachia, for example, though it is rarely explicit in professional economic writings.

In identifying situations in which the replacement-cost measures would be preferred for assessing the schooling component in human capital gains and losses, I tacitly assumed that the human-capital replacement would in fact stay in the country undertaking the replacement. It is easier to think of this in terms of the country of emigration, though the two cases of immigration (gains) and emigration (losses) are in fact parallel. Suppose that instead of a certainty that the replacement will stay, there is some degree of probability that he will not. Under such circumstances we would have to raise the figure for replacement costs to take into account the probability of emigration at the second stage. Thus if C is the replacement cost per man under the assumption that all replacements will remain, and p is the probability that such a replacement will in fact leave, the adjusted measure for replacement cost will be $C/(1 - p)$.[35] If the probability that the replacement will leave is 1, replacement cost becomes infinite. Long before this the valuation rule will have shifted us automatically to the present-value measure.

In these last paragraphs the assumption that all post-school learning was determined by schooling was in fact unnecessary. All we required to determine that replacement cost valuations would be the ideally preferred ones was evidence that they gave a smaller figure than any reasonable estimate of the true present value of the schooling component in future income streams of migrants from or to the country from whose perspective we are making the valuation. This gives us a reasonably good base on which to make any replacement cost valuations when the migrants are men without post-school experience. Unfortunately however, both human-capital services and the asset value of a man at any given time are functions of his age. If we could assume horizontal income streams we could still use schooling replacement-costs reduced by an amortization allowance in estimating the value of the education component of the human capital embodied in older men. But this is not the case. There is both post-school investment and costless learning through experience that is associated with schooling; these things are of considerable magnitude, and they are not independent of what a man does and where. The problem is too big to be ignored. I very much fear that replacement-cost assessments have only a very limited, though an important, range of applicability in the assessment of human-capital gains and losses from migration. They are strictly applicable only for young men still in or just through the higher levels of the school system and when the social internal rates of return to the schooling investments at the replacement cost and income stream levels of the assessing nation clearly equal or exceed the social discount rate.

5. *Marginal Decisions and Human-Capital Flows*

Among the most critical policy decisions with respect to investments in human capital as a development policy are (1) decisions as to whether to train

[35]Note that $(C_i p_i)M_i$ is the per annum cost of a steady out-migration rate p_i from annual accruals M_i to the potential labor force with the characteristics of category i.

certain types of high-level personnel at home or abroad, and (2) decisions concerning the importation of technical assistance personnel and the most efficient strategies for doing this. As a first approximation, it is useful once again to assess these alternatives in a simplified model in which, even though factor proportions may change, all adjustments are marginal, they occur smoothly, and factors are paid in line with their marginal products at any given time.

Let us suppose, for example, that the policy question is raised: should we train x more high-level engineers (or even any engineers at all) at home, or should we send them for study abroad? This is not likely to be a decision for a single year's crop of engineers only, but rather for a sequence of such crops extending over several or many years. We may begin, nevertheless, with the single-dated event, allocating the appropriate proportion of long-term overhead schooling costs to that year. A clue to the appropriate measurement technique is hinted at by the probability adjustments of replacement costs introduced in the preceding section. However, the problem we are posing here is a different one in two important respects. First, since we are involved in a benefit/cost assessment there can be no question of choosing which measure to use—a cost or present value measure. Both costs and yield must be taken into account. On the other hand, our problem is simplified in an important respect; because we are comparing alternative joint investments in schooling and learning through experience, we need not distinguish these components of human capital from each other, or even from other components of total human-capital assets. For the same reasons, we will not need probability adjustments in replacement cost figures. Our probability adjustments come in another way. The economic choice between the alternative strategies will depend upon the present values of expected net income streams with one choice as against the other. These present values incorporate the appropriate costs (for study at home versus abroad) in the net stream estimates, but without probability adjustments for either stream up to the point at which the student studying abroad decides whether or not to return. At that point probabilities that the student will in fact return are attached to both the return travel costs and the expected earnings streams at home for those who return from foreign study. Probabilities that students trained at home will remain at home are also attached to the expected earnings streams for those trained at home. A comparison between these two probability-adjusted net present values provides the economic criterion for decisions.

Notice that having declined to attempt a separation of the schooling from other human-capital components for either of the alternatives, we do not have internal rates of return. Nevertheless, we can compute a rate of return over cost for the choice to make the more expensive investment in training abroad. Accepting as appropriate the external discount rate already applied, we may simply divide each of the alternatives into two parts, that up to the termination of schooling (including the probability-adjusted return travel costs) and the ensuing life-income streams with their probability adjustments. The rate of return over cost for the training abroad alternative will then be the ratio of the differences in the post-schooling streams to the difference in the cost of schooling streams.

The present value estimates just discussed were assumed to take into account differences in the quality of the education, or in what would be learned in school

under the two alternatives. They could have been extended to include consideration of differences in the learning through experience that would occur by extending the period abroad into the early post-school years. Along with this would go adjustments for the delayed introduction into productive life at home, and for changed probabilities with respect to the likelihood of returning at all.[36] These elements are not easy to measure, but they are highly relevant to policy-making nonetheless; and even crude assessments are better than none.[37]

Similar methods, but without the need for probability adjustments, may be applied to analysis of alternative strategies with respect to technical assistance personnel. Myers and I sketched out such an application for assessment of the alternatives among (a) sending one man for ten years (with home leave every two years), (b) sending five separate men consecutively for two years each and (c) sending two men for alternating tours of two years each over a total period of ten years. We conclude that, under the most plausible assumptions concerning learning through experience and skill obsolescence, the most efficient alternative was likely to be the third.[38]

6. *Copper-Age Assessments and Human-Capital Epidemiology*

In most of the preceding analysis of gains and losses in human capital through migration, including the decision problems just discussed, I have conveniently stayed with marginal adjustments or with the alternative assumption that sequential effects of successive human-capital inputs are such as to maintain marginal products at a constant level despite changes in factor proportions. Although the latter assumption does not meet the requirements of the golden age, it shares some of the golden-age beauties and is considerably more helpful in dealing with pragmatic empirical problems. However, it remains essentially non-commital so far as substitution elasticities, scale effects, and allied problems are concerned. Evidently the exploration of these matters is a task for many people and many years, and can take many directions. This paper is already too long, and speculation, however systematic, is out of place. Nevertheless, by way of illustration I would like to suggest exploration of the dynamics of what might be called a "copper-age" model.

In the copper-age, total rates of investment in capital formation (human and non-human) are a rising function of the proportion of middle and high-level human resources in the population. The process at work is the epidemiological model, which diffuses information and ambition leading to self-investments according to (1) the frequency of exposure of the less-educated members of the society to better-educated images (a positive effect), and (2) the approach to an ever more resistant or immune remaining less educated population (a dampening effect).[39] If we add the proposition that the larger the proportion of better

[36]This model is developed in Bowman and Myers, 1967, and further elaborated in Myers, 1967b. It assumes that the contributions of men who remain abroad have no effect on the home country. For criticisms of this assumption see especially Harry Johnson, 1965. It is challenged also by Grubel and Scott, 1966a.

[37]For a discussion of the possibilities, advantages, and limitations of use of sample interview data for these purposes, see Myers 1967b.

[38]See Bowman and Myers, 1967.

[39]See Stone, 1965.

educated people the greater will be the pressures to find new opportunities and to innovate,[40] which in turn creates an environment that demands more highly educated skills, we have a dynamic growth model. *Ex post* a Griliches might well be able to measure all the increases in inputs, to come up with a full explanation of the growth in national product even using a constant returns to scale model.[41] However, viewed *ex ante* this becomes something very like an increasing returns to scale model with respect to the assessment of the values of high and middle-level human-capital resources.[42] Even ignoring the question of complementarities, in the copper-age, emigration of skilled men from the less developed countries becomes a matter of much greater concern than a marginal analysis that ignores such scale effects might suggest.[43] How far and under what conditions copper-age processes in fact operate or can be induced is probably THE development question.

IV. On the Importance of Knowing Your Question: or What is Appropriate When

If there is any one principle for the valuation of human capital that emerges out of all this it is: Fit your measures to your problem and keep a spotlight well trained on your assumptions. One corollary is to use the human-capital concept flexibly. Another is to define measurement units and concepts in such a way as to avoid theoretical or empirical assumptions where the same ends can be served by staying closer to empirically observable units; where this is not the case, make the assumptions inherent in the measurement methods fully explicit.

Clearly it is *not* appropriate to use the capital concept proper in aggregate production functions or in attempts to measure and parcel out contributions to national income growth. If "effective stocks" or services of diverse kinds of capital were nevertheless generally proportional to either the value of the capital asset or to its cost, we could use stock valuations as proxies for service inputs. However, no such proportionality between stocks and inputs of services prevails; both material and human capital are heterogeneous with respect to the shapes and durations of their life income streams. Paradoxically, in view of the presumed concern of capital theory with time, as soon as we attempt to analyze what has

[40]Denison has argued that most investment in schooling represents a net addition to a society's total investment, substituting for consumption rather than for alternative investments. See Denison, 1964.

[41]Zvi Griliches and Dale Jorgenson (1967) used a Divisia index of total factor productivity, taking as their production theory a constant returns to scale function together with the condition of producer equilibrium that all marginal rates of transformation between pairs of inputs and outputs equal the corresponding price ratios. Under these conditions the Divisia index will remain constant unless there are shifts in the production function. By detailed re-examination of factor-input specifications and aggregation procedures they succeeded in virtually eliminating changes in the Divisia index over the past twenty years. Note, however, that (as they recognize) this does not help us with the planners' questions concerning which alternatives to choose in investments for development.

[42]Note the relation of this proposition to the type of welfare function suggested on pages 32–33.

[43]These considerations make me very uneasy about taking the arguments concerning contributions of emigrants to their home countries as a basis for policy decisions, even when I accept those arguments within the context in which they are presented. Again, see Harry Johnson, 1965.

happened over time or what will happen *through* time, the capital concept proper (human or otherwise) lets us down. It must, for it stands still to look at future time instead of moving along with time.

Despite these remarks, use of cost estimates is both appropriate and necessary in any attempt to evaluate or plan investment policies for economic growth or development. This is quite as true of comparisons of investment rates or flows into one versus another sort of capital accumulation as for more static comparisons. Furthermore, as we compare alternative incremental investment streams and their associated incremental returns streams, we presumably will want to take into account differences in the lags of the streams of returns behind their associated costs. In other words, we will be concerned with estimation of average rates of return over the lives of various kinds of investments. We then have all the adjuncts of the capital concept except the valuation of the capital asset itself. I can see very little use for "present value" measures in dynamic growth analysis except as they form part of the analytical framework needed to compare alternative marginal lines of action that have growth implications. This is the way in which I used them in discussing decisions concerning the training of high-level man-power at home or abroad. In a more aggregate frame of reference, we will be concerned with cost streams that create assets and the income streams that flow from them, as essential ingredients of investment assessments; but once we seek really to dynamize our model and to look at growth paths the values of the assets *per se* will hardly come into it.

In view of the fact that "human resources" are also "human consumers", valuation of gains and losses through human capital movements runs into complications in the specification of welfare functions that are more easily evaded in valuations of physical capital movements. I avoided, or perhaps it would be more accurate to say that I evaded, the maximum per capita income criterion in this analysis primarily because it sets a question very different from that implied by the topic assigned to me. I could still have approached this through the back door of assessing migration-induced aggregate human-capital gains and losses to permanent-resident populations. However, there is nothing we can say about how to measure this until we specify substitutabilities and complementarities among the permanent-resident population, the migrant populations, and other factors of production. In the simplest marginal equilibrium assumptions, where the scale of migration is relatively very small, the gain or loss of human capital to the permanent-resident population is approximately zero virtually by assumption. Taking the nation-collectivity view we have something to measure, but must specify with some care what that something is. This is where the specification of the relevant welfare function comes in. I have suggested such a function in a flexible form that permits easy application of a correction factor once we make initial aggregative assessments that include the total of human capital assets in the count. Wherever possible throughout the analysis of migration (and I found it to be possible most of the time), I avoided the splitting off of estimates of the component of human capital attributable to schooling.

A full-fledged use of the capital concept proper, incorporating the whole paraphenalia of asset values, costing, and rates of return, is unambiguously

appropriate and useful in a decision context in which everything is to be assessed from the perspective of a particular point in time—the point at which the investment decision (private or public) is first to be implemented. Both costs and returns are assessed from and with reference to this location in time. From a broader societal point of view, analysis of the totality of such decisions becomes investment-resource-allocation analysis including (notably in the case of human capital formation) examination of the extent to which private decisions are in fact "efficient" ones. In this context capital is allowed to retain its concrete empirical heterogeneity along with its generalized theoretical characteristics. In principle, at least, neither problems nor fallacies of aggregation are involved, though we will often want to compromise on this to the extent of engaging in some low level aggregative assessments. In effect such low-level aggregation is involved in the application of probability adjustments to either replacement cost assessments or comparisons between investments in schooling at home or abroad. These adjustments point up also the possibilities of extending some point-in-time valuations to an analysis of alternative rates of investment in human resource formation sustained through time. But here we come back again to some of the more unavoidable problems of separating out schooling and associated on-the-job training components in income streams (and hence in human capital values), along with the whole galaxy of unresolved problems that must concern us in our attempts to better understand economic development processes and better design policies directed toward development ends. In this context the human capital idea (or better, the human investment idea) is one of the most important, but we must be wary of attempts to measure it on an other-things-equal assumption when the essence of our question concerns factor interactions in a dynamic development process—copper-age or otherwise.

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Pour une variété croissante de problèmes relevant de l'Economie, on a recours avec plus ou moins de bonheur aux concepts et mesures du capital humain. Deux de ces problèmes seront l'objet du présent article. Le premier d'entre eux est celui que pose la mesure des gains et des pertes en capital humain dus aux déplacements de populations. Ce qui importe d'abord ici, c'est de spécifier quelles sont les entités gagnantes ou perdantes, et le type adéquat des fonctions de choix social. L'auteur presente quelques éléments de réponses. Elle montre ensuite que la technique « fisherienne » de l'actualisation convenablement adaptée devrait apporter une mesure correcte de la valeur du capital humain. Les coûts de remplacement ne sont un substitut justifiable que pour les jeunes migrants ayant peu d'expérience, et même avec cette restriction, ils ont souvent été utilisés erronément. Des ajustements de probabilités pour les migrations et les re-migrations sont requis pour évaluer le coût et la valeur actualisée des effets en capital humain de différentes politiques ayant trait aux migrations. Cependant, la nature de tels ajustements différents selon les types de mesures utilisés. Le second problème est celui que soulèvent les contributions du capital humain à la croissance économique. L'auteur remarque que pour une analyse longitudinale de ces contributions, toutes les mesures de reserves de capital humain sont inappropriées. Ce qui est essentiel dans une telle analyse est la mesure des ressources en tant que flux. Il convient en outre de pousser la décomposition à un point tel qu'il soit possible de distinguer des catégories essentiellement homogènes dans le facteur travail. En guise d'illustration, l'auteur donne un procédure permettant de distinguer dans les composants du capital humain, ceux qui ont reçu leur formation à l'école de ceux qui l'on acquise au travail. Néanmoins, cela requiert quelques fortes hypothèses.

Dans l'analyse de la croissance, il vaudrait mieux éviter de diviser des hommes en composants de l'abstrait capital humain. En outre, toute catégorisation de la force travail pourrait également fournir la base de l'évaluation, en taux de rendement, des changements marginaux dans l'évolution des investissements humains. Finalement, l'auteur insiste sur la nécessité de tenir compte des modifications et des erreurs, dues aux phenomènes de développement et qui échappent aux évaluations marginales, dans toute mesure du capital humain effectuée en vue de décisions politiques touchant soit à la croissance, soit à la migration, soit encore aux deux. Surtout dans les pays en voie de développement, une prise en considération des processus de diffusion de l'éducation et des effets d'échelle de la productivité dynamique, par exemple, pourrait relevoir une mesure critique et avoir des implications politiques.