WORKING PAPERS IN ECONOMICS

RATIONAL CHOICE, LEARNING-BY-DOING AND THE PERSONAL DISTRIBUTION OF INCOME

by

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The University of Sydney
Australia 2006

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No. 51

April 1981

National Library of Australia Card Number and ISBN
0 86837 032 0

ABSTRACT

This paper examines the role of individual choice in the theory of distribution.

It is demonstrated that an empirically tractable model of earnings can be derived from learning theory in the absence of the rational choice or investment paradigm.

The paper suggests that, in the context of an imperfectly competitive labour market, the primary role of learning on-the-job is as a labour augmenting input to the production process. In such a context therefore, there is little scope for exercising individual rational choice. Accordingly, the paper concludes that the human capital , post-school, 'self-investment' hypothesis has limited application to the theory of income distribution.

I would like to express my appreciation to Dr. A. J. Phipps and other members of the Labour Economics Group, University of Sydney, for helpful suggestions and encouragement during the course of this project. I also wish to express my gratitude to the Commonwealth Public Service Board for providing the scholarship which enabled me to undertake the following analysis. Needless to say, I claim sole responsibility for all the errors and omissions in this paper.

RATIONAL CHOICE, LEARNING-BY-DOING AND THE PERSONAL DISTRIBUTION OF INCOME*

> *I ought to know by this time that when a fact appears to be opposed to a long train of deductions, it invariably proves to be capable of bearing some other interpretation.*
>
> (*Sherlock Holmes in A Study in Scarlet*, p. 81.)

I Introduction

There appears to be some consensus amongst labour economists that the time-profile of individual earnings can be, in large part, explained in terms of psychological learning theory.[1] Post-school productivity augmentation thus tends to be conceived, largely as the product of 'learning-by-doing', while on the job or, in more conventional terminology, as the product of 'work experience'. The chief area of dispute amongst economists lies in the interpretation of the role of individual 'rational choice' in respect of learning on-the-job and by implication in respect of earnings profiles.[2] In very simple terms, the point at issue is whether post-school productivity augmentation is to be interpreted strictly as the result of rational 'investment' by the individual or, alternatively, simply as an unavoidable by-product of the production process over which the individual employee exercises no control

The human capital or 'investment' paradigm, in which both learning and consequently earnings are viewed as the outcome of 'rational choice' by an individual, is by now regarded as a landmark in the history of economic thought.[3] In particular, human capitalists claim that their

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* This paper is part of the research carried out under an Australian Public Service , Postgraduate Scholarship Award.

approach brings the theory of income distribution back within the ambit of mainstream economics whereas earlier theorists had tended to stress the role of stochastic processes,while more recent alternatives have focused on the role of a variety of psychological and socio-economic variables which are largely regarded as exogenous in so far as mainstream economics is concerned.[4]

Nevertheless, in spite of the apparent popularity of the human capital investment models, one can detect an apparent uneasiness amongst proponents.[5] This uneasiness perhaps springs from the fact that most psychological theories of learning can provide a basis for an empirically tractable theory of personal income distribution without recourse to the notion of 'rational choice'. Secondly, and probably more importantly, the imposition of the individual 'rational choice' paradigm in the context of distribution theory inevitably leads to some rather implausible and relatively ruthless policy implications.[6] Finally the human capital investment model is based solidly on conventional neoclassical micro-foundations. Hence,any departure from the perfectly competitive assumptions tends to severely limit the scope for the exercise of individual choice.[7]

While human capitalists recognise the role of learning-by-doing as an integral part of the learning process, and hence, by implication, an important determinant of the personal distribution of earnings, the notion of 'costless' learning-by-doing is rejected as implausible on economic grounds.[8] The reason for this rejection is rather puzzling. The only difference between the human capital investment model and a strictly learning-by-doing model is the notion of'rational choice' on the part of the individual. Deleting the 'rational choice' paradigm still leaves an empirically tractable model of learning on-the-job and of the personal distribution of income. In terms of the criteria stressed over and over again by Mincer and also by Becker, empirical

tractability should be sufficient reason for the learning-by-doing model to be, at least, considered as a viable alternative to the investment model.[9] Why, then is the learning-by-doing model rejected out of hand by human capitalists?

The answer to the latter question lies in Becker's peculiar conception of the employee-employer relationship. Employees are viewed as consumers of learning on-the-job while employers are the suppliers. According to Becker, therefore, the notion of 'learning-by-doing' as an unavoidable and costless by-product of the production process implies an insatiable demand for learning.[10] Accordingly it is an inevitable consequence, within this theoretical framework, that learning must be provided by the firm at a 'price' to the employee, which equates supply and demand.[11] It is this notion that the firm is a supplier of both goods and learning, which forms the foundation of the human capital post-school, self-investment model and consequently the basis of the rejection of the notion of costless 'learning-by-doing'.[12]

Mincer adds a further dimension to the denunciation of the 'costless' learning-by-doing model, claiming that such a model would be incapable of explaining a labour market characterised by considerable labour turnover.[13] The foundation, however, of this criticism is not immediately apparent.

It is the objective of this paper to show that these objections to the learning-by-doing model have no real foundation. It will be demonstrated that such a model can explain the data equally as well as the human capital self-investment model. Furthermore it will be claimed th a strictly learning-by-doing model yields similar implications to the human capital self-investment model, but with less complicating and more intuitively appealing assumptions. Accordingly, the following section summarises the characteristics of a labour market in which

post-school productivity augmentation (after an initial set-up period) is solely the result of learning-by-doing. Section III derives a general earnings function from these assumptions. In Section IV the resulting model is applied to data from the 1976 Australian Population Census. Section V provides a point-by-point comparison of the implications of the two models and Section VI the summary and conclusions.

II The Labour Market Implications of Learning-by-Doing

The major implications of a model in which learning-by-doing or workforce experience is the principle source of productivity augmentation on-the-job are outlined below.

Learning-by-doing is defined as an unavoidable by-product of the production process. It thus follows that firms cannot choose to withhold such learning from their employees and likewise, employees cannot choose to forego learning on-the-job.[14]

Individuals automatically accumulate productivity augmenting learning during their period in the workforce. To the extent that the productivity of an experienced employee can be compared to that of an inexperienced accession, then differential experience can be expressed in terms of (inexperienced) labour equivalents. Conceptually, therefore, it is possible to speak of the experience of the firm's workforce as the accumulated experience of its employees, expressed as (inexperienced) labour equivalents.

The firm's rate of accumulation of experience (post-school human capital) will depend on its ability to attract and retain experienced employees. In other words at any given time, the experience of the firm's workforce will depend on the net flow of experienced labour either into or out of the firm.

Assuming individuals maximise income subject to risk, information, location and other constraints then the firm can control the net flow of experienced labour by means of a wage schedule which incorporates a premium or mark-up for experience.[15] Thus in a dynamic market where 'labour mobility is the norm rather than the exception', firms could set the premium to achieve an optimal 'net flow' of experienced labour and by 'implication the optimal 'stock' of human capital.

Since the output of less experienced employees can be duplicated by a lesser number of more experienced employees, and since the level of experience of the firm's workforce is controlled by the firm, then experience can be interpreted as a labour augmenting input in the production process. In other words experience represents an alternative to conventionally defined labour inputs in the same way as physical capital is regarded as a substitute for conventionally defined labour inputs.

In so far as the individual firm is concerned experience , as an input to the production process, is not 'costless'. Experience is only increased at the expense of a larger total wage-bill.

The optimal level of experience, as far as the firm is concerned, depends on the tradeoff between increments to the wage-bill and the resulting increments to net profitability. Thus if the value of additional output declines, then the value of an increase in experience like the value of an increase in standard labour inputs could tend to zero.

The value of increasing employment and/or of increasing the level of experience of the firm's workforce depends upon the current state of the firm as well as its expectations concerning the future economic environment. These expectations may be continually revised as a result of the individual or collective decisions of other firms, particularly

those in the same neighbourhood. For instance if all other firms are raising wages,then taking on additional inexperienced accessions might be the most appropriate response to an increase in product demand. Alternatively if the market share of a particular firm is growing at the expense of other firms within the industry,then the firm will be in a good position to use its wage premium to attract experienced employees from its less fortunate competitors. In the latter case the firm with the more favourable prospects tends to place a greater valuation on experience.

The wage rate of experienced labour is thus endogenously determined within the internal labour market of the firm. It is assumed, on the other hand, that the supply of inexperienced labour is infinitely elastic at a wage rate (entry wage) determined exogenously within the external labour market. The differential between the endogenously determined wage of an experienced employee and the exogenously determined wage rate of inexperienced labour, all else being equal, represents the value of the employee's share in the productivity augmenting benefits of learning-by-doing.

Assuming that neophytes require an initial period of relatively intensive supervision by experienced employees, then it follows that the impact of experience, in terms of output, will be an inverse function of the number of inexperienced accessions taken on during the period.[16] Moreover, it is a necessary consequence of this assumption, that a firm which is taking on inexperienced labour will offer a wage which is below the value of the marginal product of labour. Furthermore, the difference will reflect the firm's implicit outlay on the supervision of an inexperienced accession.[17]

Similarly if it is assumed that layoffs have an adverse impact on the firm's reputation as a secure employer thereby rendering it more

difficult to attract and retain experienced labour, then the rate of change in the experience of the firm's workforce will tend to be an inverse function of the number of layoffs during the period. It is a necessary consequence of this assumption that the firm will attempt to hoard some experienced labour during a cyclical downturn and consequently will offer a wage which is actually above the value of the marginal product of labour.

In general it is an implication of the model outlined above, though not necessarily of the learning-by-doing model by itself, that wages are not necessarily market clearing and are relatively inflexible in a downwards direction. Secondly, the wage rate controls the quality of labour inputs rather than the quantity. The quantity of labour is controlled in combination by the firm's school-leaver recruitment, wage policy and layoff policy. In the event of slight variation in demand, adjustment is handled solely via wage policy otherwise adjustment involves wage policy plus recruitment or wage plus layoff policy. In other words both voluntary and involuntary labour turnover is perfectly consistent with this theoretical framework.[18]

The major difference between the learning-by-doing model outlined above and the human capital self-investment model is in the roles of experience. The learning-by-doing model treats experience primarily as an input to the production process whereas the chief role of experience in the human capital model is as a produced output. Both models imply optimisation, the latter by the individual employee, the former by the firm. In the learning-by-doing model, however, optimisation does not involve the shape of the learning curve in the same way as it does in human capital theory. In the above model, learning is regarded as a characteristic of all jobs and hence the demand for learning is indistinguishable from the demand for employment. In other

words, there is no job in which no learning is involved. Moreover similar jobs in different firms are presumed to exhibit homogeneous patterns of learning. Thus neither the firm nor the individual controls the shape of the learning curve.

In terms of the above model, therefore, observed earnings reflect gross earnings. Moreover gross or observed earnings are necessarily less than the stock of human capital embodied by an individual. In the human capital 'self-investment' model, observed earnings reflect net earnings, that is earnings net of current investments but inclusive of returns from previous investment.[19] So long as all learning is 'general', then gross earnings in the human capital model is equivalent to the individual stock of human capital. In other words the firm does not share in the benefits of general 'workforce experience'. In the learning-by-doing model, both the employee's and the firm's share in the benefits of productivity augmenting workforce experience are determined by rational optimisation by the firm subject to the exigency of labour turnover.

III A general Earnings Function

In terms of the model outlined above, the earnings received by an employee of firm i with t years of work experience can be described as a function of his wage rate on entry into the workforce W, an index of the impact of productivity-augmenting work experience S, and the employee's share in the productivity benefits of learning by doing ϕ_i.[20]

Since this paper is primarily concerned with the impact of post-school learning, the human capital schooling model popularised by Becker and Mincer is accepted as the basis for determining the entry wage,[21] i.e.

$$W(N) = W_o e^{\alpha N} \qquad (1)$$

where α represents the rate of return to a year of formal education,[22] and W_o can be interpreted as the wage rate of raw-labour, i.e. labour net of formal education and experience.

The stock of human capital embodied by an individual is defined as the sum of annual depreciated increments plus the initial stock on entry into the workforce, i.e.

$$S(t) = S(0) + \int_o^t k(y) e^{r(y-t)} \, dy \qquad (2)$$

where S(t) is the index of the productive capacity or the stock of human capital embodied by an individual with t years of workforce experience, such that $S(0) = 1$, and $S(t) \geq 1$.

k(t) represents a corresponding index of gross annual additions resulting from 'learning-by-doing and r represents the rate of depreciation of the benefits of post-school learning.[23] It is worthwhile noting that (2) implies that there is no corresponding depreciation of the initial or pre-work 'stock of human capital'. This simply reflects an implicit assumption that the marginal productivity of an experienced individual can be equal to or greater than, but never less than that of an inexperienced individual (i.e. a school leaver).[24]

It is assumed that productivity augmenting work experience or learning-by-doing is subject to the law of diminishing returns and consequently that annual increments to productive capacity decline exponentially,[25] i.e.

$$k(t) = k_o e^{-\beta t} \qquad (3)$$

where β represents the rate of exponential decline.

Substituting (3) into (2) and carrying out the appropriate intergration yields the following expression for the net stock of human capital embodied by an individual with t years of work experience.

$$S(t) = 1 + k_o(r-\beta)^{-1} \ (e^{-\beta t} - e^{-rt}) \qquad (4)$$

Utilizing a quadratic approximation for the exponential terms, (4) becomes:

$$S(t) = 1 + k_o \ t - (k_o/2) \ (r+\beta)t^2 \qquad (5)$$

The wage received by an individual in firm i with N years of formal education and t years of work experience is the sum of his entry wage plus his share of the productivity augmenting benefits of workforce experience all expressed in terms of the price (wage rate) of 'raw labour', i.e.

$$w_i(N,t) = W(N) \ \{ \ 1 + \phi_i[S(t) - 1 \ ] \ \} \qquad (6)$$

Define $\phi = \sum_{i=1}^{n} (a_i \ \phi_i)$ with $\sum_{i=1}^{n} a_i = 1$

where n denotes the number of firms

a_i represents the proportion of individuals with N years of formal education and t years of work experience currently employed in firm i.

It follows that the mean earnings of an individual with N years of schooling and t years experience in the work force, can be expressed as:

$$w \ (N,t) = W(N) \ \{1 + \ \phi[S(t) -1] \ \} \qquad (7)$$

Substituting (1) and (5) into (7) yields the following expression for mean earnings:

$$w(N,t) = W_o e^{\alpha N} \ \{1 + \phi k_o t - (\phi k_o/2) \ (r + \beta) \ t^2 \ \} \qquad (8)$$

Taking logarithms of both sides yields the following expression for log mean-earnings.

$$\ln w(N,t) = \ln W_o + \alpha N + \ln \ [1 + \ \phi k_o t - (\phi k_o/2)(r+\beta)t^2] \qquad (9)$$

Let T represent years of experience coincident with peak earnings. Differentiating (8) with respect to t and solving for T we obtain:

$$T = (r + \beta)^{-1} \qquad (10)$$

substituting (10) into (9) yields the following expression:[26]

$$\ln w(N,t) = \ln W_o + \alpha N + \ln (1 + \phi k_o t - (\phi k_o / 2T) t^2) \qquad (11)$$

All of the parameters of (11) have fairly conventional interpretations. Thus W_o is the price or wage rate of 'raw labour', α the rate of return on a year of formal education, ϕk_o represents the gross average annual rate of increase in earnings attributable to post-school learning (i.e. inclusive of the depreciation and decline), while T represents years of experience at which peak earnings is achieved.

From (10) it follows that peak earnings and hence the slope of experience-earnings profile depends on the rates of depreciation and exponential decline in the earning curve and not on the level of formal schooling. Nevertheless peak-earnings age will still depend on the level of formal schooling or,more precisely,the age at entry into the workforce.[27] In other words the individual has no control over either the slope or shape of the earnings profile.

In the human capital investment model β is essentially a choice variable for the individual employee and consequently an employee does within this latter framework, exercise control over the slope and shape of the earnings profile i.e. through his investment behaviour. Thus it is the interpretation of the parameter β which represents the major divergence between the two approaches on both analytical and empirical grounds.

It should also be stressed that (11) represents the logarithmic version of gross-earnings function whereas the human capital self-investment models, by definition, always involve the concept of net earnings. It is a necessary consequence, therefore, that our estimate of β should be considerably smaller than that derived within a human capital framework.

In the human capital 'self investment' model the principle endogenous source of variation in earnings within a particular experience-education class is differences in individual investments. There may also be some variation due to inter-firm differences in the employees share of the returns from the firm's investments in firm specific training. However, in general, the endogenous variation is largely attributed, by human capitalists, to the exercise of 'rational choice' by individual investors.

Mincer has shown that, all else being equal, the variance of earnings will increase with the level of formal education.[28] He also shows that holding everything else constant and ignoring depreciation, the variance of earnings increases monotonically with workforce experience.[29]

In the learning-by-doing model, the principle endogenous source of variation in earnings, holding experience and education levels constant, is inter-firm differences in the wage premium ϕ_i. In other words, the resulting variation is due to the exercise of 'rational choice' by the firm rather than by employees as in the human capital self-investment model.

Let ψ_{it} represent the proportional differential between an employee's wage rate at time t and the entry wage so that from (6) it follows:

$$\psi_{it} = \phi_i [S(t)-1] \tag{12}$$

Accordingly, the variance in earnings can be described as follows:

$$\sigma^2(\psi_{it}) = \phi^2 \sigma^2(S(t)-1) + (\overline{S(t)-1})^2 \sigma^2(\phi_i) + \sigma^2(S(t)-1)\sigma^2(\phi_i) \tag{13}$$

It is an implication of the learning-by-doing model that learning curves for the same occupation (education class) are relatively homogeneous thus $\sigma^2(S(t)-1)$ approaches zero so that:

$$\sigma^2(\psi_{it}) \equiv (S(t)-1)^2 \sigma^2(\phi_i) \tag{13a}$$

In other words assuming $\sigma^2(\phi_i) > 0$ then the variance of earnings should

increase monotonically with experience up to T years following which some reversal may occur.

IV The Personal Distribution of Incomes: Australia 1976

In this section the general earnings function derived in the previous section is applied to data derived from the Australian 1976 Census of Population and Housing.[30] The estimation equation is restated below:

$$\ln w_{N,t} = c_o + c_1 N + \ln (1 + c_2 t - (c_2/2c_3)\, t^2) + v \qquad (11a)$$

where $w_{N,t}$ represents the mean earnings of an individual with N years of formal education and t years of work experience

$c_o = \ln w_o$

c_1 is the rate of return of schooling

$c_2 = \phi k_o$

$c_3 = T$

v represents the residual reflecting the variation in employees shares ϕ_i between firms and possible errors in the functional form.

The derivation of 123 observations of the mean and variance of earnings is described in detail in the appendix. An attempt was made, as far as possible, to estimate the parameters of the 'standard distribution'.[31] The results for the general earnings function are as follows:[32]

$$\ln w_{N,t} = \underset{((4.13))}{0.203} + \underset{((24.53))}{0.067N} + \ln (1 + \underset{((10.06))}{0.050t} - 0.5 * \underset{((10.06))}{0.050} * \underset{((24.25))}{0.032\, t^2}) \qquad (11b)$$

$$R^2 = 0.88$$

implying $W_o = \$1.23$

α = 6.7% per annum

ϕk_o = 5.0%

T = 31.44

The figures in double parentheses represent the 't' statistic while R^2 is the coefficient of determination.

All of the regression parameters are of the right sign and order of magnitude. For instance, the rate of return to schooling of 6.7 per cent per annum is consistent with many other studies.[33] Similarly, the estimate of T implies that peak earnings age lies between 46 and 56 years of age. This is relatively close to estimates provided by human capitalists.[34]

As one would expect the implicit value of the rate of exponential decline in earnings, i.e. $0 \leq \beta \leq 0.032$, is somewhat smaller than would be expected by human capitalists.[35] However this result simply reflects the fact that we are estimating a gross earnings function whereas the latter estimate net earnings functions. For a similar reason our estimate of the initial gross average annual rate of increase in earnings (i.e. ϕk_o = 5 per cent), is substantially less than Mincer's estimate of the initial gross rate of return to post school investment.[36]

The value of the coefficient of determination suggests that the model explains approximately seven-eighths of the variation in log mean earnings classified by education and experience levels. While this result is pleasing, it is stressed that it is obtained from grouped data.[37]

On the basis of the analytical implications outlined in the previous section, it was hypothesised that the variance of earnings would be a positive function of both the level of formal education and experience at least to T years following which some reversal might be expected as a result of the depreciation of the acquired stock of human capital.

This suggests that the appropriate function form may be quadratic in terms of experience and at least linear in respect of formal education.[38] With this in mind a number of alternative specifications of the variance and log variance function were investigated. The best results were obtained from a function which expressed the logarithm of the variance of earnings as a quadratic function of both experience and level of education . The resulting regression equation, accordingly, is outlined below:

$$\ln [\mathrm{Var}(w_{N,t})] = \underset{((-9.79))}{-3.915} + \underset{((7.30))}{0.433N} - \underset{((-6.10))}{0.013N^2} + \underset{((11.57))}{0.079t} - \underset{(-6.92)}{0.001t^2} \qquad (14)$$

$$R^2 = 0.80$$

Differentiating (14) with respect to t and solving for t* yields the result that the variance of earnings increases monotonically with experience for a period of approximately 39 years following which the variance tends to decline with experience. This result tends to support our earlier analytical results although t* (peak variance) and T(peak earnings) do not exactly coincide.

Likewise differentiating (14) with respect to N and solving for N* yields the empirical result that, all else being equal, the variance of earnings increases monotonically with education up to N = 16 years. In other words the variance of earnings tends to decline with the level of education for post-school categories excluding tradesmen.

V Investment and Learning or Learning?

The major justification of the human capital 'self-investment' hypothesis is the claim that it is consistent with the data.[39] It is argued as well as demonstrated in the previous section that a model based solely on 'learning-by-doing' on the job is equally consistent with the data and consequently that the empirical performance of the human capital model cannot therefore, as is often claimed, constitute the ultimate test.

The major analytical objection raised by human capitalists to assigning an exclusive role to learning theory is that the notion of 'costless' learning-by-doing cannot by definition, be consistent with the individual's human capital (earnings) production function. As long as this is, in fact, the major role of on-the-job learning, then this objection may be reasonable. It is however,argued in this paper that the primary role of learning-by-doing or experience is, in fact, as an input to the firm's production function. In other words, experience, like physical capital, should be considered as a labour augmenting input to the production process. Moreover, it is shown that, within this context, experience is not costless in so far as the firm is concerned i.e. the firm pays a wage premium in order to attract and retain experienced labour.

It is an implication of the human capital self-investment hypothesis that firms would have no incentive to differentiate between job applicants on the basis of their workforce experience.[40] In other words, general (transferable) learning on-the-job has no role other than as an input to the individual's human capital (earnings) production function. The persistent and undeniable bias of employers in favour of the more experienced (i.e. where they have achoice) would appear to be a contradiction of the human capital self-investment model.[41] On the other hand such persistent bias is readily explained by a model in which experience is an input in

the firm's production function.

Mincer's objection that a model in which learning on-the-job is costless would be incapable of explaining a labour market where 'labour mobility is the norm rather than the exception', also appears to be contradicted by the learning-by-doing model developed in this paper. The cornerstone assumption of this model is, in fact, an imperfectly competitive and relatively mobile labour market.[42] The human capital self-investment model, on the other hand, relies on the conventional neoclassical notion of perfect competition and hence costless labour-turnover, voluntary unemployment and so on. Certainly, the model outlined above is perfectly consistent with non-market clearing wages, downward wage inflexibility and the existence of voluntary and involuntary unemployment.[43]

The major objection to the human capital self-investment model, usually relates to the information requirements it imposes on individuals.[44] In order to be able to exercise 'rational choice' the individual must possess a relatively detailed knowledge of the characteristics of the learning curves offered by each firm. Human capital theory , however, is relatively silent on how an individual comes by this information.[45] Moreover, to the extent that information is imperfect and hard to obtain, the firm can exercise some degree of monopsony power and expropriate part of the returns from on-the-job learning.[46] In other words, in such circumstances, the personal distribution of income reflects the result of employer-employee bargaining rather than solely the exercise of rational choice by the individual employee. Furthermore to the extent that the firm receives some of the benefits of workforce experience, then there is, ceteris paribus, an incentive for the firm to also invest in 'learning-by-doing' (i.e. lower the supply price). Clearly, in such a context, the human capital self-investment model by itself provides

an inadequate explanation of the personal distribution of income. There will always be a zone of indeterminacy which is the subject of employer-employee bargaining.

In general, any form of market imperfection tends to limit the scope for 'rational choice' on the part of the individual and hence limits the applicability of the human capital 'self-investment' model. For instance, the existence of an 'implicit contract' between employer and employee or any other constraint on the operation of a perfectly competitive labour market, enables a firm to exercise monopsony power and hence to capture some of the returns from post-school learning.[47] Similarly, protection and other manifestations of market power increase the firm's control over the distribution of returns from on-the-job learning thereby lessening the scope for the exercise of individual 'rational choice'.[48]

Ultimately the human capital self-investment model would only appear to apply in the context of perfectly competitive labour and product markets. In the presence of market constraints, investment will largely be controlled by the firm. However since 'learning-by-doing' implies a stable learning curve, investment by the firm implies a reduction in the price of training or a raising of the individual's net earnings. Allowing for the impact of turnover, the resulting model is very similar in its implications to that developed in this paper. The major difference, being that the self-investment model requires the existence of differential learning curves for firms in the same industry whereas in the learning-by-doing model the learning curves of firms in the same industry, are assumed to be homogeneous.

In the context of an imperfectly competitive labour or product market the self-investment approach implies the simultaneous solution of the individual employees and the firm's optimisation in order to identify

the employees resultant share in the productivity augmenting benefits of learning-by-doing.[49] Unless, however, the employee is aware of his likely share, it will be very difficult for him to determine the optimum level of investment. Human capitalists attempt to overcome this information constraint by postulating correlation between the firm's and the individual's investments in learning on-the-job.[50] The reason why the outcome of 'rational choice' by the individual employee should be correlated with that of the firm is not immediately apparent.

If we acknowledge the primary role of experience as an input to the production process, then such analytical complexities do not arise. The employee's share in the benefits of productivity augmenting work experience is solely a result of the firm's optimisation.

Finally the learning-by-doing model does not require the troublesome distinction between general and firm-specific learning. The control variable is the employee's share in the benefits of learning on-the-job.

In human capital theory, the distinction between general and firm specific learning is only really relevant in the context of perfectly competitive labour and product markets. As outlined above, in the context of imperfectly competitive markets, the distinction is fairly meaningless and the operational notion is simply the employee's share in the benefits of on-the-job training.

In this section, an attempt has been made to outline some of the more common objections to both the 'costless' learning-by-doing model and the human capital self-investment model. It has been shown that the implications of the two models are very similar in the context of imperfectly competitive markets. The main claim is however, that the human capital self-investment hypothesis involves far more complicating and less obvious assumptions than the strictly learning-by-doing model.

VI Conclusions

The primary objective of this paper has been to query the role of 'rational choice' in respect of the personal distribution of income. The fundamental question asks why a theory of rational choice is required, if learning theory provides an empirically tractable explanation of earnings over the life cycle?

A major conclusion is that the human capital 'investment' or 'rational choice' paradigm depends upon two explicit assumptions. The first is the assumption that the primary role of learning on-the-job or workforce experience is as an input to the individual's human capital (earnings) function. The second is the underlying assumption of perfectly competitive labour and product markets.

Relaxation of either or both these assumptions tends to undermine the role of individual 'rational choice' in the explanation of the distribution of earnings.[51]

It is argued that the primary role of learning-by-doing is, in fact, as a labour augmenting input to the firm's production function. Secondly it is suggested that there exist informational and other constraints on the existence of perfectly competitive labour and product markets.

As a result of these objections it is concluded that the scope for exercising 'rational choice' in respect of the personal distribution of income is severely limited and consequently the relevance and usefulness of the human capital self-investment hypothesis as an explanation of learning on-the-job must be open to question.

Finally it is stressed that the notion of workforce experience as a labour augmenting input is perfectly consistent with the notion of human capital and hence that dropping the 'self-investment' assumption would not affect the apparent unity of human capital theory.

APPENDIX

Data and Sources

The data for the empirical estimation of the mean and variance of experience/earnings profiles was derived from the census of population and housing conducted by the Australian Bureau of Statistics in respect of the night of 30 June, 1976. The observations cover Australian-born male, wage and salary earners, aged 15 to 64 years inclusive and working 30 or more hours a week for a single employer at the date of the census. Employees in the agricultural sector were excluded in order to approximate the notion of the 'standard distribution' outlined by Lydall (1979).

Observations were grouped in terms of ten five-year age-intervals and thirteen education categories. The latter,based on school leaving age and post-school qualifications, were subsequently ranked in terms of years of formal education N. An estimate of the workforce experience t for each age interval/education class was then derived as follows:

$$t = \begin{cases} (b_1 - c)/2 : & b_o \leq c \leq b_1 \\ [(b_1 - b_o)/2] - c : & b_1 > c \end{cases}$$

where b_o and b_1 represent the initial and final years of the relevant age interval respectively and c represents school-leaving age or imputed age at completion of post-school qualifications.

A-typical groups were excluded. These included 15-19 year-olds claiming post-school academic and technical qualifications, 20-24 year-olds claiming higher degrees and those claiming seven years or less schooling. This yielded the 123 observations which are summarised in Table 1.

TABLE 1 Workforce Experience by Age and Formal Education

Age left School	13	14	15	16	17	18	19	Trade	Techn.	NDT	BD	GD	HD
N	8	9	10	11	12	13	14	15	17	17.5	18	19	20

Age Interval	Experience (t)												
15 - 19	4	3	2	1.5	1	0.5	0	N/A	N/A	N/A	N/A	N/A	N/A
20 - 24	9	8	7	6	5	4	3	2	1	0.75	0.5	0	N/A
25 - 29	14	13	12	11	10	9	8	7	5	4.5	4	3	2
30 - 34	19	18	17	16	15	14	13	12	10	9.5	9	8	7
35 - 39	24	23	22	21	20	19	18	17	15	14.5	14	13	12
40 - 44	29	28	27	26	25	24	23	22	20	19.5	19	18	17
45 - 49	34	33	32	31	30	29	28	27	25	24.5	24	23	22
50 - 54	39	38	37	36	35	34	33	32	30	29.5	29	28	27
55 - 59	44	43	42	41	40	39	38	37	35	34.5	34	33	32
60 - 64	49	48	47	46	45	44	43	42	40	39.5	39	38	37

(The post-schooling qualifications are Apprenticeship (TRADE), Technician (TECHN), Diploma (NDT), Bachelor Degree (BD), Graduate Diploma (GD), Higher Degree (HD)).

TABLE 2 Annual Income by Interval

Income Interval	Imputed Annual Income (Y_i)
less than $1,500	$ 750
1,500-2,000	1,750
over 2,000-3,000	2,500
" 3,000-4,000	3,500
" 4,000-5,000	4,500
" 5,000-6,000	5,500
" 6,000-7,000	6,500
" 7,000-8,000	7,500
" 8,000-9,000	8,500
" 9,000-12,000	10,500
" 12,000-15,000	13,500
" 15,000-18,000	16,500
" 18,000	20,000

For each age/education/income class there is the frequency distribution of hours worked summarised in Table 3 (noting that intervals less than 30 hours per week are excluded):

TABLE 3 Hours Worked Per Week by Interval

Interval Hours Worked	Imputed Hours Worked (L_j)
30 - 34	32
35	35
36 - 39	37.5
40	40
41 - 48	44.5
49 or more	53.5

The mean and variance of the average hourly rate for each age/education class was estimated as follows:

Let n_{ij} represent the number of wage and salary earners in the i^{th} income interval and the j^{th} hours interval , (i= 1, ..., 13; j = 1,...,6) for a particular age/education class.

Let Y_i and h_j represent imputed annual income and hours worked in the i^{th} and j^{th} income and hours intervals respectively. The mean hourly rate for the age/education class in question is then defined:

$$w = 1/52 \sum_{i=1}^{13} \{Y_i (\sum_{j=1}^{6} n_{ij})^2 / (\sum_{j=1}^{6} n_{ij} h_j)\} / (\sum_{i=1}^{13} \sum_{j=1}^{6} n_{ij})$$

The variance of earnings in a particular age/education cell is estimated as follows:

$$\text{Var} = \sum_{i=1}^{13} \left\{ \left[\sum_{j=1}^{6} n_{ij} \right] \left[(Y_i \sum_{j=1}^{6} n_{ij}) / (52 \sum_{j=1}^{6} n_{ij} h_j) - w \right]^2 \right\} / \left\{ \sum_{i=1}^{13} \sum_{i=1}^{6} n_{ij} \right\}$$

The estimated mean and variance of earnings corresponding to the estimated values of experience in Table 1 are given in Tables 4 and 5 below:

TABLE 4 Mean Earnings (per hour) by Age and Education

Age Left School	13	14	15	16	17	18	19	Trade	Techn.	NDT	BD	GD	HD
N	8	9	10	11	12	13	14	15	17	17.5	18	19	20
Age Interval	Mean earnings w												
15 - 19	2.39	2.09	2.05	2.07	2.25	2.44	2.59	N/A	N/A	N/A	N/A	N/A	N/A
20 - 24	3.02	3.11	3.17	3.25	3.42	3.51	3.60	3.62	4.14	4.52	4.62	5.04	N/A
25 - 29	3.36	3.43	3.65	3.92	4.34	4.44	4.62	4.00	4.89	5.24	5.72	5.52	6.05
30 - 34	3.57	3.64	3.96	4.30	4.82	4.90	5.37	4.22	5.31	5.85	6.62	6.57	6.84
35 - 39	3.72	3.79	4.09	4.48	5.15	5.22	5.62	4.35	5.54	6.08	7.10	6.89	7.45
40 - 44	3.73	3.80	4.14	4.58	5.19	5.32	5.56	4.39	5.76	6.29	7.36	7.12	7.60
45 - 49	3.78	3.83	4.20	4.71	5.29	5.47	5.85	4.39	5.84	6.56	7.65	7.28	7.75
50 - 54	3.82	3.90	4.44	4.96	5.46	5.41	5.61	4.35	5.92	6.79	7.89	7.53	7.95
55 - 59	3.75	3.80	4.27	4.82	5.42	5.44	5.48	4.22	5.81	6.75	7.96	7.73	8.04
60 - 64	3.66	3.65	3.99	4.37	4.87	5.14	5.12	4.05	5.54	6.37	7.68	7.75	7.69

TABLE 5 The Variance of Earnings by Age and Education

Age Left School	13	14	15	16	17	18	19	Trade	Techn	NDT	BD	GD	HD
N	8	9	10	11	12	13	14	15	17	17.5	18	19	20
Age Interval	$ Variance												
15 - 19	.69	.60	.53	.46	.47	.45	.47	N/A	N/A	N/A	N/A	N/A	N/A
20 - 24	.54	.55	.55	.60	.74	.83	.89	.65	.87	.74	1.20	.40	N/A
25 - 29	.72	.70	.82	1.01	1.20	1.14	1.58	.81	1.09	1.20	1.48	.98	1.37
30 - 34	.97	.85	1.11	1.41	1.68	1.77	2.39	1.04	1.49	1.84	1.76	1.19	1.40
35 - 39	1.01	1.08	1.35	1.79	2.30	2.31	3.27	1.23	1.84	2.55	1.91	1.50	1.30
40 - 44	1.10	1.15	1.53	2.14	2.53	2.69	3.84	1.36	2.39	3.15	2.33	2.14	2.02
45 - 49	1.15	1.22	1.76	2.31	2.84	3.19	3.99	1.38	2.81	3.44	2.43	2.24	1.94
50 - 54	1.24	1.36	2.32	2.84	3.27	3.49	4.93	1.49	2.98	3.67	2.44	2.30	1.74
55 - 59	1.20	1.25	2.11	2.95	3.41	3.30	4.52	1.46	3.47	4.15	3.02	2.83	2.79
60 - 64	1.12	1.07	1.72	2.38	3.25	3.51	4.04	1.30	3.71	4.94	3.99	3.19	4.23

FOOTNOTES

1. Becker (1964, p. 46) points out," ... there is no conflict between interpretations of the shape of earnings profiles based on learning theory and those based on investment in human capital because the former is a special case of the latter". Likewise Mincer (1974, p. 132) suggests, "What is sometimes thought to be an alternative interpretation of the earnings profiles as 'learning curves' is not at all inconsistent with the human capital investment interpretation, provided it is agreed that learning in the labour market is not costless..., " Blaug (1976, p. 837) states, "..., any psychological theory of 'learning curves' in which appreciation is partly but only partly offset by depreciation and obsolescence will likewise account for concave age-earnings profiles."

2. Mincer (1958, p. 283) for instance, stresses, "The starting point of an economic analysis of personal income distribution must be an exploration of the implications of the theory of rational choice."

3. Sahota (1978, p.12) suggests "... among the developments in economic thought of the past two decades that satisfy the criteria of Johnsonian intellectual revolutions, or Kuhnian'paradigms' or Lakatosian 'scientific research programmes', human capital theory perhaps dwarfs all others."

4. Becker (1964, p. 66) for instance suggests, "The renewed interest in investment in human capital may provide the means of bringing the theory of personal income distribution back into economics "while Mincer (1976, p. 136) points out, "In stressing the role played by individual and family optimising decisions in human capital investments,

important aspects of income determination are brought back within the mainstream of economic theory and within the power of its analytical and econometric tools." Sahota (1978, p.11) emphasises, "The hallmark of this theory, which distinguishes it sharply from its old vintage as well as from the stochastic and ability theories and which is also the focus of its critics, is its postulate of optimizing behaviour on the part of individuals; investment in oneself is the result of rational optimizing decisions (by individuals or their parents) made on the basis of estimates of the probable present value of alternative life-cycle income streams, discounted at some appropriate rate."

5. Thus Rosen (1977, p.33) concludes that, "when all is said and done, however, a theory based entirely on unobservables is bound to have limitations." Welch (1975, p.63) states, "The most important point I can make in assessing contributions of human capital theory is that it is a tool for analysis and is neither a religion nor a shrine." Mincer (1974, p.76) admits that , "the life-cycle earnings profile partly reflects biopsychological development" and that "this development is systematic and largely independent of (exogenous to) the individual's will" and " to the extent that this development creates concave earnings profile, the investment interpretation must be modified." Thus Mincer (1976, p. 138) warns, "It is not a single rigid model, but rather a way of thinking capable of development in scope and complexity."

6. Lydall (1979, p.238) suggests "... the argument tends to be spoiled by the over-enthusiasm of its supporters". In other words the 'investment' models tend to overemphasise the influence of 'free choice'. This leads Bowles and Gintis (1975, p. 82) to suggest,

"This framework provides an elegant apology for almost any pattern of oppression or inequality , for it ultimately attributes social or personal ills either to the shortcomings of individuals or the technical requisites of production." Thus Haley (1976, p.1236) explains "apparently poor people are poor because of a comparative disadvantage in producing human capital." Rosen (1972), p. 338) suggests "..., the effect of a minimum wage is to put a ceiling on the range of learning opportunities to workers."

7. Blaug (1976, p. 839), for instance, points out, "... the nearer we approach the monopsony model of firm behaviour, the less likely the relevance of the worker self-investment approach to the question of training". Lydall (1979, p.3) emphasises, "the first step towards a satisfactory theory of income distribution - as of economics as a whole - is to drop the assumption of perfect competition."

8. Becker (p.52) states his position that, "If 'practice makes perfect' means that age-earnings profiles slope upward, then according to my approach it must be treated along with other kinds of learning as a way of investing in human capital."
Mincer (1976, p. 140) notes, "Another interpretation of the shape of the earnings profile is as a 'learning curve' or as a reflection of growth of abilities with age and experience known as 'learning by doing'. This view is not at all inconsistent with the human capital investment interpretation, provided it is agreed that opportunities for learning are not costless."

9. Mincer (1958, p.291) suggests, "Ultimately, it is the degree of conformity of empirical observations with the conclusions suggested by the model that establishes its usefulness."
Becker (1964, p.69) commenting on his earlier analysis stresses

that, "... the significance of that analysis can be determined most directly through an empirical examination of the relation between learning or productivity and human capital." Mincer (1974, p. 64) suggests, "The proper question is how well the investment model handles the data and whether alternative models can do better."

10. Becker (1964, p. 9) suggests, "Presumably, future productivity can be improved only at a cost, for otherwise, there would be unlimited demand for training."

11. Becker (1964, p. 12) explains, "Some people have asked why any general training is provided if firms do not collect any of the returns. The answer is simply that they have an incentive to do so whenever the demand price for training is at least as great as the supply price or the cost of providing the training."

12. Becker (1964, p. 29) notes, "A school can be defined as an institution specialising in the production of training, as distinct from a firm that offers training in conjunction with the production of goods." Accordingly Eckaus (1963, p. 501) observes, "The complete separability of training and production costs and the complete mobility of labour makes firms into nothing more than private schools for general training."

13. Mincer (1974, p. 64) explicitly states ,"I interpret productivity augmenting work experience as an investment phenomenon: the assumption of costless opportunities for augmenting productivity, which is sometimes implied in the notion 'learning by doing' cannot be descriptive of labour markets where labour mobility is the norm rather than the exception. At any rate the investment interpretation lends itself to empirical analysis."

14. As Blaug (1976, p. 837) points out: "it is difficult to see how individuals can choose more or less learning-by-doing, although no doubt business firms will want to minimise the number of inexperienced workers, everything else being the same."

15. Gintis (1976, p. 51) points out: "the endogeneity of the wage bill is a real and concrete contingency of profit maximisation". Weiss (1980, p. 527) suggests, "the wage offered by a firm affects not only the number of job applicants to the firm but also the expected labour endowment of workers hired by the firm."

16. As Rosen (1972, p. 334) suggests, "supplying learning-type jobs requires allocating the time of skilled workers toward (informal) instruction rather than toward marketable output, wasted output of 'students' due to mistakes necessarily incurred in the learning process, additional wear and tear on physical capital and machinery etc." As Blaug (1976, p. 837) points out, "Both learning -by-doing and doing-under-supervision are costly in terms of output foregone, but the former is unavoidable and is not subject to individual choice."

17. For a detailed derivation of these analytical results see Whiteman (1980).

18. See Whiteman (1980).

19. According to Becker (1964, p. 13) "... earnings of persons receiving on-the-job training would be net of investment costs and would correspond to the definition of net earnings ... which subtracts all investment costs from gross earnings." Mincer (1976, p. 188) likewise observes "given the importance of

opportunity costs in human capital investments, observed earnings more closely approximate the 'net' than the 'gross' concept."

20. The employees share might be equivalenced to the human capital return on general on-the-job training plus a premium to deter turnover. As Ross and Wachter (1973, p. 677) suggest: "for a long-term wage contract to have operational significance, it is necessary that the contract include a wage premium that will insulate the firm from short-run changes in the economy-wide demand for labour." In the present model the firm has an option on any increment to the wage rate attributable to post-school (informal) learning. Thus in proportional terms ϕ is equivalent to the 'wage markup' over the unskilled (inexperienced) wage in Hamermesh and Goldfarb (1970).

21. See Mincer (1970, pp. 6-8).

22. In general, the schooling-model here is taken as applying in respect of any formal course ofinstruction and thus covers apprenticeship training as well as primary, secondary and tertiary education.

23. For a detailed treatment of the notion of depreciation, see Clark , Kreps and Spengler (1978). There is,in fact,some doubts as to whether the concept ought to be applied to 'human capital'. Becker (1964, p. 140) notes "there is no systematic tendency for time series profiles to decline in the last age class even though cross-section ones do." There is thus a tendency to attribute the observed decline in cross-section age-income profiles to 'cohort effects' that is to secular-increases in income due to improvements in technology

and corresponding increases in physical capital per worker. Thus Mincer (1958, p. 291) observes that "abstraction from secular trends in income imparts a downward bias of life-paths of income."

24. This assumption applies only to individuals of working-age.

25. Mincer (1970, p. 17) admits, "the functional form of the investment profile ... must be fitted by experiment, since there is no theory to specify it." In the present paper it is our basic contention that the specification of the learning profile is explained wholly in terms of learning theory. The exponential decline model however, is adopted mainly for analytical convenience. It is thus possible that a more detailed knowledge of learning theory may yield a more appropriate specification.

26. This specification of the gross earnings function is very similar to that of Mincer (1974). The major difference is that our parameter ϕ has replaced Mincer's rate of return to post-school investments otherwise the parameters of both models coincide.

27. Thus Mincer (1974, p. 83) points out, "... there is less of an interaction, if any, between experience and schooling than between age and schooling: experience profiles of log earnings are much more nearly parallel than age profiles."

28. Mincer (1970, p. 10).

29. Mincer (1970, p. 15).

30. The final results of the 1976 Australian Census were processed on a sample basis and consequently are subject to sampling error.

31. Lydall (1979, p. 231) defines "... the standard distribution covers male adults working full-time and for the full period in all industries except farming; and the income measured is pre-tax money wages and salaries." In the present paper empirical analysis has therefore been confined to Australian born males aged between 15 and 65 years, fulfilling the requirements outlined by Lydall.

32. The non-linear regression results were obtained using the TSP (Time Series Processor) for Control Data CYBER or 6000 series machines.

33. Blaug (1976, p. 840) points out "the vast majority of calculated results have fallen with the range of 5-15 per cent." Rosen (1977, p. 30) reports estimates from 7 to 9 per cent and Mincer (1974) from 7 to 11 per cent.

34. Becker (1964, p. 189) points out that "a common peak is reached in the 45-54 age class,"; Houthakker (1959, p. 26) "in all education groups annual income rises with age until a maximum is reached in the 45-54 age groups." Tinbergen (1976, p.123) "experience is being paid a maximum at forty-seven to forty-nine years depending slightly on schooling."

35. Mincer (1974) for instance assumes rates of exponential decline of between 10 and 15 per cent per annum.

36. Mincer (1976, p. 147) reports the rate of return on post-school investment at about 12 per cent , and initial investment K_o is estimated at 40-50 per cent of gross earnings. Even Mincer finds this hard to believe pointing out "the K_o coefficient is disturbingly high. It may confound a maturation phenomenon ..., or is due to some other mis-specification."

37. There are some advantages in using grouped data. Rosen (1976, p. S54) for instance suggests that "functional form resolution is much better with aggregated data, and it is easy to see where the function goes off the mark."

38. Mincer (1974, p. 101) points out, "a positive correlation between means and variances of variables is a frequently encountered empirical phenomenon ....". Sahota (1978, p. 14) reports, "Both the variance and the mean of earnings increase with positively correlated experience and schooling, and there is a positive correlation between means and variances of the earnings distribution in age and schooling subgroups."

39. See Becker (1964, p. 69) and Mincer (1974, p. 64).

40. Becker (1964, p. 24) states, "firms are not too concerned about the turnover of employees with general training and have no incentive to offer them a premium above wages elsewhere because the cost of much training is borne entirely by employees".

41. Blaug (1976, p. 846) for instance points out, "The human-capital research program is silent on why there should be such a persistent bias in the preference of employers". Thurow (1976, p. 90) also notes, "with the exception of specific skills, interest in employee quality should not exist in a wage competition model, yet it does seem to exist."

42. The concept of equilibrium underlying the model is thus dynamic as compared to the static equilibrium of human capital theory. In the words of Lydall (1979, p. 5), "The equilibrrum will be the equilibrium of forces continually in motion, containing within itself the seeds of its own development and transformation. It will be what Marshall might have called a

biological equilibrium. A Hegelian or Marxist might call it a dialectical equilibrium."

43. See Whiteman (1980).

44. Taubman (1975, p. 14) light-heartedly suggests that only an employee who is completely conversant with the work of Mincer would,in fact,be able to cope with the information requirements implied by the human capital self-investment hypothesis.

45. Lydall (1979, p. 82) suggests "It is a known fact that people vary considerably both in the information available to them and in their reasoning ability. Something must therefore be specified about assumed levels of information and ability if the theory of utility-maximization is to produce definite results."

46. In other words the model becomes something akin to a job-search model where "the firm has monopsony power in a dynamic sense because of imperfect information and the cost of search," Mortensen (1970 , p. 168).

47. Becker (1964, p. 27) clearly states, "Firms would be more willing to pay for all kinds of training - assuming wages were set at an appropriate level - since a contract, in effect, converts all training into completely specific training." Furthermore "Monopsony combined with control of a product or an occupation ... converts training specific to that product or occupation into firm-specific training. These kinds of monopsony increase the importance of specific training and thus the incentive to invest in employees." Becker(1964, p. 29).

48. Becker (1964, p. 18) explicitly points out that "Protection would serve the same purpose as the creation of monopsonies domestically, namely to convert general into specific capital so that firms can be given an incentive to pay for training."

49. Taubman (1975, p. 150) points out "Mincer's formulation only applies to general on-the-job training.... No one has yet analysed the implications of firm specific training on earnings profiles although some arrangements must lead to rising profiles."

50. Thus Chiswick and Mincer (1972, p. S40) emphasise that "... investments specific to the firm (for example training and nonvested pension funds) also increase with schooling and age ...."

51. Eckaus (1963, p. 503) points out that "Becker's conclusions that workers bear the cost of 'general' on-the-job training and firms the cost of 'specific' on-the-job training have the appeal of concreteness. Yet these conclusions based on Becker's assumptions of perfect markets and the complete separation of production costs and training costs, must be abandoned as soon as these assumptions are dropped."

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3.	N.V. Lam	Journal of the Developing Economies vol. 17, No. 1, March 1979.
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