WPSO535

Shared Investment in General Training

The Role of Information

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Making it difficult for a (recruiting) firm to know how much a worker has been trained increases a (training) firm's incentive to offer workers general training. Both minimum wage legislation and training certification discourage on-the-job-training.

Katz and Ziderman take issue with the prediction — now standard — that firms will be unwilling to finance training in transferable skills, given the absence of property rights over these investments and the possibility of workers being recruited by nontraining firms. Gary Becker has argued that for such training to take place, workers must themselves bear the burden of financing: without freely working capital markets, market failure results in too little training being demanded and provided.

Extending an approach presented in PRE Working Paper 170, Katz and Ziderman argue that potential recruiting firms possess only limited information about the type and level of general training that workers will have received in other firms. The informational asymmetry between a training and a recruiting firm reduces the net benefits a worker can obtain by moving to another (recruiting) firm — which increases the (training) firm's incentive to finance general training.

The cost to the recruiting firm of discovering a trained worker's potential productivity is high.

Katz and Ziderman discuss the role of the options value of general training in raising information asymmetry. They show Becker's training model to be a special case of zero asymmetrical information — rather than a general model of training finance.

This finding has important policy implications. Asymmetrical information counters the deleterious effects on general training of such market imperfections as minimum wage legislation (which makes it difficult for a training firm to recover training costs) and a restricted capital market.

Katz and Ziderman suggest that training certification — by facilitating interfirm mobility — discourages on-the-job training. Certification, by awarding workers property rights over their general training, limits company-financed training and places a heavier financing burden on workers. Certification makes the workers' training visible — but decreases asymmetric information between firms.

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1. INTRODUCTION

Following the seminal work of Becker (1964), it is widely accepted in the literature that firms will be unwilling to finance training which workers may use in other firms. This paper takes issue with this prediction and suggests that firms will frequently share in the cost of such general training.[1/]

Becker argues that a firm which pays for the training of workers in skills of potential use to other firms will lose these workers: since other firms bear none of the costs of general training, they can attract a worker with such training by outbidding the firm which trained him. Recognizing this absence of property rights over an investment in general training, firms will refuse to provide it. Hence, if general training is to take place, the trainee will have to pay for it. If potential trainees are unwilling or unable to pay, general training will not take place. A shortage in general training is likely to emerge; this may be especially pronounced in developing countries.[2/] In contrast, the outlook for specific training (training that is of value only in the firm providing it) is less pessimistic, since firms are willing to finance such training. Indeed, it is likely that specific training will be a shared investment between worker and employer. There is a broad literature on various aspects of sharing specific training investments.[3/] Yet apart from an early insight by Eckaus (1963), the possibility of shared worker-employer investments in general training has received but scant attention in the literature.[4/]

Implicit in Becker's result is the view that a poached worker can immediately and painlessly start working, and yield full value, in a job commensurate with his training. Obviously, this approach implies negligible transactions costs. In particular, Becker's theory seems to suggest that a

potential recruiting firm has full information regarding training carried out by other firms. No costs related to the absence of information are admitted.

The major premise of this paper is that potential recruiters do not possess much information on the extent and type of workers' on-the-job training. Workers taken for trained might turn out to possess no, or very little, general training. Also, a worker recruited for a given job may possess the wrong type of general training. All this imposes substantial information-based costs on firms that recruit rather than train. These costs include opportunity costs, actual expenses and increased exposure to risk. As a result, a recruiting firm will place a lower value on a recruited worker with general training than the firm that trained him. The wages paid to such a worker will reflect this lower value.

The informational asymmetry between a training and a recruiting firm therefore reduces the net benefits that a worker with general training can obtain by moving to another firm. We shall argue that this implies that a firm may find it feasible to finance part, or all, of a worker's general training. Indeed, under certain circumstances, only firms will be prepared to invest in general training: informational asymmetry considerations may reverse the predictions of Becker's model.

Section 2 considers the value of a worker with general training to the firm that trained him. The information about the value of such a worker that a recruiting firm is likely to possess is then examined. The cost implications of informational asymmetry between a training and a recruiting firm are discussed in Section 3. Section 4 brings together the main strands of the argument to show that firms may finance part or all of its workers' general training. Extensions and some welfare and policy implications are offered in Section 5.

2. THE VALUE AND INFORMATIONAL ASYMMETRY
OF GENERAL TRAINING

Traditionally, the benefits of an investment are measured by the net present value of the income that the investment is expected to generate in its intended use. Recently, it has become recognized that the benefits of an investment include the options it provides in the face of random shocks and changes. Hence, the value, V, of an investment in general training is made up of two components: Z, the net present value of the training for the intended employment; and OV, the less familiar options value of the training. A brief description of OV follows; a simple example illustrating the principles behind valuing an option is given in Appendix 1.

The option value of general training may have several components.[5/] For example, if the need arises, a worker's general training may be used as a basis for advanced training. Also, training for one job imparts related skills that enable the firm to employ the worker at other tasks. Perhaps most important, a given general training can enhance a worker's ability to deal with certain types of new technologies.[6/]

Thus, workers with general training provide their training firm with the ability to respond efficiently and swiftly to various potential shocks and changes. Shifts in tastes, changes in technology, the sudden departure or absence of key workers are but a few typical shocks which general training options might accommodate. The value of these options is likely to be considerable. Indeed, one simulated result has generated option values (for capital investment) that exceed 100 percent of the cost of the investment (see Majd and Pindyck, 1987.)[7/]

In the following section, we suggest that the value of a worker to a firm is an increasing function of the information it has about the worker's general training. A worker with general traini achieves his full value only

in a firm that possesses full training information about him. Hence, in order to determine the value of a worker with general training to different firms, it is necessary to consider the information available to such firms. Specifically, the difference between the information about a worker's training that is available to a training firm and to potential recruiting firms plays a crucial role in our results.[8/]

The above emphasis on the distinction between Z and OV can now be seen in terms of the main aim of this paper. The difficulty of discerning a worker's Z will differ from the difficulty of determining his OV. The loss of value due to absence of information will, therefore, vary with the relative weights of Z and OV in a worker's general training.

General training is typically provided on-the-job: it is heterogeneous, informal, and frequently tailored for individual workers. This non-standardization implies that, even for Z, certification of training is unlikely. Nonetheless, a non-training firm may, though at significant costs, obtain information regarding a worker's Z. With time and careful observation this information will unfold.

However, general training will also contain many nuances and options, of which even trainees may not be fully aware. Another firm will find it extremely difficult to determine the full extent of this, more subtle, component of general training. The option value of a worker's training can, at best, be partially discovered. Since the primary aim of poaching a worker is to employ him at his intended tasks, his general training options will not, in general, be observed. Indeed, a firm which is unsure about some aspects of a worker's training may be loath to call upon him to carry out certain tasks. His skills at such tasks may, therefore, never be revealed. Also, even if a firm does wish to discover a worker's training options, it may be forced (by

the observation time required, for example), to limit itself to a small subset of the (possible) options imbedded in his training.

Informational asymmetry, then, is particularly pronounced and intractable for the option values of training. Hence, the informational asymmetry between the training firm and other firms will tend to be an increasing function of the options component in general training. Even if the options component is small, however, there will still be a major information gap between the firm that provides the training and other firms.

3. THE VALUE OF A RECRUITED WORKER

This section examines the information-based costs incurred by a recruiting firm. Given these costs, the net present value of a generally trained worker to a recruiting firm, V_N, is smaller than his value, V_T, to his training firm. Let i denote the number of periods since a worker has been recruited. Define V^i_T and V^i_N as the value in period i a worker with general training, to the training and recruiting firms, respectively. In the event of full discovery over time, Z^i_N would increase with i. Nonetheless, given the intractability of discovering full information about OV_N, V^i_N will fall short of V^i_T, no matter how large i becomes.

The matrix in Table 1 illustrates the loss in a worker's value due to the information asymmetry, for the simple case of one type of non-option general training and one type of job requiring training. The value of a worker to the recruiting firm in a time unit during the discovery period,[9] depends on the job in which he is placed (requiring or not requiring training), and on whether or not the worker has received general training.[10] In Table 1, K will be the largest payoff and Q the smallest. Q might well be negative: placing an untrained worker in a position requiring training may be directly wasteful and destructive. Also, if the values of workers are

interdependent, as in a production line, an untrained worker can impose
negative externalities on other workers, potentially causing substantial
losses.

TABLE 1: Z VALUE OF WORKER

JOB

	Requires Training	Does Not Require Training
Trained	K	R
Untrained	Q	S

WORKER

If the recruiting firm has no prior knowledge of the probability
that a recruit has been suitably trained, it is likely to adopt a maximin
strategy. Since Q is smaller than both R and S, this implies that the firm
will employ all recruited workers at jobs that do not require training. The
value Z^i_N of a worker with general training is $(R-M-A)_i$, where M is the cost
of monitoring the worker and A is the cost of the risk-averse firm's exposure
to risk. In this two-way case, the recruiting firm will know after only one
period whether the worker is trained as it observes outcome R or outcome S.
It can then place the worker in an appropriate position. However, it seems
very possible that S and R are equal so that information can only be obtained
by employing the worker on a job requiring training; given the possibility of
Q, this may be an unacceptable risk to the firm. Hence, information might
never surface and recruiting will be effectively blocked.

For several reasons, however, the discovery process will be
considerably longer and more complex. A firm is likely to need workers with
different types of general training. The information value of trying a worker
out in a given job, and finding him untrained for that job, may be very low.
Consider, for example, a firm with one job that requires no training and 1

jobs all requiring different types of general training. Then, if a worker is not successful at job 1, say, he might be untrained, or trained in one of the l-1 other jobs. Hence, even if the recruiting firm is, in principle, prepared to take the risk of employing an unknown worker in a job requiring training, the probability of failure to discover much information is likely to cause it to desist.[11]

Many jobs involve complex tasks, the fulfillment of which is difficult to measure, and a worker's Z^i might not be directly observable. Also, many jobs are carried out by teams rather than individuals, and the contribution made by a given worker is hard to discern. Furthermore, even if a worker performs a complete job by himself, his product will depend on the effort and training of other workers and inputs, about whom there may also be an absence of information. These considerations make it likely that a worker will have to be observed for several periods to determine his Z. Alternatively, discovery may take only one period, but this period will be long.[12]

The values in Table 1 are free of random components. This assumption makes discovery appear to be easier than is the case. In reality, the value of a worker at a given job in any one period is a random variable. This value is, in general, a drawing from a distribution whose parameters are a function of the worker's training and of the job requirements. The randomness of values renders the recruiting firm's search for information concerning a worker's general training more difficult, since it implies that the firm must extract information about a worker's training by sampling. The discovery process will be lengthy and costly, further reducing the Z_N of a recruited, trained worker.[13]

In addition, the randomness of the individual's Z^i is more likely to act as a total barrier on recruiting trained workers. Recall that to block

recruiting in the deterministic case, the values of trained and untrained workers in tasks not requiring training, had to be equal. In the random case, recruiting may be blocked even if these values are not identical. When E(R) and E(S) are not too far apart, a recruiting firm gains little information from each period of employing an unknown worker in an untrained capacity. To be effective, the sampling period may need to extend over years. But, the longer the required discovery period, the greater will be the loss incurred by a trained worker. Workers may, therefore, refuse jobs which do not require their training. To expedite the process of obtaining information about workers, the firm can try out the worker in a job that requires training. As suggested above, however, an untrained worker may have a negative (expected) value in such a job. Hence, if the potential damage is large, and the firm is not convinced that he is appropriately trained, the firm may refuse to employ an unknown worker in a job requiring training.

In sum, the firm might not offer an unknown worker a job requiring training, and the worker, in turn, may reject jobs which do require training. This blocks the inter-firm movement of workers with general training. It therefore ensures firms will be prepared to finance some, or all, of a worker's general training.

Thus far it has been assumed that a potential recruiter is ignorant of the probability that a worker from a training firm has the appropriate general training. The recruiter may, however, have some idea about the proportion of such workers in the training firm's workforce. When this probability, p, equals unity, there is no asymmetric information regarding Z (though uncertainty regarding OV remains). Of course, this is unlikely, especially given the need to identify not just a worker with general training, but the particular general training that a trained workers possesses.

Since knowledge of p constitutes information, such knowledge may reduce the informational asymmetry and its consequential costs. If p is large and known outside the training firm, both the cost of each stage in the discovery process and the expected length of this process may be significantly reduced. If, however, p is small, knowledge of p outside the firm will be of little value to potential recruiters. Hence, if information on a firm's training program (but not information on individual trainees) is likely to be available to other firms, general training may be constrained. The proportions of workers trained in particular forms of Z-enhancing training, might have to be sub-optimal, in order to protect the firm's investment in training. Given that most firms are likely to require workers with various types of general training, however, such sub-optimality is unlikely to be needed.

Even if the recruiting firm does eventually discover a worker's Z^i, it will not know his options value. Observation of the worker in a given task may be an effective, though slow and expensive, means of determining a worker's general training for intended employment. The options component of training is unlikely to be revealed in this way. The options implicit in a worker's training cannot be determined by observing the worker in his intended job. Furthermore, a job rotation strategy means that a worker would be doing jobs for which he is not currently needed. Also, the discovery process for each option will be similar in nature and in length to the process of determining a worker's Z. Information on a worker's OV will remain broadly unknown to a recruiting firm. Over and above losses in Z^i, a worker moving to another firm effectively loses all of his OV.

4. PAYING FOR GENERAL TRAINING

The above discussion shows that asymmetry in information will cause the value of a trained worker with general training to be highest in his training firm. On moving to other firms, a worker's value declines by L, where $L = V_T - V_N$. This section examines the relation between the symmetry of training information, the workers' loss of value, and the financing of general training.

Let T be the cost of a worker's general training.[14] Then, if $T > L = V_T - V_N > 0$, a training firm will be willing to pay up to $V_T + L - T$ towards a worker's general traini... The worker will therefore have to contribute no less to than T-L for the training. If the worker were to move to another firm he would gain $V_T - L$ in income but forfeit his training investment, T-L. Hence, in a competitive setting, where $V_T = T$, the worker's net gain from moving is zero. The firm's share in the cost of training would be no more than L/V_T and poaching would not take place.

The worker must be able to contribute V-L for his general training for the general training to take place. Even if he is able to contribute more than V-L, however, he will not do so. On the presumption that the training firm will only pay him his transfer price, his return to investing in general training will not exceed V-L. Hence, the minimal proportion of the cost of general training that a worker will expect his employer to finance is L/V_T. If $V_T - L > 0$, therefore, the ratio $(V_T - L)/L$ constitutes the only feasible sharing scheme between worker and employer.

If L is no less than V_T, the worker's move to another firm is blocked. In this case, the asymmetry of training information reduces the value of a worker's general training in potential recruiting firms, to zero. His wage is, therefore, no higher than that of an untrained worker. The

implication is that the training firm will be prepared to pay for the full cost of the worker's general training and capture the full return on the training investment. While this is an extreme situation, it is indicative of the efficacy of asymmetric information in reducing poaching and resurrecting property rights in general training investments.

The foregoing analysis is captured in diagrammatic form in Figure 1. Informational asymmetry, Y, (standardized to the [0,1] interval), is depicted on the horizontal axis. V_T and V_N are measured along the vertical axis. The functions plotted in Figure 1 relate to increments in value over that of untrained workers. V_T, representing both the costs and the benefits of training to the training firm, is invariant with respect to the informational asymmetry. $V_N(Y)$, which depicts the relation between Y and the value of a recruited trained worker, shows a steep decline for low values of informational asymmetry (reflecting the almost inevitable loss of option values). As Y increases, V_N declines more gradually, reaching its lowest level when Y=1.[15/]

The firm will be prepared to invest up to L, the vertical distance between V_T and V_N, in the general training of a worker. For example, at Y*, the training firm is prepared to participate in a worker's general training by AB, requiring that the worker pays AY*. An increase in the symmetry of training information between training firms and other firms will raise the required share of the worker in the training investment. If this information is fully and freely available to other firms (as Y and L tend to zero), the worker will have to finance all his training (OC). This is equivalent to the case described by Becker, which is seen to coincide with the special case of perfectly symmetric information. Finally, if Y>Y**, the value of a trained worker in a recruiting firm will not exceed the value of an untrained worker.

The worker will not invest in any general training, whilst the training firm will be prepared to finance it fully.

In sum, for $0<Y<Y**$, training investment is shared by the worker and the firm. The worker's contribution towards this training for a given Y, is given by the distance between the horizontal axis and the V_N curve. For $Y>Y**$, general training is totally firm-financed. The special case of Becker, with a worker required to fully finance the program of general training, occurs at $Y=0$.

5. WELFARE AND POLICY IMPLICATIONS

In this section applications of the model to liquidity constraints, to minimum wages legislation and to certification are discussed.

Liquidity Constraints

An important and much quoted implication of Becker's model is that potentially profitable general training investments might not take place. Because of their inability to prevent workers from transferring to other firms, firms will not be prepared to finance general training. Workers, however, may not possess sufficient funds nor be able, reasonably, to obtain funds from intermediates to finance their training investment. Hence, general training may not take place. Also, if the general training program is divisible, a worker may be able to finance and purchase a part of it. In either case, non-investment or under-investment in general training is predicted.

The information-based costs imposed on a recruiting firm may mitigate or resolve this potential problem. This is illustrated in Figure 2. The worker's liquidity constraint (AL) is parallel to the horizontal axis,

intersecting with the V_N curve where informational asymmetry is Y*. In the case of symmetric information, the worker is able to finance only OA of his potential training investment OC: no training will take place if the training program is indivisible. Informational considerations alter this result. As before, no training will take place if Y<Y*. However, for Y*≤Y, the worker's liquidity exceeds the V_N curve. For this range, the worker (while still unable to pay the full cost, OC, of general training) can finance his required share of training, V_T-L, without encountering a liquidity constraint. Asymmetric information thus enables workers to participate in financing their general training, despite a shortage of capital or liquidity.

Minimum Wages

An additional source of a shortfall in general training may be the institution of legal minimum wages. If set above a certain level, minimum wages will prevent the worker's wage from falling low enough during traini⌐ to enable the firm to recover its training costs during the training period (Leighton and Mincer 1979); the result will be an insufficient supply of general training skills available to the economy.

The presence of asymmetric information may mitigate this effect. Consider Figure 3, in which information asymmetry, Y, is again represented on the horizontal axis and various financial quantities, relating to the training period, are plotted on the vertical axis. W_0 is the trainee worker's opportunity wage during his training period and AB represents the cost of his training. The curve BD (which is the obverse of V_N in Figures 1 and 2), traces out the wage received by the worker during training, for increasing levels of Y. The vertical distance between BD and AW_0 measures the (diminishing) required amount of worker finance, for increasing levels of Y.

The Becker (symmetric information) case is located on the vertical axis. For the case drawn, the firm cannot both recover its training costs AB during the training period while paying a wage greater than OB. With a minimum wage set at W_{min}, say, no general training will take place. The full cost of training (AB) must be borne by the worker; the imposition of a minimum wage (W_{min}) at a level greater than OB, has brought about a legal obstruction to general training.

Upon introducing asymmetric information, it is clear that, assuming the training program is indivisible, the minimum wage prevents general training investment from taking place only for $Y < Y*$. Where $Y > Y*$, the firm will be prepared to finance an amount of the general training such that the worker can pay the rest via a lower wage, without contravening the minimum wage laws.

Certification

Finally, we consider the implications that our model holds for educational certification. It is widely believed that an extended and more comprehensive system of educational and training certification is to be welcomed, in that it leads to freer mobility of workers and an improved, more effective, use of human capital resources. Such considerations underscore the national systems of compatible qualifications such as those currently being developed in Britain, and the well-established system of certification which is in place in West Germany. Yet, the arguments presented in this paper suggest that certification may lead to less rather than more general training, an effect that policy makers might wish to set against the better known advantages of certification. The case of West Germany may appear to constitute an anomaly here. Certification via in-service training is well-established, yet enterprise-financed training is prevalent. But,

institutional constraints on inter-firm poaching of trained workers are noteworthy in West Germany (Dougherty and Tan, 1990). The Chambers of Commerce, which exert considerable influence over member firms, strongly and effectively discourage competition for trained workers (Soskice, forthcoming), thus facilitating enterprise investment in on-the-job training.

We have noted that asymmetry in training information between training and recruiting firms may lead to tensions between the interests of firms and their trainees. The trainee prefers training that is visible and which generally identifies him outside the firm as a trained worker. He will wish to enrol in training that is capable of yielding these signals, which are well achieved by certificates of attainment. The firm, on the other hand, will wish to minimize the amount of information generated about worker's training: this it may do by avoiding training that is highly visible and which may lead to formal certification on completion.[16]/

By reducing the extent of asymmetric information concerning workers' training, widespread certification will result in diminished scope for firms to share in the financing of the general training of their workers. Certification, by awarding workers property rights over their general training, limits company financed training, and places a heavier financing burden on workers.

Endnotes

1. This paper builds on an early presentation of our ideas given in Katz and Ziderman (1989).

2. Poverty, low liquidity and badly functioning capital markets militate against the possibility of significant worker-financed general training. Becker's result, therefore, implies a dismal outlook for general training in developing countries.

3. See Parsons 1972, Donaldson and Eaton 1976, Hashimoto 1980, Hashimoto and Yu 1981.

4. Notable exception are a series of papers on firm-sponsored education (Glick and Feuer, 1984; and Feuer, Glick and Desai, 1985) and the model of Bishop and Kang (1984). Unlike our approach, which relates to general training alone, these are mixed training models, which show that firm-financed general training may take place in the presence of specific training.

5. See Weisbrod (1962), for a discussion of some of the option components in the return to education.

6. In order to tap these options, firms will, in general, have to make a further, minor investment in training (akin to the exercise price of a financial option). This further required investment will, however, be relatively low and the options will materialize quickly.

7. One particular feature of an option is that its value is an increasing function of the randomness underlying its use. In view of the large amount of randomness that firms in developing countries typically face, the option components of V in developing countries will be particularly high.

8. Of course, this information gap is unlikely to have much significance if the worker's new employer can quickly and cheaply determine a worker's Z and OV. In this case the recruiting firm incurs negligible information-based costs and therefore puts the same effective value on a worker as the firm that trained him. Under these unlikely circumstances, Becker's result would hold.

9. Clearly, it is only the discovery period that matters. After this period, when the recruiting firm knows the worker's product, the recruiting firm and the training firm have the same information about Z (though still not about the worker's option values).

10. As mentioned in Note 6, a further investment is usually needed to activate training options. Thus, no option values will be revealed in Table 1.

11. For each type of general training, there is likely to be a corresponding, but different, specific training required. Thus, trying out a worker in one of the $\underline{1}$-1 other jobs will entail additional investments in specific training, again adding to the costs of discovery.

12. In a private communication (4 Dec. 1989), Jacob Mincer points out that a trained worker has an incentive to convey information about his training to the recruiting firm, which could be verified after a relatively short period. The central question, however, is whether the trained worker would be believed, given that untrained workers may attempt to obtain a free ride by posing as trained.

13. A discussion of the technical aspects of such sampling, accompanied by some numerical examples, is given in Appendix 2.

14. It is assumed here that neither T nor V are affected by the number of workers trained.

15. For the purposes of this illustration it is assumed that as the informational asymmetry increases, Z_N tends to zero.

16. This line of reasoning suggests firms would also try to reduce training visibility by refraining from writing references for employees wishing to move to another firm. Indeed, a recent survey has shown that 40 percent of companies surveyed in the US have a formal, _written_ policy not to provide outside references--a finding in conformity with the predictions of our model (NACPR, 1989). Fear of lawsuits from disgruntled former employees who are turned down for a new job may also help to explain employers' reticence in this matter.

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Appendix 1:   Measuring the Option Value of Training

Consider a general training costing A. The main aim of this training is to enable a worker to produce a unit of good x, which is the good that the training firm is currently producing. The profitability of a unit of x produced by a trained worker is a constant equal to P_x. Furthermore, depending on the way the training is provided, it can indirectly endow the worker with skills in the production of one of two other goods, y or z, without additional costs. It is not profitable at this time to produce y or z.

The choice as to whether the indirect component of training should provide workers with skills in producing good y or good z must be made under uncertainty, since neither the profitability of y nor the profitability of z are known at this time. However, the profitabilities of a unit of y or z (P_y and P_z respectively) will be revealed sometime after the training has taken place.

P_y is a random variable and it is the firm's view that $prob(P_y = P_y^1)$ = 1-a and $prob(P_y = P_y^2)$ = a. Similarly, P_z is a random variable and the firm's view is that $prob(P_z = P_z^1)$ = 1-b and $prob(P_z = P_z^2)$ = b. Furthermore,

$$P_y^1 < P_x < P_y^2$$
and
$$P_z^1 < P_x < P_z^2$$

Hence, the training firm will determine the indirect (or incidental) aspect of the training as providing a worker skills in producing y or z according as aP_y is greater or smaller than bP_z. The option value, OV, in this case therefore is equal to $MAX(aP_y^2, bP_z^2.)$

Clearly, this is a highly simplistic example. Nonetheless, one important feature of options which immediately stands out is that a

mean-preserving increase in spread <u>raises</u> the value of the options. Thus if P_y^1 and P_y^2 are replaced by $P_y^1 - c$ and $P_y^2 + c$, where c is a positive constant, the value of giving a worker option Y rises. Over and above the damage he might cause, it will often be the case that once a worker has been employed as a trained worker, demoting him to a job not requiring training (a "non-training job") will encounter strong reistance from unions and other agencies. Such resistance can be very costly to the firm, and playing it safe, the firm will initially employ the worker in a position not requiring training.

Appendix 2: Random Payoff Matrix: A Numerical Example

In this appendix, we examine a payoff matrix in which the outputs of both trained and untrained workers are random.

It is known to the firm that a trained worker's output in a given job is e_1 with probability P_T and e_2 with probability $1 - P_T$. Similarly, an untrained worker's output in the same job is e_1 with probability P_N and e_2 with probability $1 - P_N$. e_1 and e_2 might be interpreted as success or failure at a given job, so that $e_1 = 1$, $e_2 = 0$. In all events, $e_1 > e_2$. Furthermore, the trained worker performs better than the untrained worker at all jobs so that $P_T > P_N$. The payoff matrix for this situation is:

Worker	Job Probability of e_1, i.e., Probability of Success	Probability of e_2, i.e., Probability of Failure
Trained Worker	P^T	$1 - P^T$
Untrained Worker	P_N	$1 - P_N$

Payoff Matrix Al:

The firm decides that, based on the hypothesis that an observed worker is untrained, it will accept him as trained if the error of so doing is a. Similarly, based on the hypothesis that the worker is trained, it will reject

that hypothesis if the error of doing so is b.   In general, given the asymmetry of costs between assuming a worker is not trained and assuming he is trained, the firm will cautiously choose a and b such that $b > a$.

To determine the expected number of observations of a worker necessary before his status is decided within the acceptable error limits, a Sequential Probability Ratio Test must be performed.

For any one observation, the distribution of the outcome follows a Bernoulli distribution: Let $x = 0$ if e_2 occurs and let $x = 1$ if e_1 occurs. Then the outcome in any one period of observation has a density function

$$f_T(x) = P_T^x (1-P_T)^{1-x}, \qquad\qquad x = 0, 1$$

for a trained worker, and

$$f_N(x) = P_N^x (1-P_N)^{1-x}, \qquad\qquad x = 0, 1$$

for an untrained worker.

Defining Z as $f_T(x)/f_N(x)$ we obtain,

$$Z = \left(\frac{P_T}{P_N} \right)^x \left(\frac{1-P_T}{1-P_N} \right)^{1-x}$$

so that $\ln Z = x\ln(P_T/P_N) + (1-x)\ln((1-P_T)/(1-P_N))$

$\ln Z = \ln(P_T/P_N)$ when $x = 1$ and

$\ln Z = \ln(1-P_T)/(1-P_N)$ when $x = 0$.

Using Wald's Approximation (see DeGroot 1970) the expected number of observations required to reject the null hypothesis of no training, against the alternative hypothesis of the worker being trained, is given by

$$E(N_N \mid \text{no training}) \approx \frac{(a\ln[1/(1-b)] + (1-a)\ln[(1-a)/b] =}{E(\ln(Z) \mid \text{ no training}} \quad \frac{2.910}{E(\ln Z \mid \text{no training})}$$

whereas the number of observations it would take to reject the hypothesis that

Appendix Table

	N_N		N_T		Min (N_N, N_T)	
	Expected number of observations required to reject the hypothesis that the worker is untrained		Expected number of observations required to reject the hypothesis that the worker is trained			
	a = 0.01 b = 0.05	a = 0.01 b = 0.10	a = 0.01 b = 0.05	a = 0.01 b = 0.10	a = 0.01 b = 0.05	a = 0.01 b = 0.10
A $P_N = 0.98$ $P_T = 0.99$	932	713	1067	976	932	713
B $P_N = 0.90$ $P_T = 0.99$	41	31	29	26	29	26
C $P_N = 0.50$ $P_T = 0.90$	8	6	8	7	8	6
D $P_N = 0.25$ $P_T = 0.90$	3	2	4	3	3	2

the worker is not trained when he, is given by

$$E(NT_N| \text{ training}) \approx \frac{(b\underline{\ln}[\underline{1}/(1-a)] + (1-b)\underline{\ln}[(1-b)/a]}{E(\underline{\ln}(Z)| \text{ training}} = \frac{2.910}{E(\underline{\ln}Z| \text{ training})}$$

The appendix table presents the number of observations of a worker, required for different values of P_T and P_N, using the typical a = 0.01, and b = 0.05 or b = 0.10. N_N and N_T are, respectively, the number of observations expected if the worker is trained or untrained.

The decision by the firm as to how to view a worker is made when either a or b reach a value smaller or equal to those decided upon by the firm. If the appropriate value of a is reached, the worker is accepted as trained. If the appropriate value of b is reached, the assumption that the worker is trained is rejected and he is treated as untrained.

Clearly, cases A and B in the table correspond to workers being employed in jobs which do not require training: In these cases the difference between a trained worker's output and an untrained workers output is small. Given the small difference between the two types of workers in this type of job, it is clear that they would have to be observed for a very long time before being assigned a classification.

In contrast, cases C and D are likely to relate to tasks which require training, this being seen from the large difference between the output of the trained and untrained workers. Given this difference, the workers can be distinguished with a small number of observations, though, of course, the costs of mismatching by putting an untrained worker into this job is very costly.
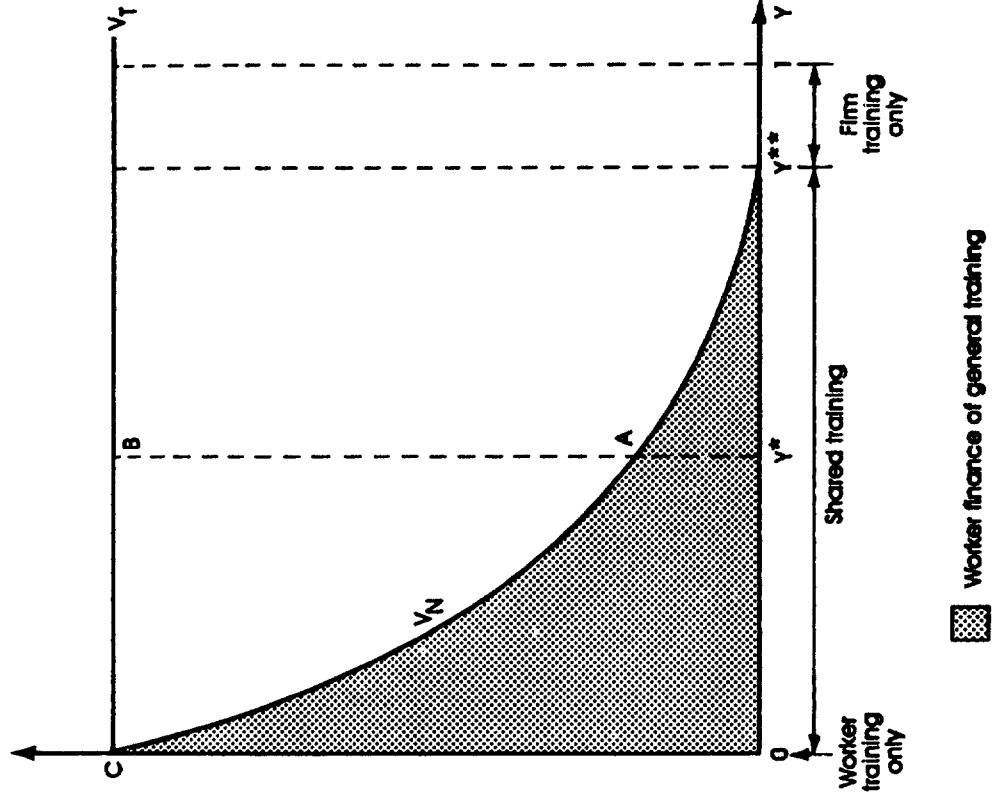
Figure 1

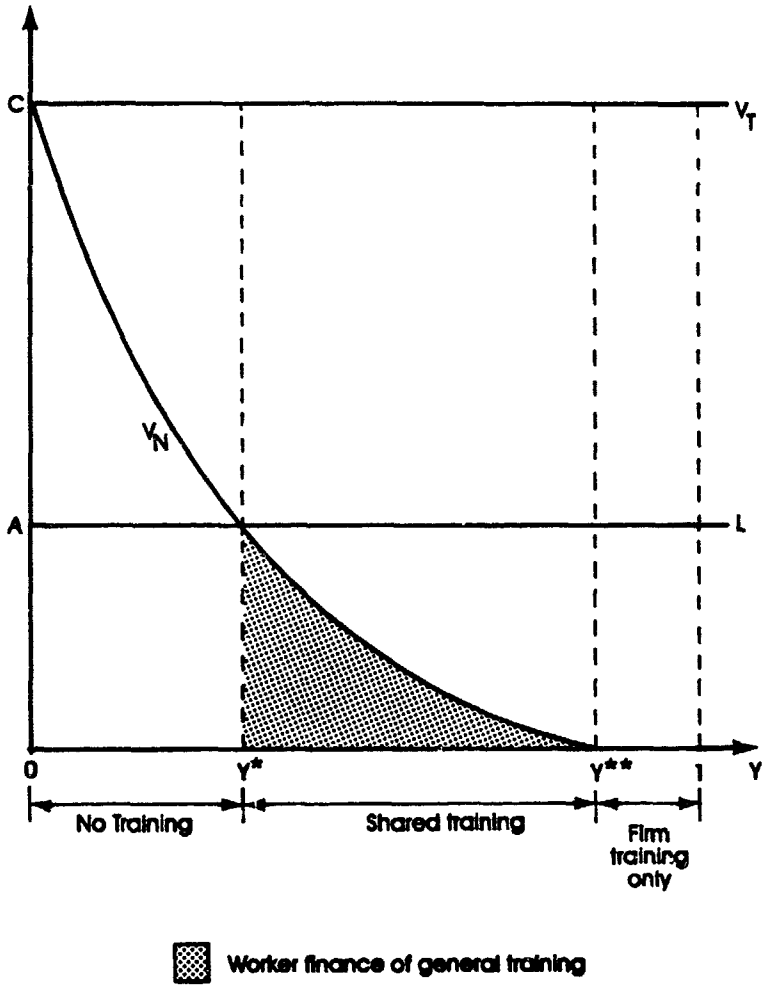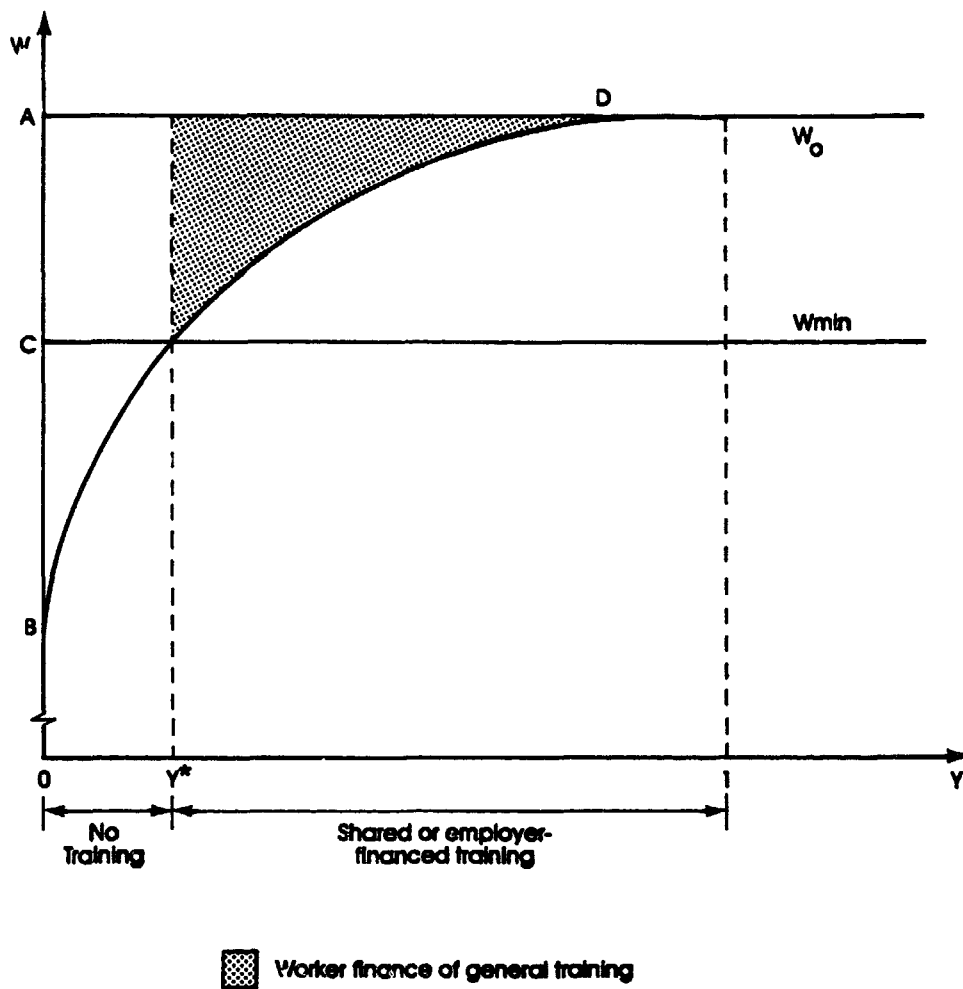Worker finance of general training

Figure 2

Figure 2

(chart labels)

C — V_T

V_N

A — L

0 — Y* — Y** — 1 — Y

No Training   Shared training   Firm training only

Worker finance of general training

Figure 3

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