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On the Two Conceptualizations of Human Investment

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Abstract

The human capital theory has from the early stage of development been subjected to a criticism that not all types of productivity enhancing activities (particularly learning-by-doing) can be accommodated within its accounting system that relies on the notion of opportunity costs. The point is culminated by the Becker-Blaug controversy concerning learning-by-doing. An alternative accounting system of human investment proposed in this paper based on the notion of user costs allows any productivity enhancing activity including learning-by-doing to be evaluated on its own within the system defining investment and yet it leads to the same behavioral rules as the original human capital theory. It thus provides a way by which the Becker-Blaug controversy is resolved.

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1. Introduction

The notion of human investment as a source of worker productivity is by now quite familiar. In fact, the quantitative studies on the sources of economic growth have repeatedly shown the importance of the improvement of labor quality as a major component of the residual factor initially termed the "technical progress" (Denison [1967], Jorgenson-Griliches [1967]). An accounting framework that has appeared to deal with the phenomenon is the human capital theory (as developed by Schultz [1971], Becker [1964] and Mincer [1974]). This theory holds that an increase in the workers' productivity can be accounted for as a result of a rational calculus on the part of individuals as to the cost and the benefit of resources put into the process of acquiring knowledge and skills. Among the costs considered are that of real material inputs directly put into the process and the opportunity cost of time spent by individuals on education and training. The opportunity cost refers to the income that the individuals would have earned had they actually spent the time otherwise doing work. Parallel to the cost at an individual level is a social cost in the form of sacrifices in the current output. Numerous studies have been conducted to measure the rate of return on the cost of investment thus defined (Hanoch [1967], Griliches [1977, 1979]).

Such an accounting framework has from the start been subject to a particular kind of criticism as Becker himself described (Becker [1964: 45-

47]). The criticism runs as follows. Considering the fact that learning-by-doing involves no sacrifice of actual production it is a phenomenon that is outside the realm of the human capital theory, and so long as such a kind of skill formation is prevalent the argument that a rationally conducted investment decision on the part of individuals lies behind any productivity increase on their part is nothing more than an exaggeration. Becker provided two counter arguments to the above criticism.

First, in reality there always exists a job with virtually no room for learning-by-doing, and that individuals face a choice between taking a flat earnings profile of such a job and taking a seniority wage profile that reflects the presence of learning-by-doing. When the latter alternative is chosen, it can be construed to involve a sacrifice of current income, whose cost can then be identified as investment.

Second, the situation that a flat wage profile is superseded by a wage profile of a job accompanying learning-by-doing can formally be understood as a special case of an infinite rate of return on human investment whereby some finite amount of benefit (productivity increase) results from zero costs. Becker, however, goes on to state that the case of an infinite rate of return largely results either from the lack of effort on the part of researchers not searching enough for alternative job opportunities or else from the lack of effort on the part of firm managers not pursuing the profit opportunities strictly enough, and therefore such a case cannot be regarded as important.

In opposition to such counter-arguments Blaug [1976: 837] has reiterated that, in reality, there can never be any job without learning-by-doing so that many facets remain where productivity increases cannot be accounted for by means of costs and returns. (This point has been repeated in a somewhat weaker form by Psacharopoulos and Layard [1979: 489-90].) It seems that the above criticism also contains an irritation over a rather ad hoc manner in which the human capital theorists extend the notion of opportunity costs. In fact, the opportunity costs that are considered to be generated alongside learning-by-doing are qualitatively clearly different from the opportunity costs associated with the input of time resources, and it seems that the assumptions and the mechanism of generating the former category of opportunity costs must be made explicit. A more fundamental criticism yet seems to be directed to the fact that the productivity enhancing effect of learning-by-doing is not evaluated for its own sake. The evaluation depends critically on what other job opportunities are present, which is quite an external affair as far as the job that generates learning-by-doing is concerned. However, because of the lack of an alternative theoretical framework to understand the problem at hand, Blaug's criticism immaturely switched to the question of empirical validity, thus leaving the main thrust of the criticism unarticulated.

The purpose of this paper is twofold; first, to reconstruct Becker's argument in a unified framework and thereby to clarify the interpretation, and second, present an alternative accounting system of human investment such that any productivity enhancing learnig activity (including, of course, learning-by-doing) is evaluated for its own sake within the system defining investment. The basis for the alternative explantation lies in the concept of user costs along the tradition of Marshall and Keynes. More specifically, a worker facing a learning opportunity is regarded as a producer who is managing his or her earnings capacity, in particular, as to how it is utilized, maintained and improved. The new framework is shown to lead to the same behavioral rules on the part of the workers as those of the original human capital theory (which will be called the "opportunity cost approach") and yet it has a much more general applicability in understanding the phenomenon of human investment, for instance, the case involving unemployment. This paper thus provides one way by which the Becker-Blaug controversy is resolved.

This paper consists of five sections. In Section 2 that follows, a general framework of analysis is specified. Section 3 clarifies the concept of the opportunity cost in the human capital theory. Section 4 develops the alternative explanation (to be called the "user cost" approach), which constitutes the core of this paper. Section 5 compares the notions of investment in the two approaches and points out the limitations of the opportunity cost concept. It concludes by suggesting other possible issues that the user cost approach is well-equipped to handle.

2. The Framework of Analysis

Suppose the economic ability of individuals is heterogeneous, and is distributed continously over a closed interval [0, 1]. Each individual lives for two periods. By allocating some of his or her own time resource for training or learning in period 1, an individual can alter the economic ability in period 2. Call the initial ability position, given as an endownment, x, and the ability position in period 2, x'. The production in this economy is supposed to proceed by combining two types of labor, hereafter called job A and job B. It is assumed that Job A is most conformable with the ability position 0, while job B is most conformable with the ability position 1[1]. The efficiency in performing each job is supposed to decline monotonically as the ability position moves away from the most conformable position. Thus writing the work efficiency of an individual with the ability position x at job A as $k_A(x)$ and that at job B as $k_B(x)$, the foregoing assumptions imply

$$\begin{aligned} &k_A'(x) < 0,\ k_A(x) > 0,\ k_A(0) = 1 \\ &k_B'(x) > 0,\ k_B(x) > 0,\ k_B(1) = 1 \end{aligned} \qquad (1)$$

where the last condition in each row is a form of normalization for the efficiency indices.

Suppose that the two jobs are also different in that job B has a learning opportunity while job A has none. The learning opportunity of job B is characterized by the fact that by spending a portion λ $(0 \leq \lambda \leq 1)$ of the total (potential) working hours on on-the-job training the ability in the next period is increased by the rate $g(\lambda; x)$. In other words,

$$x' = (1 + g(\lambda; x))\, x \tag{2}$$

where

$$g(0; x) \geq 0 \qquad g_{\lambda} \geq 0 \qquad g_{\lambda\lambda} \leq 0 \tag{3}$$

Individuals are supposed to be able to carry their acquired ability freely across different firms.

Labor, output and capital markets in the economy are all assumed to be perfect and competitive, and furthermore, the economy is assumed to be in a long-run steady state where the same market prices are maintained over periods. Such a world can easily be constructed by supposing an overlapping generations model whereby each generation maintains the same structure of time preference. For our present purpose, however, it suffices to remain solely within the confines of a subjective equilibrium of a single generation under exogenously given market prices[2].

In the following we shall denote the rate of interest by r, the wage rate (in terms of output) of job A at its most conformable ability position $(x = 0)$ by w_A, and similarly the wage rate of job B at its most comformable ability position $(x = 1)$ by w_B. The individual with the ability position x (hereafter simply called 'ability x') receives $w_A k_A(x)$ for a (necessarily) full-time work at job A while the same individual receives $w_B k_B(x)$ for a full-time work at job B. If the individual taking job B chooses to allocate

λ of the time for learning, it means that $\lambda w_B k_B(x)$ of wage is foregone in period 1. For simplicity's sake, no additional fee is supposed to be charged by employers to workers for offering a learning opportunity.

What we later focus on as a particular case of the learning opportunity is that of learning-by-doing. Because learning proceeds in the very process of performing a job, no sacrifice of time, and hence earnings, is involved. In this case,

$$g(0;\ x) > 0, \quad g_\lambda(\lambda;\ x) = 0 \tag{4}$$

and

$$x' = (1 + g(0;\ x))\ x \tag{5}$$

(4) is readily seen to be a special case of the general conditions (3) imposed on (2).

We shall distinguish the alternative case of on-the-job training from the case of learning-by-doing by specifying the conditions (3) as

$$g(0;\ x) = 0, \quad g_\lambda(\lambda;\ x) > 0, \quad g_{\lambda\lambda}(\lambda;\ x) < 0 \tag{6}$$

Finally, without loss of generality, the distribution of population over the ability interval [0, 1] is assumed to be uniform for each generation. The uniformity is merely a convenient assumption to facilitate a geometric discussion wherever possible.

3. The Opportunity Cost Approach to the Definition of Human Investment and Income Accounting.

Under a perfect capital market the rational employment behavior of an individual with an initial endowment ability x is characterized by the maximization of the present value of the earnings stream over the two periods. When the individual takes job A, the present value becomes

$$V_A(x) = w_A k_A(x) + \frac{\max\ \{w_A k_A(x),\ w_B k_B(x)\}}{1 + r} \tag{7}$$

whereas, if he takes job B, the present value becomes

$$V_B(x) = (1 - \lambda)\ w_B k_B(x) + \frac{\max\ \{w_B k_B(x'),\ w_A k_A(x')\}}{1 + r} \tag{8}$$

where x' is defined, in general, by (2). Because the individual can freely choose his job in the beginning of each period given his ability position at that time, the problem becomes that of dynamic programming over two periods. The solution is shown to be achieved, however, even when one forgets that an individual can switch the job in period 2. Namely, the current choice of job is effected by comparing the two present values, the value of $V_A(x)$ on the supposition that job A is continued in period 2 (hereafter denoted by $V_{AA}(x)$), on the one hand, and the maximized value of $V_B(x)$ with respect to λ on the supposition that job B is continued in period 2 (hereafter denoted by $V_{BB}{*}(x)$), on the other. The optimum level of λ in the latter alternative is denoted by $\lambda{*}$ (note that $\lambda{*} = 0$ in the case of learning-by-doing). A formal proof is given in the Appendix.

The situation can be explained in terms of Panels (a) and (b) of Figure 1. Panel (a) represents the case of on-the-job training while Panel (b) represents the case of learning-by-doing. The horizontal axis expresses the spectrum of economic ability x. In the upper quadrant, the solid and broken half lines emanating from the vertical axis at $x = 0$ express the graphs of $w_A k_A(x)$ and $V_{AA}(x)$, respectively. Several graphs also emanate from the vertical axis at $x = 1$. Thus, for Panel (a), the graphs of the earnings in period 1 with the intensity of learning optimally chosen $(1 - \lambda{*})\ w_B k_B(x)$, the earnings in each period with no learning at all $w_B k_B(x)$, the earnings in period 2 as a result of learning $w_B k_B(x') = w_B k_B(\{1 + g(\lambda{*};\ x)\}x)$, and the present value of the earnings stream with learning $V_{BB}{*}(x)$ are drawn as $(1 - \lambda{*})w_B k_B$, $w_B k_B$, $w_B k_B{'}{*}$ and $V_{BB}{*}$, respectively. Similarly, for Panel (b), the graphs of $w_Bk_B(x)$, the earnings in period 2 as a result of learning-by-doing $w_Bk_B(x') = w_Bk_B(\{1 + g(0; x)\}x)$, and the present value of the earnings stream with learning-by-doing are respectively drawn as w_Bk_B, w_Bk_B' and $V_{BB}*$. In either case, the intersection of the two graphs V_{AA} and $V_{BB}*$, henceforth denoted as $x*$, facilitates the borderline of choosing job A (to the left of $x*$) and job B (to the right of $x*$). $x*$ is clearly located to the left of $\bar{x}$ defined as the intersection of the graphs w_Ak_A and w_Bk_B, which in turn, expresses the borderline of choice according to the principle of static comparative advantage.

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Figure 1 about here
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Although irrelevant to the ultimate choice itself, it is important for our later discussion to understand how the rational behavior to maximize $V_A(x)$ and $V_B(x)$ is formed given the choice of a particular job in period 1. Suppose that an individual with an arbitrarily given x has taken job A in period 1. Because no learning occurs in this job the individual's ability remains the same in period 2. Therefore the rule of job choice in period 2 to maximize $V_A(x)$ is simply given by

$$\text{Choose } \begin{cases} \text{job A for } x \in [0, \bar{x}] \\ \text{job B for } x \in (\bar{x}, 1]. \end{cases}$$

While the maximized value of $V_A(x)$ is identical with $V_{AA}(x)$ for $x \in [0, \bar{x}]$ it takes a different value for $x \in (\bar{x}, 1]$. It is denoted as $V_{AB}(x)$, and is represented by the graph V_{AB} in Figure 1.

What happens if the individual takes job B in period 1? First, in the case of learning-by-doing it is obvious that the choice of the job in period 2 depends on whether or not the ability position in period 2 exceeds the critical value $\bar{x}$. That is, job B is chosen if it exceeds $\bar{x}$ and job A is taken otherwise.

As a matter of fact, the initial ability position which is transformed to $\bar{x}$ after learning is determined at $\underline{x}$ which corresponds to the intersection point S of the parallel line with the horizontal axis that emanates from P (which, in turn, is the intersection of the curves $w_A k_A$ and $w_B k_B$) and the curve $w_B k_B'$.

In the case of on-the-job training the circumstance is a little complicated due to the variability of λ. As shown rigorously in the Appendix, however, the individuals with the initial ability x sufficiently close to 0 had better not obtain any learning at all and switch to job A in period 2. Writing the value of $V_B(x)$ for such a behavior as $V_{BA}(x)$, the criterion of job choice for period 2 is facilitated by comparing the value of $V_{BA}(x)$ and $V_{BB}^*(x)$. The borderline of choice is determined by the intersection of the curves $V_{BA}(x)$ and $V_{BB}^*(x)$, and will be denoted by $\underline{x}$. Combining these considerations the rule of job choice for period 2 that maximizes $V_B(x)$ is summarized by

$$\text{Choose} \begin{cases} \text{job A} & \text{for } x \in [0\ ,\ \underline{x}] \\ \text{job B} & \text{for } x \in (\underline{x}\ ,\ 1] \end{cases}$$

where $\underline{x}$ is defined previously. It is then obvious from Figure 1 that the graphs of the optimized $V_A(x)$ and $V_B(x)$ are piecewise broken lines but that such a feature does not affect the individual's choice in period 1 at all, and moreover, that the individual will continue to take the same job once the choice is made in period 1. The two critical values $\underline{x}$ and $\bar{x}$ will be seen to play an important role in the following discussion.

The preceding discussion must all be quite familiar. Our main issue is the manner to comprehend the cost of investment. The tradition of the human capital school as represented by Schultz and Becker takes the position to perceive the earnings foregone in period 1 in comparison with the maximum earnings that would have been obtained as the cost of investment. Thus, in the case of on-the-job training (Panel (a) of Figure 1) the investment cost becomes the direct opportunity cost (foregone earnings) of learning $\lambda^* w_B k_B(x)$ with the addition of $w_A(x) - w_B(x)$ in the range of x where job A brings about a higher pay than job B, i.e., $x \in [x^*, \bar{x}]$. Consequently the economy-wide human investment cost is expressed (using the assumption of a uniform distribution of ability) by the area of the shaded form QPUTSR. In the case of learning-by-doing, however, no learning cost is required, and the sole component of the investment cost becomes the foregone earnings $w_A(x) - w_B(x)$, again, for $x \in [x^*, \bar{x}]$. The economy-wide human investment cost is then expressed by the area of the triangle QPR in Panel (b).

The returns to human investment, on the other hand, is defined as the difference between the level of earnings in period 2 after learning $w_B k_B(x')$ and the level of the maximum earnings in the same period without any learning. For both cases (a) and (b), the latter value is $w_A k_A(x)$ for $[\bar{x}, 1]$. The ratio of returns over cost minus 1 has been refered to as the (internal) rate of return to human investment, and has long been the object of empirical measurement. The graph of the rate of return is drawn in the lower quadrants of Panels (a) and (b).

Panel (a) shows that in the case of on-the-job training the graph first coincides with the horizontal axis for $x \in [0, \underline{x}]$ and then rises above zero and increases for the remaining range $x \in [\underline{x}, 1]$. Panel (b), on the other hand, shows that the rate of return becomes negative for $x \in [0, \hat{x}]$, where $\hat{x}$ corresponds to the intersection of the curves $w_A k_A$ and $w_B k_B'$ (neccesarily $\underline{x} < \hat{x} < x^*$). For $x \in [\hat{x}, \bar{x}]$ it rises monotonically and becomes asymptotic to the vertical line $x = \bar{x}$.

For both cases (a) and (b) it is easily confirmed that the rate of return becomes equal to that at the critical value x^*. Between the two cases there is a qualitative difference in that for $x \in [\bar{x}, 1]$ the rate of return takes a finite value for the case (a) while it is infinite for the case (b).

So much for a reconstruction of the discussion by Schultz, Becker and others. No matter whether it is on-the job training or learning-by-doing the notions of cost and returns of investment can be defined in terms of a unified set of accounting principles. The sole discrepancy with Becker´s argument quoted in the introduction is that in the case of learning-by doing there exists a non-negligible portion of the population for whom the investment cost is zero and the rate of return is infinite. The point we would like to raise, however, is that the logical coherence of a framework itself does not imply that it is the sole possible framework that is logically coherent. Also to answer whether it is a desirable framework or not requires an entirely different criterion. In the next section, we shall propose an alternative conceptualization of human investment.

4. The Notion of Human Investment as a Negative User Cost

An alternative approach to understanding human investment is not to identify it directly with the opportunity cost that arises when an individual´s productive capacity is put to alternative uses, but to identify it with a user cost that arises depending on whether the productive capacity is put to actual use or not in the job at hand. It will be shown that from such a viewpoint a logically coherent accounting of investment and income is derived which gives the correct criterion for investment.

The notion of user costs emphasized in Keynes´ General Theory is rendered somewhat of a side-show in the subsequent development of the macroeconomic theory as well as the microeconomics of investment. It will be helpful to begin by reviewing the concept as discussed by Keynes [1936: 53-55].

The user cost is originally conceived as a notion to take account of the depreciation in capital equipment values associated with the activity of production. Suppose that a firm's capital equipment, after a period of utilizing it in production and simultaneously making new outlays to maintain and improve the equipment optimally, has the value (i.e., the present value of earnings due in future) G. The cost of outlays made on equipment is denoted by A_1. Suppose also that the value of capital equipment becomes G' when it is not put to actual use (i.e., remains idle) during the period. This value implicitly incorporates the result of any possible activity to maintain and improve the equipment that is desirable even though the equipment itself remains idle during the period in question. The outlay thus made is denoted by B'. A_1 and B' can be regarded as investment expenditures in a narrow sense as much as they involve expenditures of real resources (including time). Both $G - A_1$ and $G' - B'$ express the value of capital equipment after the outlays on maintenance and improvement activities are adjusted for, and the difference between the two expressions is attributed to whether or not the capital equipment is put to actual use in the current period. The difference $(G' - B')-(G - A_1)$ is defined as the <u>user cost</u> and it will be denoted by U. Together with other factor outlays this cost constitutes a part of the current (prime) cost of the firm. The <u>investment</u> of the firm is then defined as the total outlay on capital equipment minus the user cost, $A_1 - U$. In the customary terminology A_1 is the gross investment, while $A_1 - U$ is the net investment. Futhermore, the <u>income</u> of the firm is defined as the value of output (denoted by A) minus the user cost, $A - U$. The capital equipment referred to above may, in fact, include the stocks of materials, goods in process and finished products[3]. The most conspicuous characteristic of this definition is that the capital equipments of the firm are not necessarily perfectly employed. And this indeed seems to be the reason why the concept of user costs has not been treated adequately in the subsequent theoretical literature. In the neo-classical theory the normal feature of the world is that all capital equipments are perfectly utilized except for temporary disturbances or economic obsolescences[4)]. Here we take up the notion of user costs from an altogether different viewpoint.

The foregoing definitions can analogously be applied to the case of an individual by regarding him or her to be a producer employing his or her own economic ability as capital and putting it to use in alternative job opportunities. Discussion follows separately for each type of learning.

(i) The Case of Learning-by-Doing

In this case the amount of resources spent for improving one's own economic ability (A_1 and B') is identically zero. The user cost is calculated for each job as the difference between the present value of the future earnings capacity in the event that the individual actually works and that in the event that the individual takes the job but does not actually work during the period in question. In the present two-period fomulation the present value of the future earnings capacity reduces to that of the maximum earnings obtainable given the ability possesed by the individual at the end of the first period.

Look at Panel (b) of Figure 1. When an individual with ability x chooses job A in period 1, the user cost is zero, and moreover, this fact is independent of the initial ability position. This is because the earnings capacity of period 2 does not change no matter whether the individual actually works or not in the job taken. (It is $w_A k_A(x)$ for $x \in [0, \bar{x}]$ and $w_B k_B(x)$ for $x \in [\bar{x}, 1]$, both evaluated in current value terms.)

On the other hand, the user cost associated with the choice of job B in period 1 varies depending on the initial ability position x. First, in the case of $x \in [0, \underline{x}]$, the effect of learning-by-doing that becomes effective when one actually performs the job is to reduce the efficiency of work at job A in period 2, and yet $w_A k_A(x') > w_B k_B(x')$ holds so that the earnings capacity for period 2 is $w_A k_A(x')$. If the individual does not actually work in period 1, the detrimental effect of learning-by-doing is avoided, and therefore, the earnings capacity for period 2 remains at the level $w_A k_A(x)$. The current user cost in this case becomes $(w_A k_A(x) - w_A k_A(x'))/(1 + r)$, which is positive.

Second, in the case of $x \in [\underline{x}, \bar{x}]$ it is easily seen that the earnings capacity for period 2 is $w_B k_B(x')$ when one actually works while it becomes $w_A k_A(x)$ when one does not work, again reflecting the fact that learning-by-doing is inactive when job is not performed. Hence the user cost becomes $(w_A k_A(x) - w_B k_B(x'))/(1 + r)$. Its value is seen to turn from positive to negative at some intermediate value denoted by $\hat{x}$.

Third, in the remaining case of $x \in [\bar{x}, 1]$ the user cost turns out to be $(w_B k_B(x) - w_B k_B(x'))/(1 + r)$. It is uniformly negative in the specified range of x.

All the preceding considerations are summarized in the column representing the user cost under the heading of learning-by-doing in Table 1. In the table are also written the gross income of period 1 and the net income defined as the former subtracted by the user cost. This net income is identical with Keynes' definition of income.

Table 1 about here

An individual worker is then considered to choose his or her job in period 1 by comparing the level of net income obtained by each job. As a consequence job A is clearly taken by individuals with $x \varepsilon [0, \underline{x}]$ while job B is taken by individuals with $x \varepsilon [\bar{x}, 1]$. In the intermediate range of $x \varepsilon [\underline{x}, \bar{x}]$ the proposed rule becomes

$$w_A k_A(x) \begin{matrix} > \\ = \\ < \end{matrix} w_B k_B(x) + \frac{w_B k_B(x') - w_A k_A(x)}{1 + r} \iff \begin{matrix} \text{choose job A} \\ \text{indifferent} \\ \text{choose job B} \end{matrix}$$

It is immediately seen, however, that this criterion is equivalent to the maximization of the present value of the earnings stream, or the comparison of $V_{AA}(x)$ and $V_{BB}^*(x)$, as discussed previously[5)]. The critical value governing the choice of job is, again, x^*, and we are left with a new approach that generates identical behavioral rules with the opportunity cost approach.

(ii) The case of On-the-Job Training

A similar discussion can be made for the case of on-the-job training. The only difference with the case of learning-by-doing is the presence of an outlay of resources made on improving one's economic ability (A_1 in Keynes' terminology) when one chooses and actually performs job B. By the very nature of on-the-job training learning occurs only when one actually performs the job, and this, in turn, implies that the outlay of resources is not made when one remains idle in the job. Thus gross income as introduced in Table 1 is now interpreted as the revenue in period 1 that can be obtained when the ability then available is utilized fully, i.e., $\lambda = 0$. The outlays for improvement in ability is now identified as a part of the user cost. The user cost is then subtracted from the gross income to arrive at net income.

The user cost for the case of job A is identically (i.e., for all x) zero, just as in the case of learning-by-doing. In calculating the user cost for job B, it is helpful to divide the range of x into two intervals, $[0, \bar{x}]$ and $[\bar{x}, 1]$. First we take up the case of $x \varepsilon [0, \bar{x}]$. In this case the earnings capacity in period 2 when job B is actually performed with an arbitrarily specified intensity of learning λ is max $\{w_A k_A(x'), w_B k_B(x')\}$, where x' is given by (2), whereas that when job B is not actually performed becomes $w_A k_A(x)$. Hence the user cost is expressed by

$$U = \lambda w_B k_B(x) + \frac{\{w_A k_A(x) - \max [w_A k_A(x'), w_B k_B(x')]\}}{1 + r} \qquad (9)$$

where $\lambda w_B k_B(x)$ is the outlay of time resources actually made for the management of economic ability. The net income (or Keynes's income) Y then becomes

$$Y = (1 - \lambda) w_B k_B(x) - \frac{\{w_A k_A(x) - \max [w_A k_A(x'), w_B k_B(x')]\}}{1 + r} \qquad (10).$$

By comparing (10) with (8), (10) can be rewritten as

$$Y = V_B(x) - \frac{w_A k_A(x)}{1 + r} \qquad (11).$$

Note that for any given x the second term in (11) is a constant. Therefore, the maximization of Y given the choice of job B reduces to that of maximizing $V_B(x)$ with respect to λ. In the previous section, we have already derived the answer to the problem at hand. Namely, for $x \varepsilon [0, \underline{x}]$ the optimum λ is 0, the job to be taken in period 2 is A, and the maximized value of $V_B(x)$ is $V_{BA}(x)$, whereas for $x \varepsilon [\underline{x}, \bar{x}]$, the optimum λ is λ^*, the job to be taken in period 2 is B, and the maximized value of $V_B(x)$ is $V_{BB}^*(x)$.

The case of $x \varepsilon [\bar{x}, 1]$ can be analyzed in the same manner, and we only give the results in Table 1. The expressions of the user cost and the net income in Table 1 (under the heading of on-the-job training) refer to the optimized values with respect to the intensity of learning λ.

The rule of job choice in our new setting is, again, that of choosing the job which gives a higher net income. Just as in the case of learning-by-doing, the result is easily seen to be exactly the same as that derived in the previous section. In particular, the comparison of net income for $x \in [\underline{x}, \bar{x}]$ reduces to that of $V_{AA}(x)$ and $V_{BB}^{*}(x)$.

In the framework of this section, the amount of investment is defined, as previously mentioned, as the external outlay (A_1) substracted by the user cost (U). By taking note of the fact that in the range of x where job B is taken $A_1 = 0$ in the case of learning-by-doing while $A_1 = \lambda^* w_B k_B(x)$ in the case of on-the-job training, the level of investment can easily be calculated using the expressions in Table 1. The results are given in Table 2, where they are also contrasted with the investment figures defined by the opportunity cost approach.

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Table 2 about here
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This table shows that both approaches naturally assign the same zero investment level for the range of x where job A is chosen, but the two figures become wide apart for the range of x where job B is taken, that is, when human investment is actually made. A further discussion of this point is made in the next section[6].

5. Conclusion: The Significance of the User Cost Aproach

We have confirmed above that both the opportunity cost approach and the user cost approach result in exactly the same criterion of human investment as well as job choice. The prominent difference between the two approaches lie in the manner to comprehend the cost of human investment, and, in particular, in the manner to place the cost in national income accounting.

The notion of investment according to the opportunity cost approach represents the magnitude of current sacrifice in national income as compared with its maximum possible level. The user cost approach, on the other hand, regards the present value of an increase in the future earnings capacity achieved during the current period as investment. Simultaneously the corresponding amount is considered to be added to the value of national income. In either approach the national income accounting system is made consistent in that it satisfies the basic accounting constraint that national income less investment is the maximum possible consumption. One sees investmant from the viewpoint of resources put into the process while the other sees investment from the viewpoint of its effect.

The significance of perceiving investment from the viewpoint of resource input is intuitively clear. There are two qualifications, however, to such an approach.

First, the size of calculated resource inputs is not necessarily a correct indicator of the magnitude of actual accumulation of human capital. A typical example is the case of learning by doing. Suppose in addition to the circumstance depicted by Panel (b) of Figure 1 that learning-by-doing also occurs in job A. In this case individuals with ability $x \in [x^*, \bar{x}]$ would now choose job A and that the static "distortion" in the resource allocation previously existing in period 1 is thereby reduced. Indeed when the extent of learning-by-doing for job A increases to become identical with that for job B the "distortion" becomes zero, in which case the sacrifice in terms of current national income in period 1 is none. In this process the accumulaiton of human capital is <u>enhanced</u> whilst the amount of investment measured in terms of the opportunity cost <u>declines</u>. Hence Becker's argument that even in the case of learning-by-doing an increase in productivity (the earnings capacity) can entirely be attributed to human investment measured in opportunity cost terms (once an infinite rate of return is allowed for) is not a valid one. Although less pathodological there is a room for the same criticism to hold for the case of on-the-job training, in particular, when the opportunity cost other than the time resource cost ($w_A(x)-w_B(x)$ for $x \in [x^*, \bar{x}]$ or the area of ΔPQR in Panel (a) of Figure 1) is relatively large in magnitude.

Second, and perhaps more fundamentally, the calculation of resource inputs for human investment is based on the presumption that resources are always perfectly utilized. In a world where workers are not necessarily fully employed (or, to be more precise, where there exists a room for some workers to be involuntarily unemployed) the definition of investment cost in the sense of a maximally possible sacrifice in the current output loses its meaning. And moreover, the recent development in the theory of the labor market has shown that there are several grounds upon which involuntary unemployment may continue to exist even in the long-run.

The user cost approach, however, turns out to avoid these two criticisms successfully. An expanded accumulation of human capital is registered as a corresponding increase in the amount of investment. Such a property is quite natural in view of the standpoint to measure the magnitude of investment from its effect. What is more important may be the second point. Because the user cost of each job is calculated on the basis of a comparison between the situation in which an individual actually works and that in which the individual does not work (or unemployed), our approach can rightly be regarded as already taking account of the possibility of unemployment. Thus if an individual with ability x becomes unemployed involuntarily it means that the user cost both for job A and job B is zero, and it will corresponding be excluded in the process of aggregation. Our definition would also provide a useful analytical framework for considering the detrimental effect of unemployment on human resources (e.g. Hargreaves-Heap [1980]). Indeed, the definition of human investment introduced in this paper not only resolves the controversy surrounding the treatment of learning-by-doing in the human capital calculus but also provides a theoretical ground for properly measuring the long-run effect of unemployment. A further extension of the analysis along the lines suggested here will be left for a future study.

Appendix

We provide here a mathematical proof of the statement made in the text concerning the individual's behavior on investment and choice of job in period 2 given the choice of job B in period 1.

For an arbitrarily given x, let

$$\hat{\lambda} = \inf \{\lambda \in [0, 1] \mid w_B k_B(x') \geqslant w_A k_A(x'), \quad x' = (1+g(\lambda;\, x))x\}$$

be defined and let it be denoted as $\hat{\lambda}(x)$. It is obvious that $\hat{\lambda}(x) = 0$ for $x \in [\bar{x}, 1]$. For $x \in [0, \bar{x}]$, on the other hand, $\hat{\lambda}(x)$ turns out to be the value of λ such that x' just equals $\bar{x}$. It necessarily takes a positive value. It then follows that

$$V_B(x) = \begin{cases} (1-\lambda)w_B k_B(x) + \dfrac{w_B k_B(x')}{1+r} & \text{for } \lambda \geqslant \hat{\lambda}(x) \qquad \text{(i)} \\[2ex] (1-\lambda)w_B k_B(x) + \dfrac{w_A k_A(x')}{1+r} & \text{for } \lambda < \hat{\lambda}(x) \qquad \text{(ii).} \end{cases}$$

Let us draw the relationship between $V_B(x)$ and λ graphically, keeping x fixed at a given level. Th expression (i) for the domain $\lambda \geqslant \hat{\lambda}(x)$ takes a local maximum at $\lambda = \lambda^*$ provided that $\lambda^* \geqslant \hat{\lambda}(x)$ whilst it becomes monotonically decreasing with respect to λ throughout the interval $[\hat{\lambda}(x), 1]$ provided that $\lambda^* < \hat{\lambda}(x)$. On the other hand, the expression (ii) for the domain $\lambda < \hat{\lambda}(x)$ is monotonically decreasing with respect to λ throughout the interval $\lambda \in [0, \hat{\lambda}(x)]$. These properties are summarized in Figure A-1.

In case 1 of Figure A-1, the value of λ that maximizes $V_B(x)$ is one of two local maximum points, $\lambda = 0$ or $\lambda = \lambda^*$. The problem then exactly matches with the comparison of $V_{BA}(x)$ and $V_{BB}^*(x)$ discussed in the main text. In Case 2 of Figure A-1, the value of λ that maximizes $V_B(x)$ is obviously 0.

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Figure A-1 about here
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With these preparations we are now ready to discuss the optimal individual behavior for the respective ranges of x.

1. $x \in [0, \underline{x}]$:

In this range of x, both Case 1 and Case 2 referred to above may occur. However, since by definition $V_{BA}(x) \geq V_{BB}^*(x)$ (equality holds only for $x=\underline{x}$), the optimal λ is zero irrespective of the relative size of λ^* and $\hat{\lambda}(x)$, and the optimal choice of job in period 2 is to move to job A.

2. $x \in [\underline{x}, \bar{x}]$:

For this range of x, $V_{BB}^*(x) \geq V_{BA}(x)$ (again the equality holds only when $x = \underline{x}$). Hence the inequality

$$(1-\lambda^*)w_B k_B(x)+ \frac{w_B k_B((1+r(\lambda^*; x))x)}{1+r}$$

$$\geq w_B k_B(x) + \frac{w_A k_A(x)}{1+r}$$

$$> w_B k_B(x) + \frac{w_A k_A((1+g(\lambda^*; x))x)}{1+r}$$

holds. This immediately implies

$$\frac{w_A k_A((1+g(\lambda^*; x))x) - w_B k_B((1+g(\lambda^*; x))x)}{1+r} < - \lambda^* w_B k_B(x),$$

which, in turn, implies $\lambda^* > \hat{\lambda}(x)$. Thus Case 1 applies. We already know that in Case 1 the maximum value of $V_B(x)$ is attained by $V_{BB}^*(x)$ or $V_{BA}(x)$, whichever is larger, while the above inequality implies that $V_{BB}^*(x)$ dominates $V_{BA}(x)$. Hence it is optimal for an individual to choose the intensity λ^* for training and also to remain at job B in period 2.

3. $x \in [\bar{x}, 1]$:

For this range of x we have already started that $\hat{\lambda}(x) = 0$. Case 1 thus holds and furthermore, $V_{BB}^*(x) > V_{BA}(x)$. Hence the optimal behavior is identical with that for $x \in [\underline{x}, \bar{x}]$.

(Q.E.D.)

Notes

1) Alternatively one can suppose that job B is also conformable with the ability position 0. So long as the efficiency curves $k_A(x)$ and $k_B(x)$ are not identical (which is effectively the same thing as saying that jobs A and B are different) the following analysis is not affected. The basic reason behind this is that an individual's choice of a job is always governed by the common principle of comparative advantage (which is well explicated by Rosen [1978]).

2) In principle, the relative wage between the two jobs (w_A/w_B) as well as the rate of interest (r) all change as a result of changes in the individual behavior. However, such "market experiments" have nothing directly to do with the logical substance of this paper. The changes in the relative market prices in non-steady state situations are also an altogether different issue from the present one.

3) An example would be helpful in understanding the notions discussed in the text. The example chosen bellow refers to the case of a firm managing its

inventory of materials used in production. Suppose that a firm spends \$4,000 for wages of employees and \$3,000 for material inputs in order to obtain a revenue of \$10,000 on its product. Suppose also that from the viewpoint of lubricating the production flows and meeting uncertain contingencies it is optimal for the firm to maintain a stock of \$5,000 worth of materials at the beginning of every production period. In this case, $G' = G = \$5,000$, $B' = 0$ and $A_1 = \$3,000$. The user cost U becomes $U = (G' - B') - (G - A_1) = \$3,000$. The (net) income to the firm is the gross income (revenue) A minus the user cost U, which is \$3,000 - \$3,000, or zero.

4) As an exception, there are theories that maintain that firms strategically choose to hold excess capacities in order to deter new entry of rival firms (e.g,. Spence [1977]).

5) As a matter of fact, the choice of no work (i.e., voluntary unemployment) is never made in th present model, for that would give zero income that is lower than the income of either job. Needless to say, such a choice may actually be made when a sufficiently high consumption value is attached to leisure. Also there is a possibility of an involuntary unemployment. This last problem is discussed in the next section.

6) The analysis of the preceding two sections can easily be extended to the cases of more than two job opportunities and more than two periods. As an example of the more than two jobs case consider job C which is most comformable with the ability position 1/2. In this case the opportunity cost of taking a particular job is calculated on the basis of a comparison with the most directly competitive job. The most fundamental assumption of the entire analyisis is that the job opportunities are given exogeneously and that the rents accuring to individuals with an ability close to the most comformable posiiton of some job do not die out even in the face of market competition.

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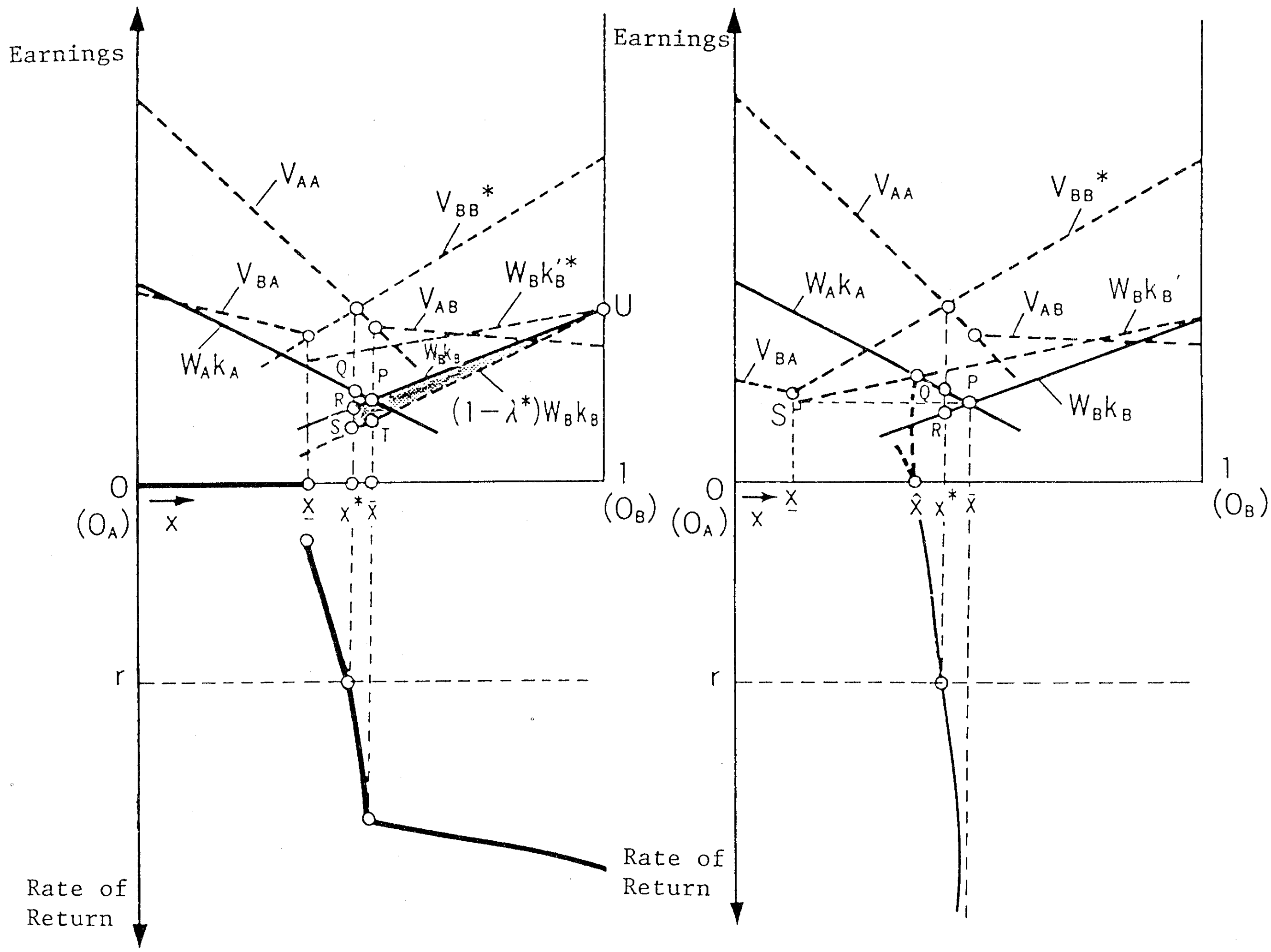
Figure 1: The Notion of Investment in the Opportunity Cost Approach



Panel (a) On-the-job Training Panel (b) Learning-by-Doing

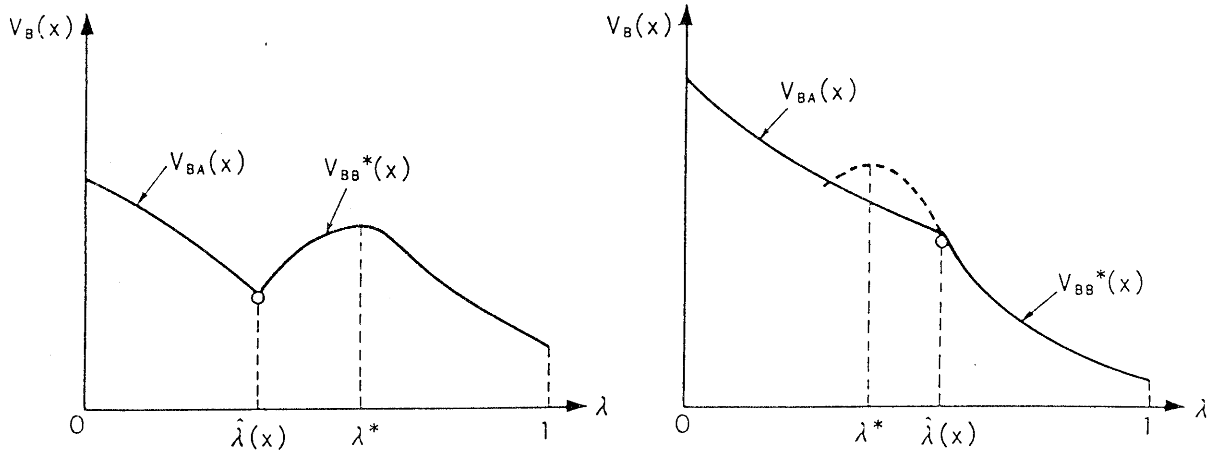
Table 1: Income Accounting in the User Cost Approach

Case	Job	Gross Income	On-the-Job Training: User Cost	On-the-Job Training: Net Income	Learning-by-Doing: User Cost	Learning-by-Doing: Net Income
$0 \leqq x \leqq \underline{x}$	A	$w_A k_A(x)$	$\frac{w_A k_A(x) - w_A k_A(x)}{1+r} = 0$	$w_A k_A(x)$	$\frac{w_A k_A(x) - w_A k_A(x)}{1+r} = 0$	$w_A k_A(x)$
	B	$w_B k_B(x)$	$\frac{w_A k_A(x) - w_A k_A(x)}{1+r} = 0$	$w_B k_B(x)$	$\frac{w_A k_A(x) - w_A k_A(x')}{1+r} > 0$	$w_B k_B(x) - \frac{w_A k_A(x) - w_A k_A(x')}{1+r}$
$\underline{x} \leqq x \leqq \bar{x}$	A	$w_A k_A(x)$	$\frac{w_A k_A(x) - w_A k_A(x)}{1+r} = 0$	$w_A k_A(x)$	$\frac{w_A k_A(x) - w_A k_A(x)}{1+r} = 0$	$w_A k_A(x)$
	B	$w_B k_B(x)$	$\lambda^* w_B k_B(x) + \frac{w_A k_A(x) - w_B k_B(x'^*)}{1+r}$	$(1-\lambda^*) w_B k_B(x) + \frac{w_B k_B(x'^*) - w_A k_A(x)}{1+r}$	$\frac{w_A k_A(x) - w_B k_B(x')}{1+r} \gtreqless 0 \Leftrightarrow x \lesseqgtr \hat{x}$	$w_B k_B(x) + \frac{w_B k_B(x') - w_A k_A(x)}{1+r}$
$\bar{x} \leqq x \leqq 1$	A	$w_A k_A(x)$	$\frac{w_B k_B(x) - w_B k_B(x)}{1+r} = 0$	$w_A k_A(x)$	$\frac{w_B k_B(x) - w_B k_B(x)}{1+r} = 0$	$w_A k_A(x)$
	B	$w_B k_B(x)$	$\lambda^* w_B k_B(x) + \frac{w_B k_B(x) - w_B k_B(x'^*)}{1+r}$	$(1-\lambda^*) w_B k_B(x) + \frac{w_B k_B(x'^*) - w_B k_B(x)}{1+r}$	$\frac{w_B k_B(x) - w_B k_B(x')}{1+r} < 0$	$w_B k_B(x) + \frac{w_B k_B(x') - w_B k_B(x)}{1+r}$

Table 2: The Amount of Realized Investment

	On-the-Job Training		Learning-by-Doing	
	Opportunity Cost Approach	User Cost Approach	Opportunity Cost Approach	User Cost Approach
$0 \leqq x \leqq x^*$	0	0	0	0
$x^* \leqq x \leqq \bar{x}$	$w_A(x) - w_B(x) + \lambda^* w_B k_B(x)$	$\frac{w_B k_B(x'^*) - w_A k_A(x)}{1+r}$	$w_A(x) - w_B(x)$	$\frac{w_B k_B(x') - w_A k_A(x)}{1+r}$
$\bar{x} \leqq x \leqq 1$	$\lambda^* w_B k_B(x)$	$\frac{w_B k_B(x'^*) - w_B k_B(x)}{1+r}$	0	$\frac{w_B k_B(x') - w_B k_B(x)}{1+r}$

Figure A-1: The Relationship between $V_B(x)$ and λ



Case 1 : $\lambda^* \geqq \hat{\lambda}(x)$ Case 2 : $\lambda^* < \hat{\lambda}(x)$