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FIRM PROVISION OF GENERAL TRAINING AND SPECIFIC HUMAN CAPITAL ACQUISITION

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Firm Provision of General Training and Specific Human Capital Acquisition

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Abstract

The existing literature on training is concerned with understanding the reasons why firms pay for the general skills of their workers, but without explaining which firms train which workers. This paper develops a theory that both explains the willingness of firms to pay for general training, and accounts for the pattern of training provision empirically observed. It is assumed that labor markets are perfectly competitive, but there is imperfect contractibility of human capital. Under these assumptions, when training and specific human capital are complements, the firm would pay for the former in order to induce the acquisition of complementary specific skills by the worker.

JEL Classification: J24, J31, J41

Keywords: training, human capital, incomplete contracts

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"Employer-sponsored training in the US is a multibillion-dollar industry. It is so huge that it has come to be known as the country's 'shadow educational system'."

"Industry Report 1995: A Statistical Picture of Employee Training in America," *Training Magazine* (Vol. 32, No 10, p 37).

1 Introduction

Why do firms pay for the general training of their workers? It is well known from the seminal work of Becker (1964) that firms have no incentive to provide general training for their workers in perfectly competitive labor markets. This is because the worker receives a wage equal to his productivity, and hence, is the sole beneficiary of any increase in such productivity.

It has been recently noted by Acemoglu and Pischke (1999a and 1999b) that any reason for firms to train workers should be based on a departure from a perfectly competitive model of the labor market.[1] In particular, it should rely on a labor market that displays a compressed wage structure. By this they mean that productivity increases more than wages do after the provision of general training. In this case, firms train because by doing so they increase productivity, and given the compressed wage structure of wages they are able to capture part of that increase (it does not all go to the worker in the form of increased wages). This, in turn, enables them to finance the training. Consequently, they argue, we need to depart from competitive theories of the labor market (where the worker receives his marginal product) if we want to explain such behavior. With this basic framework as a baseline, they go on and describe different institutions that generate wage compression in the economy and, therefore, create incentives for training provision. Those are minimum

[1] See Stevens (1994) for an earlier model of training in an imperfect labor market.

wages, unions, search and monopsony, asymmetric information, efficiency wages, and firm specific human capital.

Acemoglu and Pischke make a great contribution by answering the question posed at the beginning of the paper, and offering several reasons why firms would want to train their workers. However, their theory is not aimed at understanding which firms have a stronger incentive to train which workers. In other words, they are not concerned with taking account of the pattern of training provision observed empirically.

In this paper we revisit these questions and argue that a simple theory based on the complementarity between general and firm specific human capital can go a long way towards understanding firm provision of training and its empirical regularities. In our view, a salient feature of the labor market is the difficulty to contract on human capital. Specially in industries with continuous innovation, and rapid technological change, the particular skills that need to be developed to perform each task are highly non-describable ex-ante, and difficult to verify ex-post. This renders any contract incomplete (see Grossman and Hart, 1986; Hart and Moore, 1990; and Hart, 1995). We emphasize the importance of contractual incompleteness, in an otherwise perfectly competitive market. In such a world, the surplus generated in the relationship cannot be allocated ex-ante to create appropriate incentives. Firm and worker must bargain over the division of surplus ex-post (the Nash solution is assumed), creating a hold-up problem. We argue that when general skills and specific human capital are complements, the firm has an incentive to provide the former, in order to increase the incentives of the worker to acquire the specific skills. A worker that receives more training finds his investment in specific skills more productive, and consequently is willing to increase it. However, he will not be able to capture the entire return on that investment during the bargaining process. That way, the firm has a mechanism for extracting rents that enables it to pay for the general training. The main contribution of the paper consists of noting that in this case, the firm can use training instrumentally, since it makes the worker more willing to engage in relationship specific investments.

We later extend the model to incorporate turnover. We show that training serves yet another purpose. By inducing the acquisition of more specific skills, and hence increasing the value of the current employment relation, training also helps retain the worker. And this will be particularly the case when the worker can decide to allocate time between the acquisition of skills or the search for an alternative job.

We also show how this simple theory can account for most of the cross-sectional evidence on training. Bishop (1996) has identified several empirical regularities. He states that training is higher for workers (among other things) that have been recently hired, and who have many years of education or have performed well in tests assessing mathematical, technical and verbal ability. This suggest a strong complementarity between ability or schooling and training. Workers who are expected to have low rates of turnover also receive more training. Several job characteristics also affect the amount of training offered. Those jobs with a high value added, where the worker has a large responsibility, and needs to perform complex tasks (such as professional, technical and managerial jobs) provide more extensive training programs. In particular, sales jobs for complicated, changing and customized products. Finally, training is also affected by firm and industry characteristics. Those firms that adopt flexible and high performance production systems, and that are located in low unemployment areas tend to provide more training than their counterparts. With regards to industries, training tends to be larger in those that have low unemployment rates, and experience rapid technological progress and output growth.

Our model speaks at the use of training at the beginning of the employment relation, to induce the acquisition of specific human capital. Also, the depreciation of human capital will be more important in those industries with faster technological change. They will consequently require more aggressive training programs.[2] Complex jobs are also likely to

[2] Acemoglu and Pischke also note that the complementarity of general and specific skills can make firms willing to train their workers when there is a positive amount of specific human capital. This theory, however, could not explain the timing of training observed, as specific human capital would be lowest precisely at the begining of the employment relation or after the introduction of new technology.

require both more general and specific skills. Our theory suggests that training will be more effective there.

Recently, Kessler and Lülfesmann (2002) have developed a theory similar to ours (although in their motivation they were not trying to explaining the pattern above). They also stress the importance of contract incompleteness in making firms willing to pay for general training. Unlike this paper, they assume separability between general and specific skills in the production function. However, this comes at the expense of the Nash bargaining solution. Instead, they assume that firm and worker share the surplus so long as both parties are guaranteed at least their outside options. This bargaining game effectively generates complementarity between general and specific human capital in their model. The most important difference, however, comes from the nature and timing of the investments. In their model, the firm chooses both the general and specific training simultaneously. In contrast, in our model, the choices are sequential, the worker investing in specific human capital after receiving training.[3] Training, then, makes the worker more willing to specialize.

The rest of the chapter is organized as follows. In Section 2 we discuss a basic one-period model that provides the core of the argument spelled here. In Section 3, we expand the model to allow for the worker receiving random outside offers. In this framework one can study the effects of introducing turnover into the model, and how it affects training. Additionally, one can talk about organizational aspects of the firm. Section 4 concludes. And finally, the appendix looks at the robustness of the results in section 3 when considering an alternative model of turnover.

2 General Training

We first present a basic model to convey the main intuition of the paper. We derive the conditions that make firms willing to pay the general training of their workforce. And we

[3] This difference is not trivial when contracts are incomplete.

show how we can use the model to take account of the pattern of training advanced in the introduction.

2.1 Basic Results

Consider a firm that needs to hire a worker to produce output. Together, the firm and the worker can produce $f(t, h)$, where t is the general training offered to the worker (and paid by the firm), and h is the specific investment the worker makes in the firm. We can think of h as being the part of the human capital of the worker that is specific to the firm, and t as being the part that is transferable across different firms. We assume that $t, h \geq 0$. Implicitly in this formulation, we are abstracting away from any agency problem besides the one that arises regarding the acquisition of specific human capital.

Crucial to our analysis is the assumption of imperfect contractibility of human capital. Unlike Becker's human capital theory, we assume both general and specific human capital are observable, but non-verifiable (following Grossman and Hart (1986), and Hart and Moore (1990)).[4] This means that the labor contract regulating the transactions between the worker and the firm has to be silent with respect to these variables.

Assumption 1 (Incomplete Contracts). *Human capital is observable but non-verifiable.*

As a result of this incompleteness, the firm and the worker will have to bargain ex-post (after the investments have been made) over the division of the surplus generated with t and h. This surplus is the difference between the output that can be produced inside with the initial investments and the outside options of the firm and worker. We discuss both these elements next. The bargaining process is assumed to follow the generalized Nash

[4] The analysis would remain unchanged if general human capital were contractible, to the extent that contracts cannot specify payments contingent on the employment condition of the agent (whether the agent is employed by the firm or not). In practice, such contracts are often illegal, and no Court would enforce them (see Malcomson (1997)). But even if such contracts were feasible, they would only affect the ability of the firm to transfer the cost of training to the worker by altering her outside option. But in no case this would affect the results presented here with regards to the willingness of the firm to pay these costs.

bargaining solution, with μ being the share of the surplus the worker gets, and $(1-\mu)$ the corresponding share of the firm.

The output function is increasing in both arguments, $\frac{\partial f}{\partial t}(t,h), \frac{\partial f}{\partial h}(t,h) > 0$, and concave. Furthermore, the complementarity assumption will be prominent in the analysis:

Assumption 2 (Complementarity). $\frac{\partial^2 f}{\partial t \partial h}(t,h) > 0$ *for all* t, h*; i.e., general and specific human capital are assumed to be complements.*

Acquiring human capital is costly for both the firm and the worker. The cost functions are represented by $c_f(t)$ and $c_w(h)$ for general training and specific human capital, respectively. They are increasing and convex, with $c_f^{'}(0) = c_w^{'}(0) = 0$.

The final assumption regards the structure of the market. This will condition the outside options for the bargaining game. We assume the labor market is perfectly competitive. As a result, the firm would obtain zero profits without the worker. Furthermore, the outside option of the worker will reflect the productivity of her transferrable skills. If we denote such outside option by $w_0(t)$, this translates into the following assumption:

Assumption 3 (Perfect Competition). $w_0(t) = f(t,0)$ *for all* t*; i.e., with no specific human capital, general training is equally productive inside and outside the firm.*

To summarize, the surplus is then $S(t,h) = f(t,h) - w_0(t)$. As a result of the bargaining game, the firm obtains a payoff $S_f(t,h) = (1-\mu) \cdot S(t,h)$. And the worker gets $S_w(t,h) = w_0(t) + \mu \cdot S(t,h)$.

The timing is as follows (see Figure 1): first, the firm chooses how much to train the worker, t, and pays the cost $c_f(t)$. After observing this, the worker invests in specific human capital, h, and pays the cost $c_w(h)$. Following the investment decisions they bargain over the division of the surplus they can generate together using the levels of t and h chosen. Finally, trade occurs, and all the payoffs are realized.

We are now ready to state the first result. It says that without the presence of complementarities, the firm would not be willing to provide general training to the worker.

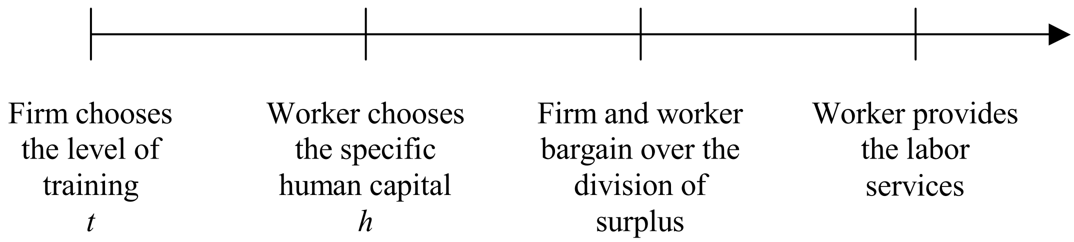

Figure 1: Timing of the model.

Proposition 1 *Suppose that* $\frac{\partial^2 f}{\partial t \partial h}(t,h) = 0$ *for all* t, h, *and that assumptions 1 and 3 hold. Then,* $t^* = 0$ *and no training is provided.*

Proof. *First of all, notice that* $\frac{\partial^2 f}{\partial t \partial h}(t,h) = 0, \forall t, h$ *means that* $f(t,h)$ *is separable, i.e., we can write* $f(t,h) = f_1(t) + f_2(h)$. *Also, the non-existence of complementarities combined with assumption 3 implies that* $\frac{\partial f}{\partial t}(t,h) = w_0'(t)$ *for all* h.

Using backward induction, the worker solves:

$$\max_h S_w(t,h) = w_0(t) + \mu\left[f(t,h) - w_0(t)\right] - c_w(h)$$

Since $S_w(t,h)$ *is also separable, we have that the optimal level of specific human capital is independent of the level of training,* $h^*(t) = \overline{h}$.

Foreseeing this behavior, the firm solves:

$$\max_t S_f(t) = (1-\mu)\left[f\left(t,\overline{h}\right) - w_0(t)\right] - c_f(t)$$

Again, we have a unique solution to this problem, namely $t^* = 0$. *To see this, we just need to realize that*

$$\frac{dS_f}{dt}(t) = (1-\mu)\left[\frac{\partial f}{\partial t}\left(t,\overline{h}\right) - \frac{\partial w_0}{\partial t}(t)\right] - c_f^{'}(t) = -c_f^{'}(t) \leq 0, \forall t$$

making any provision of training unprofitable. ■

In the absence of complementarities, an increase in training translates into an increase in the worker's outside option which exactly offsets the effects on productivity. As a result, the firm will not be able to capture any of the returns on investments in general training. Consequently, no training would be provided.

Remark 1. *Complementarity is going to be crucial in all the analysis, since the same result in proposition 1 holds for the more general case of substitute skills, i.e.,* $\frac{\partial^2 f}{\partial t \partial h}(t,h) \leq 0$ *for all* t, h.

Lets consider now the case where general and specific skills are complements. We solve the model by backward induction. The worker solves:

$$\max_h S_w(t,h) = w_0(t) + \mu \left[f(t,h) - w_0(t) \right] - c_w(h)$$

And we obtain the following first order condition:

$$\mu \frac{\partial f}{\partial h}(t,h) = c_w'(h)$$

This equation will determine the optimal choice of the agent, as a function of the training she obtains, $h^*(t) \geq 0$.

Foreseeing this behavior, the firm then solves:

$$\max_t S_f(t) = (1-\mu) \left[f(t, h^*(t)) - w_0(t) \right] - c_f(t)$$

which has the associated first order condition:

$$(1-\mu) \left[\frac{\partial f}{\partial t}(t,h^*) + \frac{\partial f}{\partial h}(t,h^*) \cdot \frac{dh^*}{dt}(t) - \frac{\partial w_0}{\partial t}(t) \right] = c_f'(t)$$

The returns on training for the firm can be decomposed into two terms. On the one hand, training increases output. However, it also increases the outside option of the worker. The net effect is $\frac{\partial f}{\partial t}(t, h^*) - \frac{\partial w_0}{\partial t}(t)$. Since $h^*(t) \geq 0$ for all t, it follows from assumptions 2 and 3 that $\frac{\partial f}{\partial t}(t, h^*(t)) \geq \frac{\partial w_0}{\partial t}(t)$. When the worker is acquiring specific skills, the productivity of training is larger inside the firm than in an alternative job. Hence, this first term is non-negative.

Secondly, by providing training, the firm creates more incentives for the worker to acquire the specific skills, reflected in the term $\frac{\partial f}{\partial h}(t, h^*) \cdot \frac{dh^*}{dt}(t)$. If we apply the implicit function theorem to the worker's first order condition we obtain that $h^*(t)$ is strictly increasing in t:

$$\frac{dh^*}{dt}(t) = \frac{\mu \frac{\partial^2 f}{\partial t \partial h}(t, h^*)}{c_w''(h^*) - \mu \frac{\partial^2 f}{\partial h^2}(t, h^*)} > 0$$

where the inequality follows directly from assumption 2, the concavity of output, and the convexity of the cost function. Incentives for specific investments are increasing in general human capital. Both these effects result in a positive provision of training being optimal.

When the worker is provided with general training the returns on her specific investments increase. By being able to use the specific skills more efficiently, training increases the willingness of the worker to engage in activities that do not have any recognition outside that relationship. However, because of the incompleteness of contracts, the worker will not be able to extract all the returns on these investments. A fraction will go to the firm to finance the provision of training. From this, we have the following result:

Proposition 2 *Under assumptions 1-3, a positive provision of training, $t^* > 0$, is optimal.*

Proof. *It is sufficient to show that $\frac{dS_f}{dt}(0) > 0$.*

We have that $\frac{dS_f}{dt}(t) = (1-\mu)\left[\frac{\partial f}{\partial t}(t, h^*(t)) + \frac{\partial f}{\partial h}(t, h^*(t)) \cdot \frac{dh^*}{dt}(t) - \frac{\partial w_0}{\partial t}(t)\right] - c_f'(t)$. Evaluating this expression at 0, the marginal cost of training drops, since $c_f'(0) = 0$. It then follows from the above discussion that $\frac{dS_f}{dt}(0) > 0$, since $\frac{\partial f}{\partial t}(t, h^*(t)) - \frac{\partial w_0}{\partial t}(t) \geq 0$ and $\frac{\partial f}{\partial h}(0, h^*(0)) \cdot \frac{dh^*}{dt}(0) > 0$. Hence, $t^* = 0$ cannot be a solution to the problem of the firm. ■

This proposition expresses the main result of the paper. Namely, that when general training and specific human capital are complements the firm has an incentive to pay for the former. We can decompose this incentive into two parts, that corresponds to the two effects above. The first piece is $\frac{\partial f}{\partial t}\left(t, h^*\left(t\right)\right) - \frac{\partial w_0}{\partial t}\left(t\right)$. When $t > 0$, $h^*\left(t\right) > 0$, and therefore, this term is positive. In words, when the worker invests in firm specific human capital, general training is more productive inside than outside the firm. The second effect is $\frac{\partial f}{\partial h}\left(t, h^*\left(t\right)\right) \cdot \frac{dh^*}{dt}\left(t\right)$. It corresponds to the increased incentive of the worker to accumulate specific skills that training provides. This further increases the difference between inside and outside opportunities. It is the bargaining over those rents that finance (and provide incentives for) the provision of training.

2.2 An Alternative Framework

Alternatively, we could consider a framework where human capital affects the cost of generating value from the transaction, rather than affecting output directly (as we posed previously). We can obtain the same results as before when training reduces the cost (bared by the worker) of providing the firm with a valuable output.

Suppose now that the worker can produce output that is valued at v by the firm (observable, but not verifiable), at a cost $c_w(v, t)$ that is fully paid by the worker.[5] The firm, again, chooses how much to train the worker, t, at the beginning of the employment relation. The interpretation, here, is that the worker provides "customized" labor services. But it is costly for him to adapt his services to the requirements of the firm. Again, the contract they sign has to be incomplete if the value of the services provided is non-verifiable.

Now the problem of the worker is:

$$\max S_w\left(t, v\right) = w_0\left(t\right) + \mu\left[v - w_0\left(t\right)\right] - c_w\left(v, t\right)$$

[5]This could be the cost of effort put into producing that output.

and its solution is denoted $v^*(t)$. The firm solves:

$$\max_t S_f(t) = (1-\mu)[v^*(t) - w_0(t)] - c_f(t)$$

In this framework, training reduces the cost of producing value, $\frac{\partial c_w}{\partial t}(v,t) < 0$. The complementarity assumption translates into:

Assumption 2b. $\frac{\partial^2 c_w}{\partial t \partial v}(v,t) < 0$ *for all* t, h*; i.e., general training reduces the marginal cost of producing value* v*.*

And perfect labor markets would require:

Assumption 3b. $\frac{\partial c_w}{\partial t}(v^*(0),t) = -\frac{\partial w_0}{\partial t}(t)$ *for all* t*; i.e., with no provision of specifically valuable output, general training is equally productive inside and outside the firm, meaning that it increases the value outside as much as it reduces the cost inside.*

Under these modified assumptions, this alternative framework would yield analogous results to the ones presented above.

2.3 Comparative Statics

We now extend the basic model above to examine some comparative statics. Suppose that the production function takes the form $f(t,h,s,\gamma)$, where s is a choice variable for the firm, and γ is an exogenous parameter (t and h are as above). s is meant to capture the choice of hiring a skilled or unskilled worker, i.e., the level of schooling (hence the terminology s). As we will see shortly, γ will parametrize the degree of complementarity among the other production inputs (t,h,s). This is meant to describe the production technology of different tasks. We allow the outside option of the worker to change with s and γ, $w_0(t,s,\gamma)$.

We make the following assumption with respect to the production technology:

Assumption 2c. $f(t,h,s,\gamma)$ *is supermodular.*

Intuitively, this assumption simply states that all the parameters are complements with each other. Formally, all the cross-partial derivatives are positive.[6] It is the natural generalization of assumption 2 for this setting.

As before, competitive labor markets yield the following (analogous to assumption 3):

Assumption 3c. $w_0(t,s,\gamma) = f(t,0,s,\gamma)$ *for all* t,s,γ.

Now denote the solution to the worker's problem by

$$h^*(t,s,\gamma) = \arg\max_h w_0(t,s) + \mu\left[f(t,h,s,\gamma) - w_0(t,s,\gamma)\right] - c_w(h)$$

It immediately follows that this solution satisfies the following result:

Lemma 3 *Suppose assumption 2c holds. Then,* $h^*(t,s,\gamma)$ *is increasing in* t,s *and* γ.

Proof. *It follows directly from the assumption of supermodularity.* ■

Specific human capital is more productive for those workers that receive higher training, that are more educated, and that are placed in tasks with stronger complementarities between these different components of output. As a result, it is not surprising that these workers will choose to invest more in the specific skills.

It will be useful to further assume that the worker's reaction function $h^*(t,s,\gamma)$ is supermodular. Intuitively, it simply states that the two instruments, t and s, that the firm has to motivate the worker to undertake the specific investments are complements. Also, they are complements to the exogenous parameter γ. One could try to derive this condition from first principles (assumptions about the derivatives of $f(\cdot)$). Indeed, very mild conditions are required. In particular, it is almost sufficient to have that the complementarities between h and t, and between h and s are increasing in γ. (Also, the complementarity between h and t must be increasing in s.) For this reason, it seems natural to interpret the

[6] *For more details, see Holmstrom and Milgrom (1994).*

parameter γ as defining the characteristics of the task to be performed, since it affects the level of complementarities among t, h and s.

We can now go on, and derive some comparative statics for the level of training provided by the firm.[7] Define:

$$\left(t^*(\gamma), s^*(\gamma)\right) = \arg\max_{(t,s)} (1-\mu)\left[f\left(t, h^*(t,s,\gamma), s, \gamma\right) - w_0(t,s)\right] - c_f(t)$$

The following comparative static on the solution to the firm's problem obtains:

Proposition 4 *Suppose that $h^*(t,s,\gamma)$ is supermodular. Then, both $t^*(\gamma)$ and $s^*(\gamma)$ are increasing in γ.*

Proof. *It suffices to see that the objective function of the firm is supermodular. In fact, if we denote $S_f(t,s,\gamma) = (1-\mu)\left[f\left(t, h^*(t,s,\gamma), s, \gamma\right) - w_0(t,s,\gamma)\right]$, we have:*

$$\frac{\partial^2 S_f}{\partial s \partial t} = (1-\mu)\cdot\left[\frac{\partial^2 f}{\partial s \partial t} + \frac{\partial^2 f}{\partial h \partial t}\cdot\frac{\partial h^*}{\partial s} + \frac{\partial^2 f}{\partial s \partial h}\cdot\frac{\partial h^*}{\partial t} + \frac{\partial^2 f}{\partial h^2}\cdot\frac{\partial h^*}{\partial s}\cdot\frac{\partial h^*}{\partial t} + \frac{\partial f}{\partial h}\cdot\frac{\partial^2 h^*}{\partial s \partial t} - \frac{\partial^2 w_0}{\partial s \partial t}\right]$$

Since the complementarity between s and t is increasing in h, we have that $\frac{\partial^2 f}{\partial s \partial t} - \frac{\partial^2 w_0}{\partial s \partial t} \geq 0$. Furthermore, from the implicit function theorem we have:

$$\frac{dh^*}{ds} = \frac{\mu \frac{\partial^2 f}{\partial s \partial h}}{c_w''(h) - \mu \frac{\partial^2 f}{\partial h^2}} > 0$$

We can then write

$$\frac{\partial^2 f}{\partial h^2}\cdot\frac{\partial h^*}{\partial s}\cdot\frac{\partial h^*}{\partial t} = \left(\frac{\mu \frac{\partial^2 f}{\partial h^2}}{c_w''(h) - \mu \frac{\partial^2 f}{\partial h^2}}\right)\cdot\frac{\partial^2 f}{\partial s \partial h}\cdot\frac{\partial h^*}{\partial t}$$

where the term in parenthesis is greater than -1. Therefore, $\frac{\partial^2 f}{\partial s \partial h}\cdot\frac{\partial h^*}{\partial t} + \frac{\partial^2 f}{\partial h^2}\cdot\frac{\partial h^*}{\partial s}\cdot\frac{\partial h^*}{\partial t} > 0$.

[7] We will assume the solution to the firm's problem is unique and well behaved. This is ensured when its objective function is concave. On the other hand, if there exists multiple equilibria, we could rephrase the results in terms of the comparative statics on the set of equilibria, following the analysis in Milgrom and Shannon (1994).

The rest of the terms are also positive, and as a result, $\frac{\partial^2 S_f}{\partial s \partial t}(t, s, \gamma) > 0$.

Using similar calculations, we get that the other two cross-partial derivatives are also positive. ■

When the different types of skills become more complementary, the firm finds it optimal to hire more educated workers, and train them more extensively. They are the ones for whom training induces more specific investments.

Now we can use this result to try to understand the empirical regularities about training discussed in the introduction. γ is a parameter reflecting the level of complementarities between the different attributes of the worker: t, h, s. We can think of this as being the task that the worker is asked to perform. And it seems reasonable to assume that more complicated tasks will have a higher γ. Then, the proposition says that when we compare two jobs, we should observe more training and selection of more educated (higher ability) workers in the one with higher cognitive complexity.

2.4 Discussion

Before moving forward with the theoretical discussion, it is worth relating these results to the available empirical evidence on training discussed in the introduction. We emphasize that the reason why firms train workers is to induce them to acquire specific skills. It is then natural to think that firms will want to train new workers at the beginning of their employment relation. Furthermore, when organizations undergo strong investments and restructurings, the value of the accumulated human capital (both general and specific) is likely to depreciate. As a result, further investments would be required. In this case too, training would help increase general and specific skills to match the requirements of the new technology or work practices introduced. Both these effects strongly appear in the data. Bishop (1996) argues that most of the training programs we observe take place either at the beginning of the employment relation, or after major organizational restructurings and introduction of new technologies.

Furthermore, we saw in the previous section that those activities where human capital is more important (both with respect to its marginal return, and the complementarity between its general and specific components) require more educated workers, but at the same time they receive a more extensive training. This is again in line with the pattern of training that Bishop (1996) describes. Training is provided mostly to well educated workers, in complex jobs that involve large responsibility.

We can also draw some normative implications for the management of human resources. The analysis suggests that training and personnel selection are two instruments the firm possesses to increase productivity. Those instruments should be coordinated and used together. Their use should also be tailored to the characteristics of the specific task the worker is meant to perform.

3 Turnover, Multitasking and Training

In the previous section, the outside option of the worker was equal to the output produced solely with the transferable human capital. As a result, the value of the worker inside the relationship with the firm was no lower than the value for the outside market. Consequently, turnover plays no role in the model, since it is always efficient to produce inside. Here we expand the previous framework to allow for a random outside value.[8] We can then explore the implications of this model for turnover and multitasking (in the form of search for outside opportunities while being on the job).

3.1 Turnover

We consider the same framework as before: the firm choosing t, then the worker choosing h, followed by bargaining and production. But before reaching the bargaining stage (and after the investments have been made) the worker receives an outside offer, x, with probability

[8] This random outside value could be due, for instance, to the existence of heterogeneity in the productivity of firms.

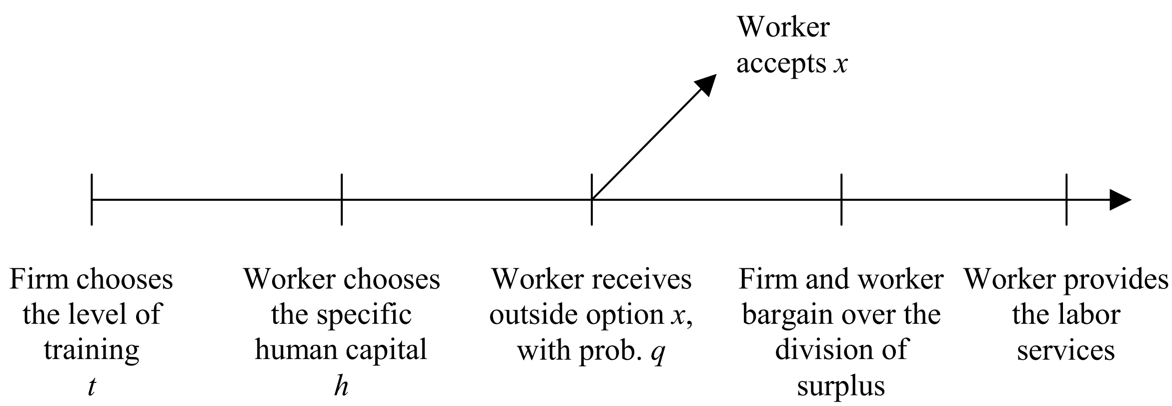

Figure 2: Timing of the model.

q.[9] The offer is randomly distributed with cumulative distribution function $G(x \mid t)$ that depends on the amount of general training received. After observing its realization, the worker will decide whether to accept it, or remain in the firm. If he stays in, we reach the bargaining stage (the offer cannot be carried on until that stage). Then, there is no further action. The firm and the worker just bargain over the division of the surplus obtained with the investments, (t, h), and then trade the labor services. (See Figure 2.)

We will assume that the distribution of offers satisfies $G(x \mid t) = G(x - w_0(t))$, with $G(\bullet)$ being differentiable. Thus, providing more training shifts the distribution of outside offers by $w_0(t)$. This would be the case, for instance, if the offers are drawn from a uniform, or normal distribution, with mean $w_0(t)$ and constant variance.

Let $S_w(t, h) = w_0(t) + \mu[f(t, h) - w_0(t)]$ be the one period surplus of the worker. Notice that when the outside offer is in the interval $x \in (S_w(t, h), f(t, h))$, the worker could accept the outside offer, even though he produces more inside. To avoid any such inefficiency we will assume the firm can make a counter offer, before the bargaining takes

[9] q does not play a major role in this discussion, but it will prove useful to extend the model in the next section to allow for on the job search.

place, and commit to it.[10] Therefore, whenever $S_w(t,h) < x < f(t,h)$ the firm will offer a wage of x, and the worker will accept it and stay in the firm.

If the worker gets an outside offer, she declines it as long as $x \leq S_w(t,h)$. She leaves if $x > f(t,h)$. And she accepts the counter offer of x, when $S_w(t,h) \leq x \leq f(t,h)$. Then, the probability of staying until the production stage is $G(f(t,h) \mid t)$.

The worker seeks to solve the following maximization problem

$$\max_h (1-q) S_w(t,h) + q \left\{ G(S_w(t,h) \mid t) \cdot S_w(t,h) + \int_{S_w(t,h)}^{+\infty} x dG(x \mid t) \right\} - c_w(h)$$

The first term is the surplus the worker gets in case he receives no outside offer. Then, with probability q he receives an offer. If it is low, the offer is rejected and the worker receives the surplus as if nothing had happened. But if the outside offer exceeds $S_w(t,h)$, his payoff will equal that offer. This corresponds to the integral term which includes both the case when there is a counter offer and the worker is retained, and when he leaves the firm. Finally, he pays the cost of the specific investment.

We can write the integral term as a conditional expectation:

$$\int_{S_w(t,h)}^{+\infty} x dG(\cdot \mid t) = (1 - G(S_w(t,h) \mid t)) \cdot E[x \mid t; x > S_w(t,h)]$$

Solving this problem will give us the optimal investment decision $h^*(t)$. When deciding the level of h, the worker takes into account all the effects that this has on his payoff. First, h increases the surplus from the one-period payoff, $S_w(t,h)$, although it has a cost of $c_w(h)$. Therefore, an increase in h has a positive effect both in the probability of staying in the firm, and on the surplus obtained from staying. However, there are two opposite effects in the last term: it increases the expected payoff conditional on leaving the firm, but it

[10] In the appendix, we develope an alternative case where the worker can hold on to the outside offer, and carry it on to the bargaining stage. Then, he could use it as an outside option when bargaining with the firm. It is shown there that all the results from this section are robust to this alternative specification.

decreases the probability of leaving the firm. The net effect is ambiguous.

Then, if we denote $S_f(t) = (1-\mu)[f(t, h^*(t)) - w_0(t)]$, the problem of the firm is

$$\max_t (1-q) S_f(t) + q \left\{ G(S_w(t, h^*(t)) \mid t) \cdot S_f(t) + \int_{S_w(t,h^*(t))}^{f(t,h^*(t))} [f(t, h^*(t)) - x] \, dG(x \mid t) \right\} - c_f(t)$$

When the worker receives no offer, the surplus is divided as before. With probability q, however, an offer comes. Then, if such offer is low it is not binding, and the firm still receives $S_f(t)$. But for offers between $S_w(\cdot)$ and $f(\cdot)$ a counter offer will be required to retain the worker, reducing profits to $[f(t, h^*(t)) - x]$. Higher offers make the firm lose the worker for the outside market (and realize zero profits).

We are interested here on the effects of training on the retention of the worker. If we go back to the problem of the worker, the following result will be useful. It states that (despite the different effects mentioned above) specific human capital acquisition is still increasing in the amount of training the worker receives.

Proposition 5 *If $G(x \mid t) = G(x - w_0(t))$, with $G(\bullet)$ differentiable, then $h^*(t)$ is strictly increasing in t.*

Proof. *It follows from the supermodularity of the worker's objective function in (t, h). To see this, realize that the sum of supermodular functions is supermodular. Since $S_w(t, h)$ satisfies this condition by assumption, we just need to check it for $\phi(t, h) = G(S_w(t, h) \mid t) \cdot S_w(t, h) + \int_{S_w(t,h)}^{+\infty} x dG(x \mid t)$.*

Denote by $g(x)$ the density function corresponding to $G(x)$. Then, after making the change of variables $y = x - w_0(t)$, we can write:

$$\begin{aligned} \int_{S_w(t,h)}^{+\infty} x dG(x \mid t) &= \int_{\mu[f(t,h)-w_0(t)]}^{+\infty} [y + w_0(t)] \cdot g(y) \, dy = \\ &= w_0(t) \cdot [1 - G(\mu [f(t, h) - w_0(t)])] + \int_{\mu[f(t,h)-w_0(t)]}^{+\infty} y \cdot g(y) \, dy \end{aligned}$$

If we apply the Leibniz' rule to the integral term we get

$$\frac{\partial}{\partial h}\int_{S_w(t,h)}^{+\infty} x dG(x \mid t) = -S_w(t,h)\cdot g(\mu[f(t,h)-w_0(t)])\cdot\mu\cdot\frac{\partial f}{\partial h}$$

Finally, using the previous expression we get

$$\frac{\partial\phi}{\partial h} = G(\mu[f(t,h)-w_0(t)])\cdot\mu\cdot\frac{\partial f}{\partial h}$$

Therefore

$$\frac{\partial^2\phi}{\partial t\partial h} = G(\mu[f(t,h)-w_0(t)])\cdot\mu\cdot\frac{\partial^2 f}{\partial t\partial h} + g(\mu[f(t,h)-w_0(t)])\cdot\left(\mu\frac{\partial f}{\partial h}\right)\left(\mu\frac{\partial f}{\partial t}\right) > 0$$

and we obtain the supermodularity of the objective function. ■

Just as in the basic model, the worker responds to an increase in training with a larger investment in specific human capital. This in turn will increase the likelihood of the worker remaining for a second period. The next proposition states these effects on retention.

Corollary 6 *If* $G(x \mid t) = G(x - w_0(t))$*, with* $G(\bullet)$ *differentiable, then* $G(f(t,h^*(t)) \mid t)$ *is increasing in* t*. As a result,* t *increases the probability of retaining the worker.*

Proof. *It follows directly from the previous lemma, as the probability of retention equals* $G(f(t,h^*(t)) \mid t)$*.* ■

Now, providing the workers with general skills serves two purposes (for the firm). The first one is the same effect identified in the previous section. Namely, that training increases the willingness of the workers to accumulate human capital specific to the firm (which makes him more productive inside). Although this effect is now weakened by the fact that with a certain probability, the worker will receive an outside offer and decide to leave. And secondly, by increasing t the firm is indeed reducing the probability that the worker leaves the firm (since the increased specificity makes him more valuable inside the relationship).

Therefore, we obtain that the general training reduces turnover by locking the worker into the relationship through an increase in the specificity of the worker.[11]

3.2 Search Effort and Multitasking

In this section we allow the worker a choice between acquiring specific human capital and searching for a good match for the second period. In this case effort is multidimensional. Then, the principal faces the problem of providing the worker with the incentives to exert effort in the dimension that is most profitable for the firm. This is what has been known in the contract theory literature as multitasking. Here, this problem arises from the ability of the worker to put effort in trying to find alternative job offers. In other words, we allow for on the job search. We introduce this possibility by letting the worker affect the probability of receiving an outside option. Let $q(e)$ be that probability, where e is meant to be the search effort. It is natural to assume that search effort is productive, and increases the probability of receiving an offer, so that $q^{'}(e) > 0$.

Let the cost of the worker be $c_w(h, e)$, which now depends on both specific human capital and search effort. We assume that the two tasks are substitutes: $\frac{\partial^2 c_w}{\partial e \partial h}(h, e) \geq 0$. Investing in specific human capital increases the marginal cost of searching, and viceversa.

Then, the worker has to solve

$$\max_{h,e} (1 - q(e)) \cdot S_w(t, h) + q(e) \left\{ \begin{array}{c} G(S_w(t, h) \mid t) \cdot S_w(t, h) + \\ + \int_{S_w(t,h)}^{+\infty} x dG(\cdot \mid t) \end{array} \right\} - c_w(h, e)$$

Denote the solution by $h^*(t), e^*(t)$. Now, let $S_f(t) = (1 - \mu)(f(t, h^*(t)) - w_0(t))$. The

[11] Of course, all this applies when holding q constant. An increase in the probability of receiving an outside offer can also decrease the incentives to train the worker.

firm then solves

$$\max_t \left[1-q\left(e^*\left(t\right)\right)\right]\cdot S_f\left(t\right)+q\left(e^*\left(t\right)\right)\left\{\begin{array}{c} G\left(S_w\left(t,h^*\left(t\right)\right)\mid t\right)\cdot S_f\left(t\right)+ \\ +\int_{S_w(t,h^*(t))}^{f(t,h^*(t))}\left[f\left(t,h^*\left(t\right)\right)-x\right]\cdot dG\left(\cdot\mid t\right)\end{array}\right\}-c_f\left(t\right)$$

Again, we are going to restrict attention to offers that come from the same distribution as in the previous section. Then we have the following result.

Proposition 7 *If $G\left(x\mid t\right)=G\left(x-w_0\left(t\right)\right)$, with $G\left(\bullet\right)$ differentiable, and $\frac{\partial^2 c_w}{\partial e\partial h}\left(h,e\right)\geq 0$, then $h^*\left(t\right)$ is increasing, and $e^*\left(t\right)$ is decreasing.*

Proof. *It suffices to show that the worker's objective function is supermodular in $\left(t,h,-e\right)$, and hence satisfies:*

$$\frac{\partial^2}{\partial t\partial h}>0,\frac{\partial^2}{\partial h\partial e}<0,\frac{\partial^2}{\partial t\partial e}<0$$

The first condition can be verified as in Proposition 5.

For the second condition, realize that

$$\frac{\partial}{\partial e}=-\frac{\partial c_w}{\partial e}+q'\left(e\right)\left\{-S_w\left(t,h\right)+G\left(S_w\left(t,h\right)\mid t\right)\cdot S_w\left(t,h\right)+\int_{S_w(t,h)}^{+\infty}xdG\left(\cdot\mid t\right)\right\}$$

Therefore, and again making use of the calculations made in the proof of Proposition 5, we get:

$$\frac{\partial^2}{\partial h\partial e}=-\frac{\partial^2 c_w}{\partial h\partial e}+q'\left(e\right)\left\{-\mu\cdot\frac{\partial f}{\partial h}+G\left(S_w\left(t,h\right)\mid t\right)\cdot\mu\cdot\frac{\partial f}{\partial h}\right\}<0$$

since $G\left(\cdot\mid t\right)\leq 1$.

Consider now the same function $\phi\left(t,h\right)$ as in the proof of that Proposition. To get the third inequality, it is enough to show that the condition is satisfied for the term $q\left(e\right)\cdot\left[-S_w\left(t,h\right)+\phi\left(t,h\right)\right]$, since the additional elements vanish. Then, if we differentiate with *respect to e, and then with respect to t, making use of Leibniz' rule we get:*

$$\begin{aligned} \frac{\partial^2}{\partial t \partial e} &= q'(e) \cdot \left\{ -\frac{\partial S_w}{\partial t} + \frac{\partial w_0}{\partial t} + G\left(\mu\left[f(t,h) - w_0(t)\right]\right) \cdot \mu \cdot \left(\frac{\partial f}{\partial t} - \frac{\partial w_0}{\partial t}\right) \right\} = \\ &= q'(e) \cdot \left\{ \left[G\left(\mu\left[f(t,h) - w_0(t)\right]\right) - 1\right] \cdot \mu \cdot \left(\frac{\partial f}{\partial t} - \frac{\partial w_0}{\partial t}\right) \right\} < 0 \end{aligned}$$

which concludes the proof. ■

By providing more training, the firm is making specific human capital a more profitable investment for the worker. Furthermore, since she knows she is more valuable inside the firm, it suppresses the incentives to search. Both these effects are beneficial for the firm.

Increasing t has positive effects on $S_f(t)$, both directly, and indirectly through the increase in h, as before. Also, it reduces the probability of the worker receiving an outside option, $q(e^*(t))$. And finally, conditional on receiving the offer, it decreases the probability that he will accept it and leave the firm, $[1 - G(f(t, h^*(t)) \mid t)]$.

We see here that training has a positive effect on the retention of the worker. First, since it induces him to accumulate more specific human capital, it makes him more valuable inside the firm (as compared to alternative jobs). And secondly, it discourages the search for alternatives because he has the possibility of being highly productive in the current job through the accumulation of specific knowledge.

4 Conclusion

This paper rationalizes the decision of a firm to pay for the general training of its workers. The explanation is based on complementarities between specific human capital and training. We rely on the inability to write comprehensive contracts on the human capital of the worker. But other than that, labor markets are assumed to be perfectly competitive. In this case, we show that firms have an incentive to provide a positive level of general training, in order to induce the acquisition of specific skills. We then argue that this model can take account of the pattern of training provision observed empirically, and documented by Bishop (1996).

We also study the implications of this theory for turnover and multitasking. Training could then be used by the firm to reduce turnover. This may come from two different effects. First, directly from the incentives on specific skill acquisition. But additionally, from the reduced incentive to search for alternative offers. When the worker can search for another job, training makes the current position more attractive, which reduces the incentives to conduct this search. Hence, general training may also increase the loyalty of the workforce.

These predictions are consistent with anecdotal evidence from the Bureau of Labor Statistics Survey of Employer-Provided Training. According to it, more than 50% of firms providing training in the sample report that one of the reasons for doing so is to retain valuable employees.[12] The theory can also help us understand the evidence in Parent (1999). He shows that firms reward skills acquired through training provided by a previous employer as much as the training they provide themselves. And yet he finds that training reduces turnover.[13] Our theory suggests that workers might be voluntarily acquiring specific skills themselves after being trained, and hence are more likely to stay in the job.

The relation between training and turnover has also been noticed in the popular press. Wessel (2001) describes the case of United Technologies Corp. (UTC). This company offers a generous training program for its employees, even paying them college education. And they report that only 4% of the workers who get company-financed college degrees leave the firm each year, compared to 8-10% for those who do not participate in this training program. This suggests that, even though turnover might be a concern when deciding to train workers, firms also benefit from increased loyalty when they do it.

[12] For more details, see the report from the US Department of Labor, Employment and Training Administration, 1996.

[13] Parent (1999) interprets these results as training containing a significant specific component. However, Loewenstein and Spletzer (1999) suggest this is not the case, as most of the training is indeed general.

5 Appendix: Two-Period Model Keeping The Outside Offer

In this appendix we show how the results from the model with turnover are robust to changing the assumptions about the availability of the outside offer. In the paper, it was assumed that the worker receives the outside offer after the investments have been made, but he cannot carry it through the bargaining stage.

Now, we will allow for the worker to bargain with the firm with the offer in his hands. This changes the bargaining game, since now the outside option of the worker is not $w_0(t)$ anymore, but $\max(w_0(t), x)$ instead. That is, if the outside offer is lower that $w_0(t)$, the worker can always neglect it (or hide it). However, if it is bigger than that, and he can keep it until the bargaining stage with the firm, then the new outside option for the worker is x. The objective function of the worker becomes:

$$\max_{h,e} -c_w(h,e) + (1-q(e)) \cdot S_w(t,h) +$$

$$+q(e)\left\{G(w_0(t) \mid t) \cdot S_w(t,h) + \int_{w_0(t)}^{f(t,h)} [x+\mu(f(t,h)-x)] \cdot dG(\cdot \mid t) + \int_{f(t,h)}^{+\infty} x dG(\cdot \mid t)\right\}$$

If we make use of the same assumption about the distribution of outside offers we made in the text, the previous problem simplifies considerably. We obtain:

$$\max_{h,e} -c_w(h,e) + (1-q(e)) \cdot S_w(t,h) +$$

$$+q(e)\left\{\begin{array}{c} G(0) \cdot S_w(t,h) + w_0(t) \cdot [1-G(0)] + \int_0^{+\infty} xg(x)\,dx + \\ +\mu \cdot [G(f(t,h)-w_0(t)) - G(0)] \cdot [f(t,h)-w_0(t)] - \mu \int_0^{f(t,h)-w_0(t)} xg(x)\,dx \end{array}\right\}$$

Then, we have an analogous proposition to the one presented in the core of the paper. And all subsequent results should also follow through.

Proposition 8 *If $G(x \mid t) = G(x - w_0(t))$, with $G(\bullet)$ differentiable, and $\frac{\partial^2 c_w}{\partial e \partial h}(h,e) \geq 0$, then $h^*(t)$ is increasing, and $e^*(t)$ is decreasing.*

Proof. *Again, we need to show that the objective function satisfies:*

$$\frac{\partial^2}{\partial t \partial h} > 0, \frac{\partial^2}{\partial h \partial e} < 0, \frac{\partial^2}{\partial t \partial e} < 0$$

It is easy to verify the first condition for the first terms of the objective function. The only nontrivial part, and the one we will concentrate on, corresponds to the terms

$$q(e)\left\{\mu \cdot [G(f(t,h) - w_0(t)) - G(0)] \cdot [f(t,h) - w_0(t)] - \mu \int_0^{f(t,h)-w_0(t)} xg(x)\,dx\right\}$$

If we differentiate this expression with respect to h we get (applying Leibniz' rule, and simplifying):

$$\frac{\partial}{\partial h} = q(e)\left\{G(f(t,h) - w_0(t)) \cdot \frac{\partial f}{\partial h}\right\}$$

Then,

$$\frac{\partial^2}{\partial t \partial h} = q(e)\left\{G(f(t,h) - w_0(t)) \cdot \frac{\partial^2 f}{\partial t \partial h} + g(f(t,h) - w_0(t)) \cdot \frac{\partial f}{\partial t} \cdot \frac{\partial f}{\partial h}\right\} > 0$$

To obtain the other two conditions, realize that

$$\frac{\partial}{\partial h} = -\frac{\partial c_w}{\partial e} + q'(e)\left\{\begin{array}{c} -S_w(t,h) + G(0) \cdot S_w(t,h) + w_0(t) \cdot [1 - G(0)] + \int_0^{+\infty} xg(x)\,dx \\ +\mu \cdot [G(f(t,h) - w_0(t)) - G(0)] \cdot [f(t,h) - w_0(t)] \\ -\mu \int_0^{f(t,h)-w_0(t)} xg(x)\,dx \end{array}\right\}$$

Again, if we apply Leibniz' rule, and we simplify the expressions, we get

$$\begin{aligned} \frac{\partial^2}{\partial h \partial e} &= -\frac{\partial^2 c_w}{\partial h \partial e} + q'(e)\left\{-\frac{\partial S_w}{\partial h} + G(f(t,h) - w_0(t)) \cdot \frac{\partial S_w}{\partial h}\right\} < 0 \\ \frac{\partial^2}{\partial t \partial e} &= q'(e)\left\{\mu \cdot [G(f(t,h) - w_0(t)) - 1] \cdot \left(\frac{\partial f}{\partial t} - \frac{\partial w_0}{\partial t}\right)\right\} < 0 \end{aligned}$$

This completes the proof. ■

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