POSTSCHOOL LEARNING AND HUMAN RESOURCE ACCOUNTING

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The central concern of this paper is with the treatment of human resources in dynamic applications of capital and growth accounting. Despite many advances, national accounting conventions still give biased profiles of the economy, but the time is ripe for experimentation with measures that can correct those biases and provide a more adequate base for assessment of long-term economic performance and prospects.

In the first section, the logic and feasibility of forward and backward measures of formation of human capital in the simplest case (of full-time schooling) is examined in parallel with physical capital. In a dynamic economy, which is rarely if ever in equilibrium, these approaches complement each other; they are poor substitutes. In section two a number of conceptual and measurement issues are considered with particular reference to human-capital investment periods and the treatment of appreciation, depreciation and obsolescence of human versus physical capital. Here special attention is given to the extended periods of investments in human resources, which overlap with realization of returns, and to the processes and agencies through which postschool investments are made. The last section presents a brief statement concerning asymmetries in disequilibrium biases with respect to the formation of human relative to physical capital. Drawing upon section 1 with regard to forward and backward measures and section 2 with regard to the critical importance of postschool learning, new possibilities in contributions of national accounting to a dynamic analysis of economic development are suggested.

Few economists today would challenge the proposition that formation of productive skills properly is viewed as an investment. Indeed, the notion of human capital can be traced back at least to William Petty. Nevertheless, there is a bias of conventional national income accounting against treatment of human resources as a form of capital. This bias derives primarily from the categorization of expenditures into household (consumption) and business (investment) sectors, following essentially a Keynesian model.[1] Unfortunately, this institutional classification, which is very unsatisfactory for analysis of economic growth or of determinants of the distribution of income, sometimes has been confounded with the more fundamental distinction between "investment" as generation of potential future income (consumption) streams and "consumption" as outputs exhausted or used up in the current period.[2] Clearly it is time that we revised and elaborated national accounts to accommodate the fact that production for the future includes formation of human resources. Such adjustments are important whatever the arguments over what constitutes human resource formation and how capital values and inputs might best be measured. Such, indeed is also the central theme of the Kendrick and the Sharma-Ram papers in this issue of the *Review*.

This paper had its origin in two broad questions. First, what are the main problems common to capital theory and capital accounting for both human and

[1]This point is well stated by Mark Blaug [7] pp. 16–22. For a general analysis of consumption and investment as an inseparable sequential process, see Bonner and Lees [8].

[2]There have of course been many other definitions of consumption, each serving particular theoretical and/or empirical purposes. One of the tidiest for analytical purposes is set forth in Lancaster [23].

non-human capital? Second, in what respects do problems and solutions for these two broad categories of capital differ? It seems clear that the most difficult accounting problems in measurement of human as of non-human capital are tied up with its utilization over an extended span of time. Given the fact that services of human capital are continuously priced in the markets, this problem would be less serious in dealing with human than with physical capital were it not that the former task is complicated by a more extended time span of capital formation overlapping the time span of utilization. The pervasiveness of technological change and associated obsolescence makes these problems both more interesting and more important.

The discussion will be organized in three parts. Section I is focused on the opposition of value versus cost measurements of capital and shows how this controversy looks in relation to human capital. Observed paths of postschool life earnings are treated here in parallel with paths of net earnings of physical capital as a preliminary simplification. Other important dissimilarities between human and non-human capital are considered, however. In Section II the analysis turns to consideration of human-capital investment periods, including brief remarks on what agencies or sectors make the investments and the implications for interpretation of national accounts. Section III develops briefly a theme I have discussed elsewhere: asymmetries in disequilibrium bias with respect to formation of human and of physical capital. This is linked with remarks concerning the place and limitations of national income accounting in relation to other approaches for analysis of economic growth in a real world that is never quite in equilibrium or on a steady state trajectory.

1. Forward and Backward Measures of Physical and Human Capital

In a static perfect-equilibrium world it would not matter whether capital stocks were measured and aggregated in value or in cost terms. The figures would be the same because internal rates of return would be the same for all investments. Criterion interest or discount rates and the internal rate on a particular investment would match. In Hicks' terminology,[3] for any particular date t the "forward" measure (the flow of future net yields discounted back to t) would give the same result as the "backward" measure (costs cumulated up to t). But the real world is not on a perfect equilibrium path. For any particular sort of capital, even when it is new, the cost measure will differ from the present-value measure if the discount rate applied is other than its own internal rate of return. This raises problems for capital accounting even if we set human capital aside and even for current accounts. Problems are multiplied in growth accounting. Are the problems greater or different when human capital is brought into the system?

It will facilitate discussion at this stage to introduce an important simplification with respect to human capital. I assume here that the entire stream of the individual's earnings is determined at the moment he completes his full-time schooling and enters the labor market. That stream can take any reasonable time shape as evidenced in empirical observations; there is no need to assume the

[3]See his *Capital and Time* [17].

horizontal streams of the Mincer-Becker "schooling model."[4] This simplification is solely for the purpose of excluding any further costs for the formation of human capital after completion of schooling. At that moment we have a finished unit of human capital. But this does not exclude appreciation; there will be gains in earnings over time due to the maturation of effects of earlier investments in human capital. From the present-value point of view, the total human capital embodied in a man who has completed his schooling could in principle be measured as the discounted value of his expected future stream of earnings, regardless of what part of that productivity may properly be attributed to the schooling or to other investments in him and regardless of the cumulated cost of those investments. This seems a logical way of valuing the human capital stock. Nevertheless, all of the estimates of human capital and human investment in papers at the thirteenth general conference of the IARIW 1973 (as in prior work by John Kendrick and by Nancy and Richard Ruggles) are built up from cost estimates. This is consistent with the standard practice of measuring physical capital stock and gross physical capital formation in cost terms. Treatment of old capital raises recognized problems but no questions are raised about valuation of new physical capital in cost terms. These conventions for non-human capital are taken as the guide in estimation for human capital, but for the latter a large part of costs are incurred without market transactions and quasi-market bases of estimation of costs are used.

It is not difficult to understand why cost rather than value estimates have been used for valuation of capital and capital formation in convention national accounting. On current account gross capital formation is quite easily estimated in cost terms from observable payments for the resources going into the formation of the capital (with interest on them over the construction period). The awkward fact that important parts of the stock of physical capital never change hands after the first sale (even if they are marketed initially) forces accountants into other ways of adjusting for depreciation and obsolescence. Moreover, important parts of physical capital, notably plant and equipment in industry, are not rented out; there are no transactions from which to make direct forward estimates of present values or changes in yields of physical capital, whether it is new or old. Adjustments for depreciation (or appreciation) and for obsolescence are therefore at best relatively arbitrary modifications of the initial cost estimates. It is not accidental that in growth accounting the treatment of capital inputs in rental-value terms appeared relatively late. Neither is it accidental that from the first economists building human-capital inputs into their analysis of determinants of growth used weights based on rental values, which were readily at hand in census data for the United States.

Some of the problems and issues may be clarified by taking a look at treatments of human and of non-human or physical capital in some recent growth models. T. W. Schultz was the first to put human capital explicitly into an analysis

[4]This model was first developed by Jacob Mincer, in 1958 [26]. It was subsequently adopted and elaborated by Becker [4] and by Becker and Chiswick [6]. It has been used in a series of recent papers by Jacob Mincer and by colleagues and students of both Becker and Mincer. For an excellent statement of the schooling model and its relationship to analysis of post-school investments, see Jacob Mincer, 1974 [28].

of growth.[5] He started with estimates of changes in the embodied-education component of human capital stock measured in constant cost terms. He then estimated inputs of human capital into production by applying appropriate rental ratios to the cost estimates, varying the rental ratios with levels of schooling. Setting minor differences in adjustments and some errors of computation aside, the result in the aggregate is the same estimated contribution to increased output per employed person as Denison reached more directly by weighting different amounts of embodied education by their rental values.[6] While Schultz used a rather round-about way to estimate contributions of education to growth, his approach serves well to illustrate an important problem for growth accounting. Schultz's and Denison's results could converge only because Schultz applied different rental/cost ratios to different components of his human capital stock estimated at cost.[7]

A comparison between Denison on the one hand and Jorgenson and Griliches on the other brings out some important issues concerning consistency in treatment of physical and human capital inputs for growth accounting.[8] (It illustrates also how far human capital concepts have in fact been adopted in making adjustments for changes in the "quality" or composition of human resources.) Jorgenson and Griliches used essentially the same method as Denison for estimating changes in inputs of (educational) human capital into production in that they also weighted by marginal products.[9] Unlike Denison, they attempted insofar as possible to obtain marginal-product or rental-value weighting for inputs of physical capital as well. They claimed that in this and some other respects Denison was inconsistent. We have here two quite different starting points in perceptions of the problem.

Despite his use of rental-value measures to construct an index of inputs of human resources adjusted for embodied education, Denison is essentially a "capital at cost" or capital "volume" man. He follows this logic in statements about his treatment of education as well. To start with, he emphasized that his measures of contributions of education to growth do not include effects of changes in the quality of any given amount of education. But that is not all; he does not want to pick up such changes. The education weights stand for resources that were

[5]See reference [33].

[6]See Denison references [12] and [13].

[7]Although Denison and Schultz are roughly comparable when contributions of education to growth are expressed per employed person, they differ in their treatment of total contributions of education. Consistently with his human-capital orientation, Schultz first estimated the aggregate education embodied in the employed labor force and changes in that aggregate; net additions to the labor force thus add their embodied education to the total human capital inputs. Denison, on the other hand, worked essentially in an index number framework. He estimated the change in amount of education embodied on the average in a member of the labor force as one index, changes in the sheer numbers employed as another index, with a statistical adjustment assigning the interaction term between these two indexes. Thus Denison did not fully accept or apply the human capital concept. For a discussion of this along with other similarities and contrasts between Schultz and Denison see my analysis, in reference [10].

[8]The original Jorgenson-Griliches article and the series of exchanges between them and Denison were assembled by The Brookings Institution, in *The Measurement of Productivity*, 1972. See references [14], [15], [18], [19], [20].

[9]They differed, however, in that Denison made an adjustment for ability.

put into the formation of human capital; for any given "amount" of education aggregated in terms of resources absorbed by the education, increases in yield then become increases in output per unit of input, or productivity changes. Following the same mode of thought, Denison insists on a constant-cost valuation of physical capital; if new physical capital produced at the same resource cost has higher yields, by his line of argument this must be regarded not as an increase in capital inputs but rather of output per unit of input. In Denison's words, as modern new capital goods enter production,

> output would rise more than if replacement had been by new goods of an old type. The difference is the contribution of the development of better capital goods which can be supplied at the same cost as the old, a contribution which I wish to ascribe to advances in knowledge.[10]

This is the capital-volume view of measurement of inputs, which would carry with it an analogous cost approach to aggregative measurement of capital stock—ideally of human as well as of non-human capital.

Jorgenson and Griliches agree with Denison in objecting to Solow's vintage model, in which change of total factor productivity was used to estimate quality-adjusted inputs of capital. However, they would like ideally to weight the various sorts of both physical and human capital by marginal products rather than by cost. The coordinate measure of capital stock would of course be in terms of a present value. It is only lack of the needed price data that prevent Jorgenson and Griliches from carrying out this procedure as part of their effort to "explain" as much of observed growth as possible.[11]

The link between cost and value accounting for analysis of growth is indicated clearly enough if we consider the implications of the Jorgenson-Griliches statements concerning desirable extensions of national accounts for application to the study of productivity change. They make three suggestions:

> (1) allowing rates of return to differ not only by legal form of organization but also by industry and type of asset; (2) incorporating the educational sector into a total economy-wide accounting framework; and (3) constructing measures of research (and other intangible) capital and incorporating them into such productivity accounts.[12]

If human capital is estimated in cost terms, the first of these stipulations must apply to and within the education sector as well as to other parts of the economy. Both the volume or cost and the value approaches to capital, human and non-human, have a place in growth accounting. However, neither alone nor in combination do they provide a causal analysis of how growth takes place.

But let us leave growth accounting and capital inputs aside. What may we say of aggregative estimates of human capital stock in cost or in value terms?[13] Evidently use of value estimates is the more appropriate if we are interested in an assessment of the national wealth looking to the future. This sort of aggregation is

[10][15] page 102.

[11]For a clear statement on this, see [19], page 87.

[12]*Ibid.*, page 89.

[13]Some of these issues were discussed with specific reference to human capital in my 1961 essay on Human Capital Concepts and Measures [9].

easily challenged, however. Such estimation will be sensitive, among other things, to assumptions concerning the growth of other factors and relationships between the productivity of human capital and the pace and form of technological change. Aggregation in cost units has a certain solidity in that it adds up what has in fact happened. Furthermore, it is useful to specify what part of the society's resources over a particular period of time has gone into formation of one and another sort of human capital (and of all sorts taken together). Accounting for human capital formation in cost terms poses some special problems which are discussed by other papers in this session. On the other hand, data on which to base depreciation adjustments may be more satisfactory for human than for most non-human capital—at least so long as we adhere to the simplifying assumption of no post-school investments in human capital formation.[14]

It is sometimes argued that whatever the limitations, aggregative assessment of non-human capital in cost terms has two theoretical justifications. First, the measures are comparatively firm indicators of the resources used for what can be classified unambiguously as investment purposes. Second, there are broad tendencies for the cost and value of units of new capital to converge. It is asserted that human capital cannot meet either of these conditions. If we define human capital broadly, this opens up far too wide a field for discussion here. Let us see what this challenge might mean in application to one of the relatively manageable components of human resource formation—schooling.

It is sometimes alleged that motives for obtaining education are mainly "non-economic." But if people are strongly motivated to obtain education for reasons over and above any anticipated monetary returns, we should expect that the private internal rate of return would be lower than rates of return on other investments of comparable risk. Using the market or criterion discount rate we would find that present values of privately realized incremental income streams would then fall short of the privately incurred cost of the associated increments to education. But for men, at least, this has not usually been the case; even correcting for "ability" and family background, education seems to pay off. Whether through prevalent underestimation of the private pay-off to education, or because capital markets are biased against loan and equity funds for investment in education, or because there is non-monetary rationing of access to places in schools, private monetary internal rates of return commonly have been high rather than low. Thus the discrepancy in monetary terms alone usually is in favor of schooling; that is, at going rates of interest private present values of education commonly exceed costs. Under these circumstances, motivation would scarcely seem to be the relevant question in determining the legitimacy of counting costs of education as an investment. However, questions concerning motivation may still be important, along with other matters, in determining whether there are tendencies, at least, toward convergence of private costs of education with the value of its anticipated monetary yields in the future.

[14] Also, there is no need, as there may be with stock estimates of non-human capital, to resort to an estimate of the value of capital at the base date as the initial volume measure on which to build up the cumulated cost valuation. On this problem with respect to social accounting for non-human capital, see Hicks [17] Chapter XIII and page 159 in particular.

It has been alleged also, especially in the last year or so, that whatever the situation has been, the "social demand"[15] for education has now far outrun any economic justification for such investments. This would imply that current costs greatly overstate values of education, especially when costs are measured inclusive of collective subsidies, as for social accounting they must be. If these allegations are well founded, there is indeed malallocation of resources. Even so, we must ask whether this educational over-investment should be treated differently in our accounting from the distortions of investments in physical capital that accompany subsidy programs in other sectors of an economy. Challenges of this sort would seem to be the same in principle, whether it is human or non-human capital that is being assessed.

Until very recently, studies of investment in education have been confined to men, but this situation is changing. We now have many studies relating education of women not only to market wages or to rates of labor force participation and to career patterns, but also to "efficiency" in consumer behaviour, to fertility rates, and related topics.[16] Meanwhile, studies of what determines achievement in school continually reconfirm the importance of supportive conditions in the home. Building on theories of the allocation of time, and taking into account the rising value of time among women as well as men, researchers are accumulating evidence to support the proposition that the productivity of women in non-market activities is raised by education along with increases in wages—at least in early years of work experience. A modest proxy measure for the value of time spent in household activities is the wage rate for women whose schooling and experience in the labor market match that of the housewife; a more generous indicator would be the wage rate of employed women of the same age and schooling. The evidence for industrially advanced nations, at least, directly supports inclusion of all women in human-capital accounts, with corresponding adjustments in the national income to include associated values of household production. Moreover, there is indirect evidence that diffusion of schooling among women may be an important contributor to economic growth at earlier historic stages and contemporary lower levels of development—bringing effects that spill over from private to larger social returns. These influences are difficult to trace out explicitly, however.

Discrepancies between private and social rates of return to investments, whether in human or other forms of capital, can arise from many sources. Furthermore, these discrepancies can persistently distort measures of costs or of realized returns and capital values, and they can lead to persisting discrepancies between forward and backward estimates of capital in social terms even when these estimates converge in private accounting. It has been a favorite belief of

[15]The term "social demand" has become standard usage among many manpower and some educational planners, especially in Europe and Latin America. It refers in fact to the demands for education by individuals, which would be strictly "private" demand in Kendrick's usage and in that of most human investment theorists. The designation "social" demand derived from the assumption of those using it that the motives that lead men to take more formal education are non-economic.

[16]This literature is growing rapidly, and only a small part of it is as yet in press. Among published materials, see [25] on consumption and [34] for a series in this vein on fertility. Some of the new work on women was included at a conference organized by T. W. Schultz for the National Bureau of Economic Research and held at Chicago June 4–5, 1973. These papers appeared in a supplement to the *Journal of Political Economy*, Vol. 82, No. 2, Part II, March/April, 1974.

academic people that there are substantial unmeasured positive social spill-over effects of education, yet there is very little hard evidence for this view. Neither is there much support for Arrow's hypothesis that the "screening function" of education is its main effect, for his related argument that the private value of this screening function in provision of information far exceeds its social value—hence that education costs much more than it is worth to society.[17] Theoretical models purporting to show that social returns to investments in physical capital exceed private returns, leading to underinvestment, can be paired off against models that deny such effects or even reverse them.[18] All of this is important and challenges further exploration. However, once we move into this range of argumentation we had better substitute flying gear for our accountants' hats, and not merely or even mainly because of complications related to human-capital accounting. Social-private discrepancies are not a problem particular to the development of national accounts that include investments in people.

2. Human-Capital Investment Periods and the Treatment of Appreciation, Depreciation and Obsolescence

There are a number of important contrasts between human and non-human capital in patterns of appreciation, depreciation, and obsolescence—and in their measurement.

(1) A large fraction of human capital sells its services in the market, which gives us a better basis for non-arbitrary adjustments for depreciation and obsolescence of human capital. This could easily be demonstrated under the assumption of no post-school investment in human resources.

(2) There is almost certainly a wider range of adaptability in adjustments of human-capital services to technological change than is the case for physical capital. In fact a major component of human capital is the ability to adapt and to innovate. This ability speeds up change and hence accelerates obsolescence of capital of all kinds, while it also retards the obsolescence of human capital in the face of change.

(3) Even in industrially advanced nations, a sizeable part of human capital measured in cost terms is embodied in women who are employed in the household or subsistence sector. Many women move into and out of the wage market. Whereas physical capital that is not rented usually is utilized nevertheless in production for the market, human capital employed in the household contributes mainly to outputs that are not measured in the ordinary national accounts.

(4) Finally, there is no clear terminal point in the time span of investments in human capital. Many individuals incur costs of investment in themselves well beyond the date of entry to the labor market. In addition, employers often invest in the training of their employees.

Although the second point on this list (about adaptability and innovative powers) is very important, it can be set aside here. The third point (relating to

[17]See [3].

[18]The first contributions to this analysis were Alchian [1] and Arrow [2]. A different position is taken by Rosen [31], who assumes learning-by-doing to be vested in the firm, whereas Arrow assumes no such vesting. A discussion of some facets of this subject is included in Bowman [11].

women) has already been discussed; I shall come back to it very briefly, in discussing point (4).

The first of the four points just listed referred to the fact that we can get repeated readings on rental values of human capital because its services are sold in the market. However, very little use has been made of this fact for national income accounting. In the growth studies the rental values used as weights may be taken from observations of earnings by education, disregarding age distributions, or they may be standardized for age. In his famous study of *Why Growth Rates Differ*, Denison took the latter course; he constructed earning streams from United States census data for each schooling group and computed the annual average for a working life. He made a separate adjustment for changes in age of the labor force, treating age and education effects as independent of one another and thus ignoring the interactions between effects of schooling and of experience on productivity. In other words, Denison implicitly adds to the assumption of no post-school investment a further assumption of independent effects of age and education. This is to treat the inputs from educational capital as though there were neither appreciation nor depreciation of that capital over its productive life; appreciation and depreciation are shifted to a separate age variable. Jorgenson and Griliches introduced fewer refinements in their treatment of human capital inputs, and like Denison they bypassed the question of appreciation and depreciation or obsolescence in human capital. In contrast to Denison, Jorgenson and Griliches made no adjustment for "ability" because they were attempting to adjust for labor quality regardless of the sources of that productive power, not to specify contributions of embodied education in particular.[19] But neither Denison nor Jorgenson and Griliches followed through fully on incorporation of human capital (or of educational components of human capital) in analysis of the national income and its growth.

The disregard of adjustments for depreciation and obsolescence of human capital has not gone entirely unnoticed. It has been discussed, for example, in connection with tax policies and biases in the tax treatment of investments in human versus physical capital.[20] Also, in a more general context Mark Blaug stressed the point that treatment of education as consumption distorted the net national product accounts.[21] He points out that in such accounts additions to the stock of physical capital are net estimates, after deductions for depreciation and obsolescence, but there is no such deduction from gross expenditures on education. (It should be added, however, that neither, in such accounts, is there any adjustment for the time cost of the individual's investments in himself.)

There was no place, to my knowledge, where balance sheet analysis included explicit adjustments for depreciation (or appreciation) of human capital logically comparable to treatments of physical capital until Kendrick incorporated such

[19]Note that Denison's adjustment was applied throughout; he did not introduce any adjustments for assumed change over time in the ability of men or women with one or another level of schooling. Jorgenson and Griliches were explicit in their arguments that "ability" associated with given levels of education in fact had not changed over time. That being the case, there was no reason for an adjustment for ability in their analysis, since they wanted indicators of human capital but were not concerned to separate out the part of that capital that could strictly be attributed to schooling.

[20]One of the earliest to discuss this topic was Richard Goode [16].

[21][7] page 18.

adjustments in his human capital accounts for the United States.[22] Yet even fine adjustments of this sort are not difficult given data relating schooling, age and earnings. Perhaps one of the reasons for neglect of human capital depreciation even in the United States, where data are rich, has been that where human capital has been treated as a stock (the relevant perspective in connection with depreciation) it has been measured in terms of costs, even though for human-capital service inputs in growth accounting a system of weighting by rental values is used. But adjustments could have been made from cost-based measures of gross formation of human capital. I suggested some possiblities along these lines a dozen years ago in my article on "Human Capital Concepts and Measures"[23] and Kendrick's application of a double-declining-balance method to human capital uses cost valuation as his base.[24] How important such adjustments may be for capital accounting will depend upon the magnitude of demographic changes in the age-education structure of the population. Further experimentation following Kendrick's and other methods for various nations and dates would be well worth while.

Point (4), it will be remembered, referred to the fact that investments in the formation of human capital continue well past the age at which men leave school. It is time that we recognized this fact and looked at its implications. The difficulty, of course, is in properly specifying these investments, with empirical estimates of their scale and timing. Most of the work on this problem has dealt only with men and has proceeded from an assumption that all deviation from a horizontal stream of life earnings is to be explained by net post-school investments of individuals in themselves—net, that is, of depreciation and obsolescence. This is the exact opposite of the assumption of no such post-school investments that was made explicitly in Section I and that usually has been implicit in treatment of human capital inputs for national income accounting; let us call it the Mincer assumption. The new empirical estimates of costs of post-school investments made by Mincer for the United States are more satisfactory and simpler methodologically than those made by him a decade ago.[25] Nevertheless, the findings remain highly sensitive to the rates of interest used in their derivation.[26]

As soon as the existence of post-school investments by individuals in themselves is given consideration, the data advantage of human over physical capital for estimation of depreciation fades, and we run into problems of full

[22]These are incorporated in the tables presented by Kendrick in the article appearing elsewhere in this issue. The details of this and other facets of his estimation procedures are laid out at length in the manuscript of a book that is going through the editing process at the National Bureau of Economic Research at the present time.

[23]See reference [9].

[24]Actually Kendrick used a double-declining-balance with "shift-to-straight-line depreciation" adjustment to give a good approximation to the shapes of life paths of present values of human capital. He applies these adjustments to cost-based estimates of human capital, however; his figures are not present-value figures for the human capital stock. He starts depreciation on intangible capital from age 28, assuming that depreciation is complete by age 75.

[25]References [27] and [28].

[26]The interest rates are derived from the data as average internal rates of return to schooling and post-school investments jointly. The assumption in using this rate is that internal rates of return to schooling and post-school investments are the same, and also that these are the criterion rates in individual decision-making.

identification of gross human capital formation, inclusive of human capital formation in the post-school years. Refined adjustments based on a Mincer model of human capital would require that for estimation of gross human capital formation we add to estimates such as those prepared by Sharma and Ram for India an estimate of postschool investments by individuals in themselves. However, unless we assume zero depreciation, the estimates using Mincer's procedures still fall short of full gross investments. Moreover, once postschool investment is taken into consideration, one cannot estimate appreciation and depreciation (including obsolescence) directly from the shapes of observed streams of earnings. Instead, as in dealing with physical capital, the mathematical form of the path of depreciation has to be assumed.[27]

It should come as no surprise that the initial models including post-school investment were more satisfactory in application to men than to women; women more often move in and out of the labor market. Paths of postschool investment and earning for women are modified, relative to those for men, both by this irregular labor force participation and by expectations (on the part of both the women and their employers) that long-term commitments to career development will be weaker. Evidence of the effects of these factors, overtly discriminatory behavior aside, is gradually emerging. What is more difficult to identify is the course of learning and productivity in household activities. While explorations of these problems are proving fruitful for understanding many aspects of women's behaviour, the results suggest also that observed wage rates for married women in the labor force at any given time are reasonable proxy measures for the values of time in the home. The time profiles are very much flatter at each level of schooling (with much less post-school investment) than are those for men.

Finally, once we acknowledge that post-school investments in human resources do in fact occur, it becomes obvious also that not all such investments are made by individuals in themselves. In fact the cost measures based on studies by Mincer (and others[28] using essentially similar theoretical constructs) are confined entirely to opportunity-cost estimates of earnings foregone in obtaining the additional training or learning. Both direct money outlays by individuals on post-school training and costs born by others are omitted.

The most important sort of post-school formation of human capital that would not be captured by individual opportunity-cost estimates of human capital formation are probably investments of employers in their employees. This is not the whole of costs born in the first instance by the employer, however, for a part of such costs may be shifted to employees in the form of lower earnings; the part so shifted becomes an investment of the individual in himself and would be counted in the opportunity-cost estimates based on analysis of the time paths of earnings. Implications for human-capital accounting are two-edged. On the one hand, that

[27]As it was by Kendrick (see footnote 24), and also, in a very different way, by Moreh [29]. Moreh's article, which appeared (in September 1973) after this paper was initially written, is an attempt to construct post-school investment estimates from an analysis of observed life income streams in the style of Mincer and related recent work. On these developments see reference [11].

[28]There has been a sudden burgeoning of studies applying optimal control theory and some of its less formal relatives to the analysis of the time shapes of earning streams. For a summary discussion and comparison of these see [11].

part of business costs of training that are shifted to employees would be counted twice if we include it in expenditures of the firm for training and also in opportunity cost estimates of what individuals invest in themselves.[29] On the other hand, most of the costs of training that appear initially in business expenses are reported in a form that does not enable statisticians to separate them out from other expenditures. Indeed, investments in training by business firms usually will appear, when they appear at all, with operating expenses and not with investment.[30] Most important are the investments in training that firms do not shift to workers, and that can constitute a substantial acquisition of capital assets to the firm in the value of future additional productivity of employees who are attached to the enterprise on a long-term basis. These assets do not appear as such on the firm's balance sheet. Lester Telser[31] has demonstrated the importance of such "firm-specific" human capital in its effects on reported profit rates; firms with large hidden assets in specific human capital have larger reported rates of profit because profits are compared with a capital base that is too small. (That base is too small because the human capital assets that are attached to and virtually vested in the firm are not counted.) Human capital formed in this way appears neither in estimates of human-capital formation nor in estimates of human capital inputs into production, since it never appears as wages. The pattern of ownership thus confounds identification of real sources of national income. This can be a serious distortion in accounts for economic growth where there have been substantial investments by firms in their employees, as occurs, for example, in the modern sector of Japanese industry.

It may be worthwhile at this point to compare Kendrick's treatment of learning at work with the preceding analysis in view of the leading role he has played in bringing this and other components of human capital formation into the national accounts. Kendrick does not use the type of theoretical model I have just discussed. Instead he conducted an extensive search for data on direct costs to the firm of its training activities. His measure includes estimates of the costs of initial non-productive time of newly hired persons (in training, orientation, and so on), which he developed in detail by sectors and occupations. It includes rougher estimates of other formal training costs incurred by businesses. Kendrick was not concerned with dividing the costs and benefits of on-the-job training between individuals and the enterprise; indeed, whether or not the firm shifts its direct costs of training to workers (as lower wages than they would receive otherwise) is irrelevant for purposes of aggregative estimation of human capital formation. In this respect there is no logical difference between aggregative accounting of investments in schooling and investments in training on the job (or in other training or education outside of the regular school system, whatever its timing). On the other hand, Kendrick's estimates do not include the cost of foregone productivity of individuals who are spending part of their time as learners in the

[29]Conceptually one may treat the "true wages" as the sum of observed wages and the value of the training to individuals who receive wage payments less than they would receive otherwise, if the firm did not implicitly "sell" training to the workers. The training is thus an *output* of the firm. This, of course, is not the way it will appear in the firm's accounts.

[30]Some of the firm's costs will be hidden costs, in lower regular product output than would have been produced without the training activities.

[31]See [31].

training activity, even though he did include such estimates in his costing of formal education. One of the reasons for Kendrick's decision to avoid the Mincer type of model is undoubtedly his desire to avoid the circularity that would follow if he made use of the sorts of cost estimates of investments of individuals in their own post-school capital formation that have been developed thus far and then went on to use those estimates as part of the base for his subsequent aggregative estimates of rates of return to investments in intangible human capital. In other words, it may be more the desire to estimate aggregative rates of return than the rounding out of national accounts *per se* that dictated his choice.[32] It should be added that although Kendrick omits a significant part of post-school learning at work, he adds to his aggregative estimates a wide range of other sorts of activities, approximating in most respects the coverage of Machlup's book on the knowledge industry.[33] Many of these additonal components of Kendrick's estimates of intangible human capital formation may be relatively short-term in their effects, and whether some should be regarded more as consumption than as investment is a legitimate question. In a growth context many of these items are relevant primarily as they facilitate information flow to maintain efficiency in the allocation of resources in a highly complex market economy. But many are also crucial for the diffusion of technological advance and the countering of obsolescence. As such they should be regarded as complementary with schooling in the implementation of economic progress. How many, and which, of these diverse activities should be subsumed under the rubric "human capital" instead of being classified in other ways in the national accounts is not entirely obvious.[34]

3. Disequilibrium Bias and Growth Accounting

Periods of exceptionally rapid growth seem normally to begin with conditions of substantial disequilibrium in the composition of the capital stock, human and non-human. But we do not have to take such extreme examples to justify concern with disequilibrium in the process of growth. Economic growth will be understood as a real process only when we admit disequilibrium into our analytical models. This has implications for social accounting if such accounting is to contribute to understanding economic growth. Indeed, the whole problem of discrepancies between forward and backward estimates of the value of capital is a disequilibrium phenomenon. This is important enough even when we ignore biases in the formation of human capital and its utilization. Concern about disequilibrium turns up as still more crucial when human capital is given the attention it deserves. This is a theme about which I have lectured on both sides of the Atlantic, and a few

[32]Compare the paper by Sharma and Ram [35].

[33]Included in Kendrick's estimates are figures for (1) informal education, (2) special religious education, (3) education in the military, and (4) employee training. The first of these includes estimates of the education components of private, business, and institutional costs of radio, T.V., records, musical instruments, books, maps, periodicals, libraries and museums. Kendrick used Machlup's estimates [24] of proportions of these costs attributable to education.

[34]One of the most promising directions of current research concerns the relationships among the human capital embodied in educated farmers, agricultural research, and channels for the communication of information to farmers in their interactive effects on productivity in agriculture. All of these elements are important, but it is useful to distinguish between what might be termed "human capital proper" and information services, nonetheless.

main points that link the argument to national income accounting are worth summarizing, even if in quite dogmatic fashion.

(1) First, I suggest that the arguments over constant-cost versus marginal-product weighting in measurement of changes in capital inputs for growth accounting are not a matter of right or wrong, better or worse. Rather, we are dealing with specification of two complementary perspectives, both of which are needed as soon as we recognize that real life is a series of less-than-perfect equilibria. Even if we accept for convenience the assumption that we are on one traverse after another between steady-state paths, it would be difficult to justify an assumption that a dynamic economy is ever for long on a steady-state trajectory. And even if we want only to describe what has been going on we need both perspectives, in an initially disaggregated form. Comparison of results with different accounting procedures will give us more insight than use of either approach alone provided we plan our analysis in such a way as to admit meaningful comparison and contrast.

(2) Remaining still within a national accounting framework, we may gain substantial understanding of growth processes by a disaggregative analysis that specifies different rates of return for different sectors of the economy, which of course incorporates admission of disequilibria, as Jorgenson and Griliches pointed out.

(3) Regardless of how large a fraction of the increases in productivity can be moved from the output-per-unit-of-input to the input side by redefinition and/or improved measurements of "inputs," accounting estimates of the sources of productivity change do not constitute causal analysis of the processes of growth. Neither, of course, do the various highly simplified growth theories. But we have hardly begun to explore possibilities in an intermediate zone between accounting on the one hand and esoteric mathematical growth theory on the other, and where beginnings have been made attention to human resources is still notably lacking.[35] The time would seem to be ripe for creative progress in this area. Among other things, new light may be shed on contributions that could be made by national accounting to studies of growth that go beyond revisions of the national accounts. At the least, more use might be made of various versions of the estimated "residual" treated as a dependent variable in explanatory models that transcend national accounting systems.

(4) So far as I am aware, all empirical attempts to assess the determinants of growth seek to do so by specifying year-to-year changes in inputs of resources. None to my knowledge explicitly considers also the extent and effects of distortions in composition of the capital stock, human and non-human, at the starting point (or at intervening stages) of the period covered by the empirical

[35]Manpower planners talk about related questions, but they provide no analytical models and they use no prices; their work has remained remote from any and all theories of growth processes, as it has from data and concepts of national income accounting. Hicks has made notable strides in relating a more dynamic "neo-Austrian" capital theory to problems in social accounting, but he has nothing to say about human capital. Uzawa's attempt to introduce basic micro-theoretical concepts into dynamic growth analysis offers important fresh ideas that could help bridge the gap between simple mathematical growth theories and a more realistic growth dynamics that incorporates learning by the firm. He comes closer than any of the other mathematical growth theorists to incorporating a human-capital component that is related to the concept of firm-specific human capital; see [38].

analysis. The importance of incorporating indicators of bias in capital composition (and also of the pace of aggregate post-school learning) in an empirical analysis of economic growth was brought home to me most vividly by studies of economic growth and of labor market structures in Japan. But Japan is not the only puzzle. Last year I had occasion to re-examine the estimates of growth rates and components of growth in 26 countries brought together (mainly from Denison and Correa) in Nadiri's paper for the 1971 meetings of IARIW.[36] Even substituting estimates that credit a greater growth-point contribution of education in Japan, it turns out that there is a small but significant negative correlation ($R^2 = 0.15$) between estimated rates of growth and absolute growth-point contributions attributed to education. Obviously, this does not tell us anything about where and when more investments in education would be sound or foolish growth policy; however, it does suggest that we take a fresh look at what has been going on.

(5) There is a fundamental asymmetry in the degree to which distortions in the mix of human and physical capital can move toward an excessive relative weighting of human capital on the one hand, physical capital on the other. (a) Human readiness for rapid adaptive learning, both individually and in collaborative groups, limits the pace at which new methods of production and new equipment can be utilized effectively. This constrains the extent to which physical capital can overshoot a balanced relationship to learning potential and adaptive skills in any given period, and hence cumulatively up to any year $t = 0$ that may be taken as the initial year of a period over which growth is to be studied. (b) Aggregate learning potentials essential to accommodation of new sorts of physical capital are a function in part of the diffusion of formal schooling. But that schooling is not constrained by the pace or cumulative extent of investments in physical capital. Hence schooling can substantially overshoot economically optimal levels at any given time. This is the more likely, even accepting a model of economically rational human-investment decisions to explain individual behaviour, because there are such vast public subsidies to schooling. (c) However, even so the asymmetry is limited if we take into account the fact that productive capability of the labor force is by no means purely a function of formal schooling. Viewing human capital from the value orientation, it is clear that the human component in the "real capital" of the firm and of the society cannot indefinitely outrun physical capital; learning by doing is a critical part of the acquisition of know-how and adaptive skills. In other words, a very important component in the acquisition of readiness for the new rests upon learning of kinds (both individual and group) that depend on past experience in productive endeavor. Institutions of the labor market can contribute to relative over- or under-development of critical learning, but only within limits that are constrained by investments in physical capital. Considerations such as these suggest a family of econometric models to explain changes in output per unit of measured input.

Evidently the data requirements for analysis along these lines are very substantial, although beginnings can be made with data that are far from ideal for the purpose. Preliminary empirical tests can be carried out long before we would

[36]See [30].

be in a position to build the formation of human resources at work systematically into most national accounts. Meanwhile, as national income accounting becomes increasingly more sophisticated, it may provide an improved base for wider ranging explorations in the dynamics of growth.

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