

THE STRUCTURE OF WAGES AND  
INVESTMENT IN GENERAL TRAINING

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**ABSTRACT**

In the standard model of human capital with perfect labor markets, workers pay for general training. When labor market frictions compress the structure of wages, firms may invest in the general skills of their employees. The reason is that the distortion in the wage structure turns “technologically” general skills into “specific” skills. Labor market frictions and institutions, such as minimum wages and union wage setting, are crucial in shaping the wage structure, and thus have an important impact on training. Our results suggest that the more frictional and regulated labor markets in Europe and Japan may generate more firm-sponsored general training than the U.S.

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# 1 Introduction

In the standard theory of human capital as developed by Becker (1964), there is a sharp distinction between *general* and *specific* human capital. Skills which are only useful with the current employer are specific whereas skills which are as useful with some other employer are general. In competitive labor markets, workers capture all the benefits of their general human capital, and employers have no incentive to invest in these skills. In this paper, we develop the theory of human capital when labor markets are imperfect. In contrast to the standard theory, labor market frictions imply that firms may be willing to invest in the general skills of their workers. In particular, if these frictions distort the structure of wages within the firm away from the competitive benchmark and to the benefit of unskilled workers, it will be profitable for the firm to provide workers with general skills. We find that contrary to conventional wisdom, for firms to pay for general skills, credit market problems are neither necessary nor sufficient. The key is labor market imperfections which make *technologically general* skills effectively *specific*, because trained workers do not get paid their full marginal product when they change jobs.<sup>1</sup>

The link between the structure of wages and training enables us to investigate the impact of labor market institutions on human capital accumulation. There are important differences between labor market institutions of Anglo-Saxon economies, Continental Europe and Japan. For example, in contrast to the U.S. and the U.K., in Germany, and Sweden unions play a very important role in wage determination, and there are wage floors set by minimum wages and unemployment benefits. Many economists believe that these institutional differences compress the structure of wages (e.g. Blau and Kahn, 1996, Edin and Topel, 1997). Comparisons of wage dispersion and returns to education support this view. For example, in the mid 1980s, the log difference of ninetieth and tenth percentile wages was 1.73 in the U.S., 1.11 in the U.K. as opposed to 0.83 in Germany, 0.67 in Sweden, 1.22 in France and 1.01 in Japan (OECD, 1993). Many economists believe that distorted wage structures reduce not only employment, but also investments in human capital (e.g. Lindbeck, et al. 1993). In contrast, our theory predicts that a compressed wage structure will induce firms to pay for training, even though the skills are technologically general. Therefore, the European and Japanese labor market institutions

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<sup>1</sup>In the standard theory, firms pay for skills that are specific, and which skills are specific is determined by technology. In contrast, we focus on skills that are technologically general, in the sense that absent frictions, they will be as useful with other employers. Market structure and institutions determine, in equilibrium, which skills are turned into effectively “specific” skills. Becker (1964) realized that this may happen when he wrote that “in extreme types of monopsony ... job alternatives for trained and untrained workers are nil, and all training, no matter what its nature, would be specific to the firm.” (p. 50, 3rd ed.), but did not pursue this further.

may contribute to, rather than reduce, human capital accumulation. In line with these predictions, the incidence of training appears to be higher in Europe and Japan than in the U.S.: OECD (1994, Table 4.7) reports that 23.6 percent of young workers in France, 71.5 percent of those in Germany and 67.1 percent of new hires in Japan receive formal training. By way of comparison, only 10.2 percent of U.S. workers receive any formal training during their first seven years of labor market experience.<sup>2</sup>

Even in the U.S., which has a less distorted wage structure and less training than other countries, there is evidence that firms bear part of the cost of investments in technologically general skills.<sup>3</sup> For example, Barron, Berger and Black (1997) report that productivity growth associated with training exceeds wage growth by a factor of ten, even though firms claim that most of this training is valuable at other employers. Further, many temporary help agencies in the U.S. also provide general training to new employees, such as computer and typing skills, and bear the monetary costs (Krueger 1993). Studies of the costs and productivity of apprentices have also typically concluded that apprentices do not pay for the full cost of training. In particular, Ryan (1980) reports sizeable net costs of apprenticeship training in a U.S. shipyard. Similarly, von Bardeleben, Beicht, and Fehér (1995) find that the net costs of training are substantial in large German firms, even though the content of these programs are highly regulated and apprentices are given exams by outside boards, which implies that the skills are mostly general.

The main idea of our paper can be explained using Figure 1, which draws the product of a worker,  $f(\tau)$ , as a function of his skills,  $\tau$ . Suppose that this worker can quit his employer and work for another firm, and in the process, he incurs a cost  $\Delta$ . Assuming that he will receive his full product upon quitting, the worker's outside option is  $v(\tau) = f(\tau) - \Delta$ . Suppose that the current employer can pay this outside option and keep the worker. So the worker receives  $w(\tau) = f(\tau) - \Delta$ . In this case, the employer has no incentive to invest in the worker's skills because its profits are equal to  $f(\tau) - w(\tau) = \Delta$  irrespective of the value of  $\tau$ . The perfectly competitive labor market can be thought of as the special case with  $\Delta = 0$ , so in competitive markets, employers do not invest in the general skills of their employees. Next consider the case where the wage structure is compressed (distorted against more skilled workers), that is  $f(\tau) - w(\tau) = \Delta(\tau)$  and  $\Delta'(\tau) > 0$  as the dotted curve in the figure. The firm now makes greater profits from workers with high  $\tau$ . Therefore, as long as the costs of worker training are not too large,

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<sup>2</sup>However, it has to be borne in mind that these training data are collected using different methods and are not easily comparable.

<sup>3</sup>The evidence in Bishop (1987) suggests that in the U.S., wages across workers doing the same job in the same firm differ much less than productivity, so that even in the U.S., the structure of wages is distorted against more skilled workers.

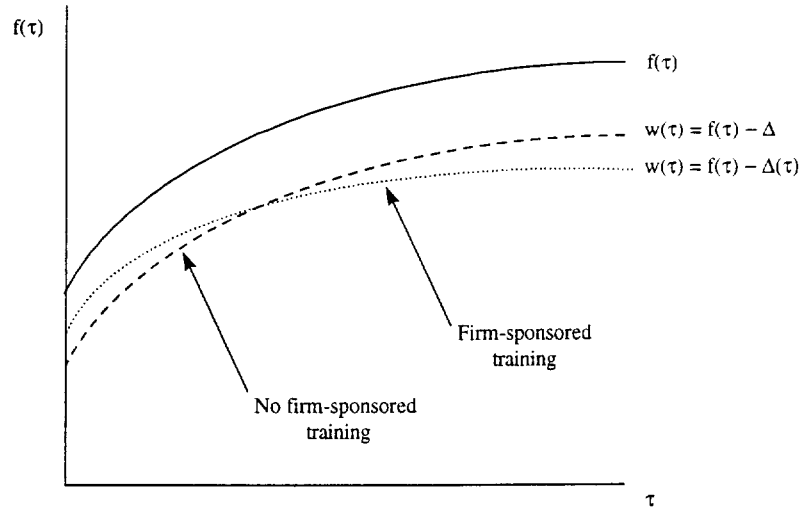


Figure 1: The Wage Structure and Training

the firm will invest in  $\tau$ . This is the basic story of our paper.

The main contributions of our paper are the focus on how labor market imperfections transform technologically general skills into specific skills and the link we draw between the structure of wages and training. Our finding on how labor market institutions distort the structure of wages and encourage training are also novel. These results will be discussed in Section 2, which will also establish that when the structure of wages is distorted, firms may invest in general skills and workers may not, even when workers have access to perfect credit markets.

Why should the structure of wages be distorted against more skilled workers? We analyze this issue in Section 3. We show that a range of labor market institutions, such as union wage setting and minimum wages, and plausible frictions, such as search, informational asymmetries and efficiency wages, can lead exactly to this type of distortion. Further, even when trading in the labor market is frictionless, the interaction between technologically general and specific skills may induce firms to invest in the general skills of their workers. Therefore, our model predicts that in a variety of circumstances, we should observe firm-sponsored investments in general training. Moreover, such investments should be more common when labor market frictions and institutions distort the structure of wages against more skilled workers. Other papers on firm-sponsored invest-

ment in general training have investigated much more specific models, some of those similar to the ones we analyze in Section 3, and so they will be discussed there.

## 2 Partial Equilibrium

### 2.1 The Environment

Consider the following two-period model. In period 1, the worker and/or the employer choose how much to invest in the worker's general human capital, which we denote by  $\tau \in \mathbb{R}_+$ . There is no production in the first period, and we denote the wage of the worker in this period by  $\omega(\tau)$ , which is conditioned on the training that the worker receives. For example,  $\omega(\tau) < 0$  represents a payment from the worker to the firm. In period 2, the worker either stays with the firm and produces output and is paid a wage rate,  $w(\tau)$  as a function of his skill level (training)  $\tau$ , or he quits and obtains an outside wage. We assume that with probability  $q$ , the firm and the worker receive a negative shock, cease to be productive together and separate. With probability  $1 - q$ , the worker and the firm can continue their productive relation.  $q$  will therefore be a measure of turnover in our model. There is no discounting, and all agents are risk-neutral and have preferences defined over the unique good of this economy.

Each worker produces output  $y = f(\tau)$  independent of the number and human capital of other workers.<sup>4</sup>  $f(\tau)$  is an increasing, differentiable and concave function. The cost of acquiring  $\tau$  units of skill is  $c(\tau)$  in terms of the final good and is incurred by the firm (although the worker can pay for it by having  $\omega(\tau) < 0$ ). We assume that  $c(\tau)$  is everywhere strictly increasing, differentiable and convex, and  $c'(0) = c(0) = 0$  and  $\lim_{\tau \rightarrow \infty} c'(\tau) = \infty$ . These ensure that the first-best training level,  $\tau^*$ , is given by  $c'(\tau^*) = f'(\tau^*)$ , and from the assumptions on the cost of training,  $\tau^* > 0$ .

The assumption that there are no (technologically) firm specific skills is extreme, but serves to highlight the economic mechanism we are interested in: the presence of frictions may transform technologically general capital into firm-specific human capital. In Section 3.6 we will discuss how technologically specific and general skills interact.

We consider two cases below. The first is the *credit constrained regime* where the worker cannot make any transfers to the firm for providing him with human capital, nor can he take a wage cut during training in order to compensate the firm for the expenses of training. In terms of our notation,  $\omega(\tau) \geq 0$ . The second case is the *perfect credit*

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<sup>4</sup>This assumption is not as restrictive as it appears. For example, if total output is a function of human capital  $H$  and physical capital  $K$ ,  $F(H, K)$ , exhibits constant returns to scale and  $K$  can be adjusted freely, the output of a worker  $y = f(\tau)$  will be independent of the level of  $H$ . This is because an optimizing firm will keep the ratio of physical to human capital,  $K/H$ , constant.

*markets regime* where the worker is not affected by credit constraints, so  $\omega(\tau) < 0$  is possible.

## 2.2 Training in a Perfectly Competitive Labor Market

If a worker quits after the first period, she receives a wage of  $v(\tau)$  in the outside labor market. In this section, we take the outside wage structure  $v(\tau)$  as given and look at the determination of the internal wage structure  $w(\tau)$ . To start with, suppose that the labor market is competitive, which implies  $v(\tau) = f(\tau)$ , and the worker can quit and take a job in the outside market at no cost. Therefore, workers have to be paid their full marginal product:<sup>5</sup>  $w(\tau) = v(\tau) = f(\tau)$ . The following result is immediate:

**Proposition 1** *Suppose we are in the credit constrained regime and labor markets are competitive. Then  $\hat{\tau} = 0$ .*

Due to the severe credit constraints, the worker cannot be made to bear the cost of training, so no investment takes place, even though the optimal amount of training,  $\tau^*$ , is strictly positive. It is sometimes asserted that credit constraints faced by workers may induce firms to invest in general training. Proposition 1 shows that credit constraints are not sufficient for firm sponsored investments in training.

Before we turn to the core of our analysis, it is also useful to state the main conclusion of Becker (1964), that with perfect credit markets, first-best training is achieved and workers pay for it.

**Proposition 2 (Becker)** *Suppose we are in the perfect capital markets regime and labor markets are competitive. Then  $\hat{\tau} = \tau^*$  and  $\omega(\tau^*) = -c(\tau^*)$ .*

Note that the presence of separations with probability  $q$  is of no consequence because the worker will get exactly the same returns for his general human capital in the outside market.

## 2.3 Frictional Labor Markets with Credit Constraints

In this section, we model frictional labor markets by assuming that  $v(\tau) < f(\tau)$ . That is, despite that fact that  $\tau$  is general human capital, if the worker separates from the firm, he will get a lower wage than his marginal product in the current firm. In the next section, we discuss in detail how different forms of frictions and institutions determine  $v(\tau)$  and its relation to  $f(\tau)$ . For now, the fact that  $v(\tau) < f(\tau)$  implies that there

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<sup>5</sup>Recall that marginal product of the worker is equal to  $f(\tau)$  not  $f'(\tau)$ .



is a surplus that the firm and the worker can share when they are together. For the exposition in this section, we adopt the Nash bargaining approach. We also start with the credit constrained regime and return to the case of perfect credit markets below.

Asymmetric Nash bargaining and risk-neutrality imply that  $w(\tau)$ , the wage at the current firm, is

$$w(\tau) = v(\tau) + \beta [f(\tau) - v(\tau) - \pi_0], \quad (1)$$

where  $\beta \in [0, 1]$  is the bargaining power of the worker.  $\pi_0$  is the outside option of the firm, that is how much profit the firm would obtain if the worker left and took alternative employment. Without loss of generality, we normalize  $\pi_0$  to 0.

An important point to note is that the equilibrium wage rate  $w(\tau)$  is independent of  $c(\tau)$ , the cost of training. This is a feature of the temporal structure of our economy. The level of training is chosen by the firm, and then the worker and the firm bargain over the wage rate. At this point the training costs are already sunk.

Profits of the firm are:

$$\pi(\tau) = (1 - q) [f(\tau) - w(\tau)] - c(\tau) = (1 - \beta)(1 - q) [f(\tau) - v(\tau)] - c(\tau).$$

where we have incorporated the fact that with probability  $q$ , there will be an involuntary separation, and also imposed that all the costs of training are borne by the firm because the worker is credit constrained. The firm chooses  $\tau$  to maximize  $\pi(\tau)$ , which gives the first-order condition:

$$(1 - \beta)(1 - q)(f'(\hat{\tau}) - v'(\hat{\tau})) - c'(\hat{\tau}) = 0. \quad (2)$$

The necessary condition for  $\hat{\tau} > 0$ , that is for the firm to invest in the general human capital of the worker, is  $\pi'(0) > 0$ . Since  $c'(0) = 0$ , necessary conditions for firm sponsored investment in general training are:  $f'(0) > v'(0)$  and  $(1 - \beta)(1 - q) > 0$ .

**Proposition 3** *Suppose we are in the credit constrained regime, labor markets are frictional,  $\beta < 1$ , and  $q < 1$ . Then as long  $f'(0) > v'(0)$ , the firm will invest a positive amount in general skills.*

This is the central result of our paper. In contrast to the case of competitive labor markets, in frictional markets, the firm may have an incentive to invest in the general skills of its workers. The condition,  $f'(0) > v'(0)$ , nests the key idea of our model;<sup>6</sup> it

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<sup>6</sup>The additional requirements that  $\beta < 1$  and  $q < 1$  are straightforward to understand. They ensure that the firm gets some rents from the relation, that is some of the bargaining power is vested in the firm and the relation does not end with probability 1.

implies that the wage structure is compressed at the point of no training, encouraging the firm to invest in the general skills of the worker. What is relevant to the firm is the wage it will pay  $w(\tau)$ , that is the internal wage structure. However, the internal wage structure is endogenous, and is linked to the external wage structure,  $v(\tau)$ . In particular, (1) implies  $w'(\tau) = \beta f'(\tau) + (1 - \beta)v'(\tau)$ . Therefore,  $f'(\tau) > v'(\tau)$  is equivalent to  $f'(\tau) > w'(\tau)$ , so that wages increase less with skills than does productivity and the firm makes higher profits from trained workers. In other words, the internal wage structure is distorted only when the external wage structure is.<sup>7</sup>

Even though a distorted wage structure encourages firms to pay for training, equilibrium training,  $\hat{\tau}$ , is generally strictly less than the first-best training level,  $\tau^*$ . In particular, as long as  $\beta > 0$  and  $v'(\tau^*) > 0$ , or if  $q > 0$  it immediately follows from equation (2) that  $\hat{\tau} < \tau^*$  ( $\beta = 0$ ,  $q = 0$ , and  $v'(\tau^*) = 0$  are necessary but not sufficient to ensure  $\hat{\tau} = \tau^*$ ).

A key comparative static result is immediate. Let  $v(\tau) = a\tilde{v}(\tau) + b$ . Then, everything else being equal, a reduction in  $a$  increases investment in training,  $\hat{\tau}$  (see equation (2)). A decrease in  $a$  reduces the outside option of skilled workers relative to the outside opportunities of the unskilled, compressing the wage structure. This implies that the firm can capture additional rents from the skilled, so it invests more in the worker's skills. Therefore, contrary to conventional wisdom, a more compressed wage structure can improve human capital investments.

Another useful comparative static result is with respect to turnover,  $q$ . (2) immediately implies that  $d\hat{\tau}/dq < 0$ . Therefore, turnover reduces training, because the firm only benefits from training when the worker stays and produces in the second period, and higher turnover makes this less likely. It is often argued that high turnover economies such as the U.S. do not generate sufficient investments in worker skills, and that this represents an important market failure (e.g. Blinder and Krueger, 1996). Indeed, cross-sectional comparisons reveal that high turnover countries have lower training. For example, Topel and Ward (1992) find that the median number of jobs held by male worker with ten years of experience is six in the U.S. labor market, while it is one (Acemoglu and Pischke, 1998) or two (Dustmann and Meghir, 1997) in Germany, where young workers are much more likely to receive formal training (see also OECD, 1994). But the statements regarding turnover, training and market failures are difficult to interpret against the background of Becker's model of training: as we saw, in competitive markets either  $\hat{\tau} = 0$  or  $\hat{\tau} = \tau^*$  irrespective of the level of  $q$ . Our model explains these correlations and suggests why high turnover causes low training, and why this may represent a market

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<sup>7</sup>This is a feature of Nash Bargaining. Other bargaining solutions will give similar results, but would make the dependence of the internal on the external wage structure less transparent.

failure.<sup>8</sup>

While we find an important link between general training and turnover, we should stress that it is not differences in worker mobility which lead to variations in firm-sponsored training. To see this, suppose that differences in  $q$  are being generated by differences in workers' costs of moving to a new employer,  $\Delta$ . As long as these costs do not differ by skill level (i.e.  $\Delta'(\tau) = 0$ ), as in the baseline case in Figure 1, the firm may be able to extract a fraction of the rents created by imperfect mobility, but will not invest in training. Therefore, the mere presence of mobility costs is not sufficient for training. In the same vein, the presence of turnover is not sufficient for training: with  $v'(\tau) = f'(\tau)$  everywhere, there would be no training irrespective of the value of  $q$ .

## 2.4 A Note on Welfare

Interestingly, the distortion of the wage structure may actually improve welfare. This is the well-known theory of the second-best at work. If workers are credit constrained and cannot invest in their general skills, training outcomes are inefficient. Another distortion, in this case in the labor market, may induce firms to undertake some of these investments, and improve output and welfare.

If labor market frictions did not affect any other choices, a move from  $v(\tau) = f(\tau)$  to  $v(\tau) = af(\tau) + b$  with  $a < 1$ , i.e. tilting the outside wage function down as in Figure 1, would increase human capital investments. This will also increase net output since equilibrium training  $\hat{\tau} = 0 < \tau^*$  when  $v(\tau) = f(\tau)$ . Naturally, in practice, increased frictions will have a number of allocative costs, such as lower employment. These costs need to be compared to the benefits in terms of better training incentives. In any case, the implications of labor market frictions on training are worth bearing in mind when suggesting labor market reforms. For example, proposals for reducing union power and removing other regulations in the German labor market, which are on the current political agenda, could have unforeseen consequences regarding the German apprenticeship system where employers pay for the general training of their workers.

## 2.5 Firm Sponsored Training Without Credit Constraints

We now discuss the impact of labor market frictions on training in the presence of perfect capital markets. The truth is presumably between these two extreme cases, but our analysis in this section will give the general idea. Most important, we find that

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<sup>8</sup>Since  $\hat{\tau} < \tau^*$ , a further reduction in  $\hat{\tau}$  would reduce welfare. Also note that if the training differences across countries are due to variations in the intensity of specific training, the standard theory would predict the negative relation between turnover and training, but there would be no market failure. However, we find this unlikely because most observed training is through formal training programs.

contrary to common beliefs, credit market problems are *not* necessary for firms to bear the cost of general training. Whether they do or not is once again determined by the labor market imperfections and institutions which shape the wage structure.

We also assume that training investments by firms and workers are chosen non-cooperatively. In particular, the worker and the firm simultaneously choose the amount of money they wish to spend on training, respectively,  $c_w$  and  $c_f$ . The amount of training is  $\tau_{nc}$  such that  $c(\tau_{nc}) = c_w + c_f$ , or  $\tau_{nc} = c^{-1}(c_w + c_f)$ . Then the worker will maximize  $v(\tau_{nc}) + (1 - q)\beta [f(\tau_{nc}) - v(\tau_{nc})] - c_w$  by choosing  $c_w \geq 0$  and will take  $c_f$  as given. Intuitively, with probability  $1 - q$ , the worker stays with the firm and in this case his wage is  $\beta f(\tau) + (1 - \beta)v(\tau)$ . With probability  $q$ , he is forced to quit, and receives  $v(\tau)$ . The first order condition for the worker's contribution is:

$$\begin{aligned} v'(\tau_{nc}) + (1 - q)\beta [f'(\tau_{nc}) - v'(\tau_{nc})] - c'_w &= 0 & \text{if } c_w > 0 \\ &\leq 0 & \text{if } c_w = 0 \end{aligned} \quad (3)$$

Similarly, the firm maximizes  $(1 - q)(1 - \beta) [f(\tau_{nc}) - v(\tau_{nc})] - c_f$  by choosing  $c_f \geq 0$  and taking  $c_w$  as given. Note that with probability  $q$  there is a quit, and the firm gets nothing from its investment in the worker. The first order condition for the firm is:

$$\begin{aligned} (1 - q)(1 - \beta) [f'(\tau_{nc}) - v'(\tau_{nc})] - c'_f &= 0 & \text{if } c_f > 0 \\ &\leq 0 & \text{if } c_f = 0, \end{aligned} \quad (4)$$

which is essentially the same as (2). Inspection of equations (3) and (4) implies that generically, one of them will hold as a strict inequality. The implication is that one of the parties will bear the full cost of training. More precisely, let  $\tau_w$  be the level of training that satisfies (3) as equality, and  $\tau_f$  be the solution to (4). Then:

**Proposition 4** *Suppose  $\tau_f > \tau_w$  then the firm will bear all the cost of training and  $\tau_{nc} = \tau_f$ . In contrast if  $\tau_w > \tau_f$ , then the worker bears all the cost of training, and  $\tau_{nc} = \tau_w$ .*

Despite the fact that training is general, and the worker is *not* credit constrained, the firm may end up paying for all the costs of training. Therefore, for our results that firms pay for general training (with little or no contribution from workers) to be true, we do not need the workers to be severely credit constrained. It is also interesting to observe that the more distorted the wage structure is (i.e. the lower is  $v'$  relative to  $f'$ ), the more likely is the firm to pay for training. Therefore, our model predicts that in economies with compressed wage structures such as Germany and Sweden, employers

should pay for general training, while in the U.S. it may be the workers who bear the cost of a range of training investments (such as vocational courses). Moreover, when the firm is paying for training, a further distortion in the wage structure increases training, whereas when workers are paying for training, a distortion in the structure of wages will reduce training. Finally, inspection of (3) and (4) shows that, somewhat paradoxically, a larger bargaining power for the firm makes it more likely that the firm, rather than the worker, will finance the costs of training.

The analysis in this subsection assumed that contributions to training are made non-cooperatively, in the sense that the firm and the worker did not write a binding contract in period 1 determining training and second-period wages. It is generally appreciated that these types of contracts are difficult to write and enforce. Nonetheless, it is instructive to also analyze the case where training decisions are made cooperatively. It is no longer possible to make predictions regarding how the cost of training will be shared, because it is always possible for the worker to pay more for training in period 1 and contract for a higher wage in period 2. What is of interest, however, is that even in the presence of cooperative investments, the amount of training is generally suboptimal. As long as  $q > 0$ , when the firm and the worker decide to increase training, they will create a positive externality on the worker's future employers, who will also benefit from his higher training because  $v(\tau) < f(\tau)$ .<sup>9</sup>

### 3 Specific Mechanisms and the Role of Institutions

The previous section described our simple theory of firm sponsored investment in general training. The key ingredient was a compressed wage structure such that  $f'(\tau) > w'(\tau)$ . We found that the crucial condition to ensure this is  $f'(\tau) > v'(\tau)$ , that is, outside opportunities for the worker should improve less than his productivity when he acquires more skills. Therefore, the shape of the outside wage function in the skill-wage space,  $v(\tau)$ , is of crucial importance. Even though this is taken as given by the firm and the worker, it is an equilibrium object. In this section we discuss how a range of plausible labor market frictions lead to a distortion in the external wage structure,  $v(\tau)$ , inducing firm sponsored training. We place special emphasis on the role of different institutional arrangements in influencing  $v(\tau)$  and equilibrium training. Throughout this section, we simplify our discussion by assuming that the worker is severely credit constrained, and cannot pay for any of the training costs, so we only study the firm's incentives to invest

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<sup>9</sup>The exception is the model discussed in subsection 3.6, where  $v(\tau)$  is less than  $f(\tau)$  but equal to the marginal product of the worker with the new employer so that there are no externalities. See Acemoglu (1997) for a more detailed discussion of this type of inefficiency in the context of a model with search frictions.

in skills. Our aim in this section is to bring out the major ideas rather than analyze each model fully. For this reason we keep the exposition as simple as possible.

### 3.1 Minimum Wages and Other Wage Floors

Perhaps the most common intervention in the labor market is the imposition of wage floors, due to minimum wages and high reservation wages caused by unemployment benefits. Minimum wages and replacement ratios are relatively low in the U.S. and the U.K. as compared to the higher levels in France and other European economies. How do these institutional differences affect training?

It is well known that the imposition of a minimum wage can never lead to more training when labor markets are competitive (Rosen, 1972). The intuition for this result is simple: because workers pay for training through lower wages, a minimum wage may prevent the firm from reducing wages enough during the training period. This is the rationale behind the introduction of “training subminima” in many recent U.S. minimum wage laws.

Now consider a labor market with frictions, where  $v(\tau) = f(\tau) - \Delta$ , due to, say, a moving cost, unrelated to skill. It is important to realize that this distortion does not in and of itself lead to firm-sponsored training;  $v(\tau)$  is not distorted, thus (2) from the previous section would imply  $\hat{\tau} = 0$ . Also suppose that the firm has all the bargaining power ( $\beta = 1$ ) so that  $w(\tau) = v(\tau)$ .

Next consider a wage floor  $w_M$  due to either minimum wages or unemployment benefits which increase the value of unemployment to workers (independently of skill). The structure of wages is then:

$$w(\tau) = \max \{w_M, f(\tau) - \Delta\}, \quad (5)$$

which is kinked at  $w_M$ , thus distorted at low levels of  $\tau$ . The firm then chooses  $\tau$  to maximize  $f(\tau) - w(\tau) - c(\tau)$ . We will have  $\hat{\tau} > 0$  as long as the firm chooses to operate, because the condition for a positive training level, a distortion in the structure of wages, is satisfied. Hence, in the presence of labor market frictions, minimum wages will *increase* training (unless they induce the firm to shut down).<sup>10</sup>

Notice the stark contrast of these predictions to the standard human capital model. With competitive markets, a minimum wage just below  $f(0)$  is most detrimental to

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<sup>10</sup> The exact level of training depends on the relative positions of the kink in the wage relation and  $\tau^*$ . In particular, let  $\bar{\tau}$  be such that  $f(\bar{\tau}) - \Delta = w_M$ . Then, if  $\bar{\tau} \leq \tau^*$  and  $c(\bar{\tau}) \leq \Delta$ , the firm will operate and choose  $\hat{\tau} = \bar{\tau}$ . If  $\bar{\tau} > \tau^*$  and  $f(\tau^*) \geq c(\tau^*) + w_M$  then the firm will operate and choose  $\hat{\tau} = \tau^*$ . Finally, if  $\bar{\tau} > \tau^*$  and  $f(\tau^*) < c(\tau^*) + w_M$ , or if  $\bar{\tau} \leq \tau^*$  and  $c(\bar{\tau}) > \Delta$ , then the firm will choose not to operate.

the accumulation of general human capital because it prevents the worker from taking a wage cut in the first period to compensate the firm for the costs of training. With frictions, in contrast, such a minimum wage would not shut down the firm, and would imply  $f'(0) > w'(0) = 0$ , inducing the firm to invest in general training

Given the contrast between our results and those based on Becker's theory of general training where workers bear the costs, it is instructive to look at the empirical evidence regarding the impact of minimum wages on training. At the international level, our result is consistent with the pattern that the more heavily regulated European labor markets generate more firm-sponsored training than the U.S. At the micro level, the evidence is mixed. Leighton and Mincer (1981) find negative effects of minimum wages on training, while Grossberg and Sicilian (1997) find negative effects for male workers and positive effects for women.

## 3.2 Unions

Another important institutional difference across economies is the role played by unions. In Germany and Scandinavian countries unions are heavily involved in wage determination, while in the U.S. they have traditionally been less prominent and their importance has been declining. Furthermore, it is commonly believed that unions compress the wage structure against more highly paid workers (Freeman and Medoff, 1984).

In this subsection we turn to union wage setting (instead of individual Nash bargains discussed above). We assume that a union can set the entire wage structure  $w(\tau)$  at the beginning of the period, and then the firm chooses training. Hence, this model is an analogue to the standard monopoly union (right-to-manage) model, except that we replace the firm's labor demand decision with the training decision. We assume that  $f(\tau) \geq v(\tau)$  and the union sets  $w(\tau) \geq v(\tau)$  so that the workers do not leave for outside opportunities. The firm maximizes  $\pi(\tau) = f(\tau) - w(\tau) - c(\tau)$ .

We start with the simple case where the union can only choose one wage for all training levels,  $w(\tau) = w$ , and we will then see that the union cannot improve over this situation. The union will anticipate the behavior of the firm which can be summarized by the first order condition,  $f'(\tau) = c'(\tau)$ . It is immediately obvious from the fact that the wage does not vary with skill that the firm will choose the efficient training level  $\tau^*$ .

The union simply maximizes the wage income of the worker (since the worker is not paying for the costs of training). However, it has to make sure to obey the participation constraint of the firm,  $\pi(\tau^*) \geq 0$ , otherwise the firm will prefer not to hire any workers. This implies that the union will set the wage so as to extract all rents and force the firm

down to zero profits. Therefore, the optimal wage is  $w^* = f(\tau^*) - c(\tau^*)$ .<sup>11</sup>

The firm invests in training because  $f'(\tau) > w'(\tau) = 0$ . The training investment is efficient because the union gets a fixed payment and the firm is the full residual claimant. This immediately implies that the union cannot do better by choosing the whole wage schedule,  $w(\tau)$ . If there were ex ante heterogeneity among covered workers, the union would no longer choose a single wage. However, it can be shown in this case that the union would still choose to compress the wage structure and induce the firm to invest in training.

The predictions of our model once again contrast with the standard theory. We predict that by compressing the wage structure, unions should encourage firms to sponsor training programs. In contrast, in the standard approach a distortion of the wage structure against more skilled workers would reduce the return to training and workers would be less willing to invest. The general pattern predicted by our model is once again consistent with international comparisons. But, the micro evidence is mixed. Studies by Duncan and Stafford (1980) and Mincer (1983) based on the PSID, Lillard and Tan (1992) based on the CPS, and Barron, Fuess, and Loewenstein (1987) based on the EOPP find negative effects of union status on training. Barron, Berger, and Black (1997), on the other hand, report insignificant union effects using the EOPP data and find positive effects for formal training in the Small Business Administration survey. Lynch (1992) also finds positive effects for formal training in the NLSY. For the UK, Booth (1991) reports more training for union workers and Green (1993) finds more training for unionized workers in small establishments but not in large establishments.

### 3.3 Search and Monopsony

Consider the same set-up as in Section 2, but in the second period the worker has to find a new firm if he quits. With probability  $p_w$ , the worker is successful and finds a new firm and with probability  $1 - p_w$  the worker is unemployed and receives benefit  $b$  which is independent of  $\tau$ .<sup>12</sup> If he finds an employer, he has to bargain with this firm to determine wages. Since there is no further period, the worker's outside option in this second bargain is 0. Assuming the same bargaining power,  $\beta$ , for the worker as above, he will get a wage  $w_2(\tau) = \beta f(\tau)$  and his new firm will capture a proportion  $1 - \beta$  of the output. The fact that there is no further period is a special, but nonessential, feature. In

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<sup>11</sup>Interestingly, this result does not depend on whether the rest of the economy is unionized or competitive and whether bargaining is establishment based or centralized. In all cases, the union will set  $w = w^*$  and induce training  $\tau^*$ .

<sup>12</sup>All our results would hold in the case where  $b = b(\tau)$  and  $b'(\tau) < f'(\tau)$ , as is the case for most unemployment insurance systems.



the Appendix we analyze the case where this economy has infinite horizon and establish the same result.

The outside option of the worker in the bargain of the first period is  $v(\tau) = p_w\beta f(\tau) + (1 - p_w)b$ . The first order condition for the firm's investment in training is  $(1 - \beta)(1 - p_w\beta)f'(\tau) = c'(\tau)$ . As in Section 2, the condition for firm-sponsored training is  $f'(0) > v'(0)$ . This is equivalent to:  $p_w\beta f'(0) < f'(0)$  which will be satisfied if  $p_w < 1$  or  $\beta < 1$ .

We refer to this situation as search induced monopsony; because it is costly for the worker to change employers, the firm has some monopsony power and this enables the firm to capture part of the higher output due to the worker's higher productivity. The costs of leaving the current firm, which underlie the monopsony power of the firm, are twofold. First, the worker anticipates that his future employers will also bargain with him and capture a certain fraction of his productivity. Thus, the monopsony power of potential future employers contribute to the monopsony power of the current employer. Second, a worker who quits can suffer unemployment and this reduces the return to quitting. Moreover, the possibility of unemployment reduces the return to leaving the current firm especially for the more skilled workers, because skills are not useful when unemployed. This also contributes to the distortion in the wage structure and to firm-sponsored training (see the Appendix and also Acemoglu 1997, for further details).

Interestingly, this model predicts that when the labor market is more "frictional" in the sense that  $p_w$ , the exit rate from unemployment, is lower and unemployment higher, we should observe more training. The same result is obtained in the dynamic model discussed in the Appendix. This result is once again contrary to conventional wisdom that labor market frictions reduce human capital investments, but in line with broad international comparisons. OECD (1993) reports the monthly exit rates from unemployment as follows: 48.2% in the U.S., 22% in Japan, 7.6% in Germany and 6.7% in France. So the economies with lower exit rates once again are the ones with more investments in training, as predicted by our model.

### 3.4 Asymmetric Information

Skills may be technically general, but outside employers may be unable to ascertain whether a worker actually possesses these skills or in what amount or quality. If this is the case, the outside wage will not reflect these uncredentialed skills, or not reflect them fully so that  $f'(\tau) > v'(\tau)$ . This has been suggested by Katz and Ziderman (1990) and analyzed by Chang and Wang (1996). Bishop (1994) finds empirical support for this notion using data from the National Federation of Independent Business Survey.

However, information advantages of the incumbent employers may lead to firm spon-

sored training even if the skills are easily observable. For example, the content of German apprenticeship programs are well-known, thus  $\tau$  is observed by outside firms, but the initial employer still has superior information regarding the ability of its workers. We have analyzed this case in Acemoglu and Pischke (1998), and the following adverse selection model is based on our previous work. Workers have two different abilities denoted by  $\eta$ . A proportion  $p$  are low ability and, for simplicity, we normalize their ability to  $\eta = 0$ . The remaining proportion  $1 - p$  are high ability with  $\eta = 1$ . The production function is  $f(\tau, \eta) = \tau\eta$ .

The incumbent firm does not know the ability of a particular worker at the beginning of period 1. At this time, it must decide about training. At the end of period 1 it learns the worker's type and offers a wage which can be contingent on ability. Outside firms do not know worker ability, but observe the level of training the worker has received. They offer a wage,  $v(\tau)$ , conditional on training, but not ability. Workers quit their original employer whenever the outside wage is higher,  $v(\tau) > w(\tau, \eta)$ . We also assume that there are other reasons for quits. Even if  $v(\tau) \leq w(\tau, \eta)$ , workers will separate for exogenous reasons with probability  $\lambda$ .

To avoid issues of bargaining with asymmetric information, we give all the bargaining power to the incumbent firm by setting  $\beta = 0$ . Therefore, a firm will offer a wage of 0 to low ability workers. In addition, it will offer the lowest possible wage to high ability workers,  $w(\tau, \eta) = v(\tau)$ , and will lose a fraction  $\lambda$  of these workers to turnover. The outside market is competitive, but as noted above, cannot distinguish high ability workers from the low ability ones. Competition will therefore ensure that the outside wage equals the expected productivity of workers who separate. Since some high ability workers quit,  $v(\tau) > 0$ . This implies that all low ability workers will also quit to take advantage of the higher outside wage. In equilibrium, expected productivity and the wage in the outside market are:

$$v(\tau) = \frac{\lambda(1-p)\tau}{p + \lambda(1-p)}.$$

The incumbent employer keeps a fraction  $(1 - \lambda)(1 - p)$  of workers, all of which are high ability. Therefore, profits are given by:

$$\pi(\tau) = (1 - \lambda)(1 - p) [\tau - w(\tau, 1)] - c(\tau) = (1 - \lambda)(1 - p) [\tau - v(\tau)] - c(\tau).$$

In words, the firm pays the cost of training for all workers because worker ability is not observed before training. After training all low ability and a proportion  $\lambda$  of high ability workers leave, the firm pays  $v(\tau)$  to the remaining workers, and makes profits equal to  $\tau - v(\tau)$  per worker. The first order condition for training is:

$$\pi'(\tau) = (1 - \lambda)(1 - p) [1 - v'(\tau)] - c'(\tau) = 0. \quad (6)$$

The firm only retains highly skilled workers, so  $f'(\tau) = 1$ . Since we also have  $c'(0) = 0$ , the necessary and sufficient condition for firm sponsored training is  $v'(0) < 1$ , our familiar condition that the wage structure should be compressed. It is immediate to see that this condition is always satisfied, because  $v'(\tau) = \lambda(1-p)/[p + \lambda(1-p)] < 1$ . Intuitively, the presence of low ability workers in the second hand market implies that firms view workers in this market as lemons, and therefore are unwilling to pay high wages. More important, they do not increase their wage offers by much for workers with higher  $\tau$ , because training is not useful to low ability workers who are the majority of those in the second hand market.

Many of the assumptions in this example are inessential and were only made for reasons of exposition. The crucial assumption is that training and ability are complements, which we captured by the multiplicative production function  $f(\tau, \eta) = \tau\eta$ . To see the importance of complementarity between unobserved ability and training, consider instead that  $f(\tau, \eta) = \tau + \eta$ . The outside wage in this case is:

$$v(\tau) = \frac{p\tau + \lambda(1-p)(1+\tau)}{p + \lambda(1-p)} = \tau + \frac{\lambda(1-p)}{p + \lambda(1-p)}.$$

The outside wage now increases one for one with  $\tau$ , that is  $v'(\tau) = 1$ . Therefore, (6) is satisfied at  $\tau = 0$ , and the firm does not invest in the training of its workers. This is due to the fact that training raises the productivity of the more and less able by an equal amount. Asymmetric information still leads to rents for the incumbent firm, but it does not lead to a distortion of the wage structure.

In Acemoglu and Pischke (1998), we present empirical evidence for adverse selection among German apprentices. We show that apprentices who leave their training firm because of the military draft (an exogenous separation) earn more than those who stay at the apprenticeship firm and other quitters. Unlike other quitters *and* workers who stay at the training firm, military quitters are freed from the adverse selection problem, because the reason for their separation is observed by the outside market.

### 3.5 Efficiency Wages

Suppose that the firm invests in general training in the first period. In the second period, it chooses what wage to offer to the worker. There is a moral hazard problem which requires the firm to pay an efficiency wage. The worker can either exert effort at cost  $e$  in which case he produces  $f(\tau)$  where, as before,  $\tau$  is general human capital. Or he exerts no effort and produces nothing. If  $e$  or a variable highly correlated with  $e$  were contractible, there would be no moral hazard problem.<sup>13</sup> Instead, a worker who exerts

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<sup>13</sup>It is natural that the effort level of the worker is not always observed. Also, in most firms, rather than the output of an individual worker, only the output of a whole division is observed, and this is not

no effort has a probability  $q$  of getting caught. We assume that both the firm and the worker are risk-neutral, and there is a limited liability constraint, so that the worker cannot be paid a negative salary. Finally, to simplify the analysis, we assume that the firm has all the bargaining power.

Since a worker caught shirking will receive 0, the incentive compatibility condition to exert effort is:

$$w - e \geq (1 - q)w.$$

Therefore, the firm trying to minimize costs would choose  $w = e/q$  if it can. There is also a participation constraint for the worker to be satisfied. We assume that the participation constraint takes the form  $w \geq f(\tau) - \Delta$  where  $\Delta > 0$  is the amount of output or utility that the worker loses by changing jobs, which is independent of skill.

It is clear that the optimal wage structure, which satisfies the incentive and participation constraints above, is:

$$w(\tau) = \max \left\{ \frac{e}{q}, f(\tau) - \Delta \right\}.$$

The firm will then choose  $\tau$  to maximize profits  $f(\tau) - w(\tau) - c(\tau)$ . Observe that this wage function is identical to (5) in the case of minimum wages, with  $e/q$  replacing  $w_M$ . As in that case, this distortion will encourage firms to invest in general training (as long as  $e/q$  is not so high as to shut down production). So in general  $\hat{\tau}$  will be positive.<sup>14</sup>

### 3.6 Firm Specific Human Capital

Our analysis has so far concentrated on general human capital for clarity. However, it is undoubtedly true that there exist skills which are much more useful in the current firm than the outside. Becker's (1964) classic analysis discussed investment in such skills and concluded that the firm should pay for at least part of the costs. Although Becker's analysis once again assumed competitive markets, in the presence of purely specific skills, markets will not be competitive in the most usual sense of this word. In particular, if a worker has some skills that can only be used in one firm, then for one of

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easy to use to provide incentives to individual workers.

<sup>14</sup>The exact conditions for training are the same as those given in footnote 10. The assumption that the incentive compatibility constraint is independent of future job opportunities, and thus of skills, is not crucial. The result holds as long as the constraint induces a relation between wages and skills less steeply sloped than  $f(\tau)$ .

The model by Loewenstein and Spletzer (1998) has a similar flavor. In their model firms can commit ex ante to pay a certain wage in the second period in order to reduce turnover. Whenever this constraint is binding for the firm, the firm has an incentive to invest in the worker's general skills.

the commodities, there is only one buyer and one seller, so price-taking behavior does not apply. In this subsection we will show that this deviation from perfect competition can also support firm investment in general skills.

Assume that output in the second period is now given as  $y = f(\tau, s)$  where  $s$  is firm specific human capital. In the first period the firm again chooses  $\tau$  at cost  $c(\tau)$ . The source of the firm-specific skill,  $s$ , is inessential: it could be acquired during the first period that the worker spends with the firm (for example, via a learning mechanism as in Jovanovic, 1979), so  $s > 0$ . Alternatively, the firm chooses how much to invest in these skills with some cost function  $\phi(s)$  such that  $\partial f(\tau, 0)/\partial s > \phi'(0)$  so that the firm would always like to have some positive amount of firm-specific skills. Both scenarios are equivalent for the purposes of this section.

Let us also adopt Bertrand competition among outside firms so that  $v(\tau) = f(\tau, 0)$ . More generally, even if  $v(\tau)$  is not equal to  $f(\tau, 0)$  it will be independent of  $s$  since  $s$  is only useful in the current firm. The independence of  $v(\tau)$  of  $s$  is the crucial ingredient in this case.

Assuming Nash Bargaining once more, we have  $w(\tau) = \beta f(\tau, s) + (1 - \beta)f(\tau, 0)$ . The firm will then choose:

$$\max_{\tau} \pi(\tau, s) = f(\tau, s) - w(\tau, s) - c(\tau).$$

As before, this implies that the firm will invest  $\hat{\tau} > 0$  only if  $\beta < 1$  and  $\partial f(0, s)/\partial \tau > v'(0)$  or if  $\partial f(0, s)/\partial \tau > \partial f(0, 0)/\partial \tau$ . Therefore, for firm sponsored investment in *general* training we need  $\partial^2 f(\tau, s)/\partial \tau \partial s > 0$ , that is a complementarity between firm-specific and general skills. In fact, since  $c'(0) = 0$ , it is necessary and sufficient for firm-sponsored investments in general training that  $\partial^2 f(\hat{\tau}, s)/\partial \tau \partial s > 0$  and  $\beta < 1$ . Although plausible counter-examples can be found, complementarity between general and specific skills is a fairly weak requirement. So our analysis suggests that under a wide set of circumstances, firm-sponsored general training is likely to exist.

To summarize, if firm specific skills and general skills are complements in the production function, increasing general skills raises productivity more than outside wages, enabling the firm to invest in these general skills. If specific and general skills do not interact, the outside wage function has the same slope in  $\tau$  as the production function. In this case, specific skills generate rents from the current employment relationship, but these rents are the same at all levels of general skill. The firm has therefore no incentive to invest in general skills.<sup>15</sup>

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<sup>15</sup>Related ideas have been discussed by other papers. Stevens (1994) considers skills which are neither completely general nor completely specific and notes that this will mean that workers are unlikely to face a perfect outside labor market for these skills. However, she does not consider the interaction

This result also goes in the direction of suggesting that European and Japanese economies should generate more investment in general training than their U.S. counterpart. As these economies have lower turnover, we might expect workers to have more firm-specific skills, so that  $s$  will be higher in Europe than in the U.S. This immediately implies that  $\hat{\tau}$  should also be higher in Europe. Therefore, our analysis in this subsection suggests that everything else being equal, we might expect more general training in economies with low turnover, because they will generate more firm-specific skills.

Finally, the formulation above is also useful in contexts other than merely specific training. For example,  $s$  above could be physical capital of the firm. If firms have different levels of physical capital, and physical and general human capital are complements, then firms with more physical capital would like to employ workers with more human capital. Suppose there is one firm which has a higher stock of physical capital than other firms. It would be profitable for this firm to invest in the workers' human capital if physical capital is not perfectly mobile. This conclusion again crucially depends on the existence of some frictions. With perfect markets, the firm could just sell its physical capital to the new employer when the worker quits, and the worker would receive his full marginal product on the outside market. This is not the case if the capital market is imperfect. At first sight, this example seems to contradict our general premise that *labor market imperfections* are needed for firm financing of investments in general human capital. However, this is not so. If capital is immobile, then the employer with a larger stock of physical capital has some degree of monopsony power over the human capital of the worker, which is the source of the distortion in the wage structure. In other words, the imperfection in the capital market spills over into the labor market.

## 4 Conclusion

When the wage structure is distorted away from competitive wage structure and in favor of less skilled workers, firms may want to invest in the general skills of their employees. Contrary to previous research, we showed that for this result to hold, workers do not need to be credit constrained. What matters is the form of labor market frictions and institutions. These results contrast with the standard theory based on Becker's seminal work where firms would never invest in general skills. We also found that more frictional and regulated labor markets may increase investment in training by distorting the wage

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between specific and general skills as a source for firms' investments in general training. Franz and Soskice (1995) discuss the case where general training is a by-product of specific training, i.e. the complementarity is on the cost side rather than on the output side as in our analysis above. Bishop (1996) points out that individual skills may be general, but the particular mix of these general skills used by any single employer could be firm-specific.

structure and encouraging firms to invest in the skills of their employees.

We view the presence of many firm-sponsored general training programs, such as the German apprenticeship system, and the fact that U.S. employers send their workers to vocational and technical training facilities without reducing their wages as evidence that the forces we emphasize are present. Also, the fact that training programs are more prominent in Europe and Japan, which have more regulated and frictional markets and more distorted wage structures, is in line with our approach. Future empirical work should test the more micro-level implications that follow from our analysis and contrast them with those of the standard theory.

This paper also has implications for the interpretation of empirical results on the returns to training (e.g. Lynch, 1992). The wage returns to training only reflect the total increase in productivity if labor markets are competitive. Our work predicts that, whenever employers pay for training, the true returns may exceed the returns to training measured in terms of the wage, which are often estimated to be quite large already.

## 5 Appendix: A Continuous Time Version of the Search Model

Consider a continuous time infinite horizon version of the model of Section 3.3. Namely, each worker is matched with a firm, and the firm decides whether and how much to invest in the general skills of the worker. The worker has no funds and cannot commit to a lower wage in the future in return for training now. The productivity of a worker who receives training  $\tau$  is  $f(\tau)$  in every period. For simplicity, training is only possible in period  $t = 0$ . Both firms and workers are risk-neutral and discount the future at the rate  $r$ . All worker-firm matches come to end at the exogenous rate  $q$ . Also a worker, once unemployed, finds a new firm at the rate  $p_w$  which is independent of his training level, and a firm after losing its worker finds a new worker at the rate  $p_f$ . The worker that the firm finds will be a random draw from the pool of unemployed workers, irrespective of the value of training. So workers with different levels of training have the same probability of getting a job.

Suppose all workers have training  $\bar{\tau}$ , and consider a worker with training  $\tau$ , then the value of being employed for this worker as a function of his training level  $\tau$ ,  $J^E(\tau)$ , is:

$$rJ^E(\tau) = w(\tau) + q(J^U(\tau) - J^E(\tau))$$

where  $J^U(\tau)$  is the present discounted value of being unemployed for a worker of training  $\tau$ . This equation is a standard dynamic programming equation (see for instance Pissarides, 1990). The worker gets  $w(\tau)$  every instant he is with the firm and loses his job at the flow probability  $q$ , in which case he gets  $J^U$  and loses  $J^E$ . In turn we have:

$$rJ^U(\tau) = b + p_w(J^E(\tau) - J^U(\tau))$$

And for the firm, the value of employing a worker with training  $\tau$  is:

$$rJ^F(\tau) = f(\tau) - w(\tau) + q(J^V - J^F(\tau))$$

and the value of being unfilled vacancy is:

$$rJ^V = p_f(J^F(\bar{\tau}) - J^V)$$

Nash Bargaining in this context implies that the present discounted values should be shared. Therefore,  $w(\tau)$  will be chosen so as to maximize:

$$(J^E(\tau) - J^U(\tau))^\beta (J^F(\tau) - J^V)^{1-\beta}$$



This gives a standard wage rule:

$$w(\tau) = \beta f(\tau) + (1 - \beta)rJ^U(\tau) - \beta rJ^V$$

or substituting for  $rJ^U(\tau)$  :

$$w(\tau) = \frac{(p_w + r + q)(\beta f(\tau) - \beta rJ^V)}{r + q + \beta p_w}$$

Now in period  $t = 0$ , since the worker is credit constrained and cannot invest in training, the firm will maximize:

$$J^F(\tau) - c(\tau) \tag{7}$$

by choosing training  $\tau$  and taking the training level of all other workers,  $\bar{\tau}$ , as given.  $\bar{\tau}$  only influences  $J^V$ , which is in turn independent of the value of  $\tau$ . So the level of  $\bar{\tau}$  does not influence the choice of  $\tau$ . For this reason, the first-order condition of (7) takes the simple form:

$$(1 - \beta)f'(\hat{\tau}) = (r + q + \beta p_w) c'(\hat{\tau})$$

Since  $c'(0) = 0$ , for all  $\beta < 1$  and  $r + q + \beta p_w < \infty$ , the firm will choose  $\hat{\tau} > 0$ . Since all other firms are solving a similar problem, we also have  $\bar{\tau} = \hat{\tau}$ , and a unique symmetric equilibrium.

The reason why  $\beta < 1$  is necessary for firm-sponsored training is familiar from the text. However, the second condition is interesting. First it requires that  $r < \infty$ , thus the future needs to feature in the calculations.  $q < \infty$  is also required which means that the worker should not be leaving the firm for sure. Finally,  $p_w < \infty$  is necessary. In fact,  $p_w \rightarrow \infty$  is the case of perfectly competitive labor markets: the worker finds an employer immediately. Therefore, this last requirement reiterates that labor market imperfections are necessary for firms to invest in the general skills of their workers. Moreover, it is clear that as  $p_w$  increases, there is less investment in training. Since, steady state unemployment in this economy is equal to  $u = q/(q + p_w)$ , this implies that higher unemployment is associated with more investment in training. The reason is that a higher rate of unemployment causes a more distorted wage structure by reducing the outside option of more skilled workers.

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