The Theory of Human Capital Revisited: On the Interaction of General and Specific Investments*

by

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Summary

Human capital theory distinguishes between training in general-usage and firm-specific skills. In his seminal work, Becker (1964) argues that employers will not be willing to invest in general training when labor markets are competitive. However, they are willing to invest in specific training because it cannot be transferred to outside firms. The paper reconciles Becker's theory. We show that there exists an incentive (though not technological) complementarity between employer-sponsored general and specific investments: the possibility to provide specific training leads the employer to invest in general human capital. Conversely, the latter reduces the hold-up problem that arises with respect to the provision of firm-specific training. We also consider the virtues of long-term contracting and discuss some empirical observations that could be explained by the model.

Keywords: General Training, Specific Training, Hold-up Problem

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1 Introduction

Human capital theory distinguishes between investments in general-usage and firm-specific skills. While a trained employee can utilize general human capital at any firm in a frictionless labor market, returns on specific training are realized only in an ongoing relationship with the training firm. Established human capital theory separately copes with those phenomena. In his seminal work, Becker (1964) found that an employer will never devote own resources to general training,[1] because labor market competition for trained workers does not allow her to accrue any returns from those expenses. Conversely, she will engage in specific training since these investments give rise to a bilateral monopoly situation between employer and worker, which is true even though the worker is in principle free to leave his current employer and get hired by another firm. In equilibrium, the returns from specific investments are therefore shared between firm and worker in some fashion, and the employer voluntarily provides specific training [though presumably not the efficient amount] even if she bears all of its costs.

The present paper reconciles this theory. Our main innovation is to show that employers will invest in general human capital even if they operate in a frictionless economy where trained employees can appropriate the full return on those investments in the labor market. As the decisive step to this conclusion, we find that general and specific investments cannot be separately analyzed. Rather, the presence of an outside option for the agent makes the returns from either type of investment interdependent even if (as we posit) there exists no technological link between them.[2]

The idea of our approach can be illustrated as follows: suppose first that an employer can provide only general training. Then, as in the Beckerian world, she will not invest unless market imperfections prevent the employee from recovering the full return on his human capital. Imagine now, though, that the firm can also expend investments in relationship-specific training. Recalling that specific training by its very nature drives a wedge between the (expected) market wage and the marginal product from a continuation of the labor relationship after the training period, post-training negotiations

[1] In equilibrium, no general human capital is then accumulated if the agent is wealth-constrained and cannot finance training from own funds, or if training is non-contractible and the agent himself has no access to a training technology.

[2] Franz and Soskice (1995) and Acemoglu and Pischke (1999), among others, have recognized that employers may invest in general training if general and specific investments are complements in the production function.

lead both parties to share the *total* product from an ongoing relationship. Importantly, this 'overall value' is determined by the employer's investments in specific *as well as* general capital. If labor markets are perfect, the agent's minimum share coincides with the marginal return from general investments. Hence, provided that this minimum payment is binding, the employer still recovers no return on general training becauses these investments impose a binding constraint in the bargaining process. However, if the return on specific training is sufficiently large relative to the return on general human capital (or if the agent's bargaining power in wage negotiations is large), the agent's share in second-period bargaining will exceed his outside option wage. Thus, the worker's negotiated future salary within the firm strictly exceeds the maximal payoff he can realize in the labor market. The fact that the worker's outside option is non-binding, in turn, feeds back on the employer's investment incentives: in particular, she now recovers a part of the marginal return from her expenditures in specific *and* general training, and rationally disburses funds in both training forms.

We therefore find that, in general, employers will invest in general training even if it is non-contractible, or if the agent does not contribute to the costs of training. Moreover, we show that the interplay of general and specific training at the same time enhances the firm's provision of specific training relative to a scenario where general human capital formation is not taken into consideration. This second main result again has a simple explanation. In situations where the agent's outside option turns out to be binding for given investment levels, the employer reaps the *full* return from specific investments, because the worker's wage then coincides with his return from general training. Since the employer anticipates that (for given investments) the outside option is sometimes binding, her investment incentives in specific training increase as compared to a setting without general training where the worker's outside wage is no constraint in bargaining. To summarize, general and specific human capital are *incentive complements* even though their returns are technologically disconnected, and their interaction triggers a higher provision of *both* training forms relative to a situation where the training technology (or the model builder) allows for only one type of human capital accumulation.[3]

[3]We will also demonstrate that, if general training is contractible and the agent is not wealth-constrained, the parties may agree on a training level in excess of the first best: since general and specific training are strategic complements, a higher amount of general training stimulates the provision of specific investments, and thus further alleviates the hold-up problem that arises when specific training is non-contractible.

Becker's finding on the unfeasibility of employer-sponsored general training is at odds with empirical results.[4] The present paper thus complements the recent theoretical literature on human capital which primarily tries to resolve the Beckerian puzzle. This literature usually focuses on general training, and disregards specific investments. Katz and Ziderman (1990) and Acemoglu and Pischke (1998), among others, suppose that the relation of employer and agent during the training period generates information on the agent's type or level of training that is not shared with outside firms.[5] This informational asymmetry gives rise to a lemon market type of situation [Greenwald (1986)] where outside firms offer less than the agent's marginal product, and the employer invests in general human capital. Acemoglu (1997) shows that a similar situation arises in a model where the employee must engage in costly search for a new employer after the present relationship breaks off. Finally, Acemoglu and Pischke (1999) motivate the prevalence of employer-financed general training by the existence of compressed labor markets where the wedge between outside wage and true marginal product increases in the level of general training that has been provided to an individual. They also show that compressed wage structures can endogenously emerge in econnomies with wage floors or wage-setting unions. Acemoglu and Pischke (1999) summarize the fundamental argument behing all of those approaches as follows: *"The key (to firm-sponsored training) is labor market imperfections, which imply that trained workers do not get paid their full marginal product when they change jobs, making technologically general skills de facto specific."* [Acemoglu and Pischke (1999, p.540]. Our paper endogenizes the source of market frictions by explicitly incorporating specific investments into the analysis.[6]

[4] See, for example, Soskice (1994), von Bardeleben, Beicht and Fehr (1995) and Harhoff and Kane (1997) for Germany, and Ryan (1980) and Bishop (1991) for the US. For Germany with its institutionalized apprenticeship system, Franz and Soskice (1995) estimate that the employer spends an average net cost per apprentice of about DM 12300 (for 1985). Since the training period in Germany is usually 3 years and the average gross wage of a trained worker ("Facharbeiter") in the industry is about DM 70000, the overall training costs per employee may roughly coincide with 8-9 monthly salaries of a trained worker.

[5] See also Chiang and Chiang (1990a, 1990b) and Chang and Wang (1995).

[6] Our model can account for the fact that employers frequently sponsor general training of their employees only after a prolonged period of in-house training. If in-house training is considered as primarily relationship-specific, it may take some period of accumulation of these skills until the employer anticipates that, after the employee was educated in general training, his Nash-value inside wage exceeds the market valuation of general skills. Since the employer recovers no return from general investments in the first periods, he rationally postpones his agreement to a participation in general training programs until a sufficient level of specific human capital has been accumulated within the firm.

We also examine different sorts of long-term arrangements between employer and employee. If investments are non-contractible but firm-specific human capital is sufficiently important, an initial contract which simply prescribes a second-period wage implements first-best investments. This outcome holds even though the initial contract is a 'contract at will' that can unilaterally be abandoned by either party, and thus reflects a common characteristic of most labor contracts [Malcomson (1997)]. If termination fees are feasible and the level of general training is contractible, efficiency is even generically attained. This second result still holds in presence of match specific shocks that lead to equilibrium separation with a positive probability. In equilibrium, the precontracted second-period salary is not renegotiated and strictly exceeds the employee's market valuation if the relationship continues. Conversely, if it is ex-post efficient to separate, the employer pays a positive termination fee to the agent. These patterns are in line with the frequent empirical observation of sticky wages, and also conform with evidence from European countries where firms have to bear substantial redundancy payments (in form of monetary penalties or a necessary authorization by government agencies) when they want to terminate a labor relationship [see Malcomson (1997)]. In contrast to common beliefs, we find that these payments may be optimal if the institutional framework, as in Germany, permits the contractibility of general training to a large degree.

Our theoretical model bears on both the literature on incompleting contracting, and on the strategic-bargaining literature. The incomplete contracting paradigm postulates that economic relationships cannot be governed by complete, fully state-contingent contracts. Although bargaining ex post can make up for missing clauses after the parties expended relationship-specific investments, they may fail to invest efficiently since renegotiation implies a split of the corresponding returns. In absence of any initial contract, this hold-up problem leads to underinvestments [see Grossman and Hart (1986), Hart and Moore (1990)], while simple long-term contracts may restore efficiency in some situations.[7] Our analysis of long-term contracting in an employment context is closely related to the contributions by MacLeod and Malcomson (1993a, 1993b). Their articles, though, do not explore situations where the employer provides

[7]In particular, efficiency is attained when investments are selfish, i.e., if their returns are recovered by the investing parties for given terms of trade [see Edlin and Reichelstein (1996)]. Conversely, no contract can improve upon the non-contracting outcome when investments are purely 'cooperative', i.e., if the non-investing party appropriates the corresponding returns for given terms of trade [Che and Hausch (1999)].

general training, which is the focus of the literature on human capital.[8] We will briefly assess their specific results on the implementability of efficient investments in Section 4 below.

We also apply recent result from the literature on strategic bargaining. In particular, the so-called "outside option principle" is of crucial importance for our findings. This principle has been derived in a version of the Rubinstein game where (at least) one party can take an outside option [see Shaked and Sutton (1984), Binmore, Rubinstein and Wolinsky (1986) and Sutton (1986)]; it says that the presence of an outside option does not affect a player's threat point, but rather imposes a lower bound on his payoff in negotiations. Therefore, an outside option does not influence the bargaining outcome as long as a player's payoff (in absence of an outside option) exceeds the outside option value. Conversely, if the outside option binds for one of the parties in a transaction, this party receives exactly this value in unique equilibrium, while the other party captures the remaining part of their joint surplus. The bargaining game developed in MacLeod and Malcomson (1993a, 1995) preserves these features, and additionally accounts for the possibility of long-term contracts: each party is in equilibrium tied to an initial wage contract unless its outside option binds, whereas the initial contract becomes spurious otherwise. The present article utilizes these approaches.

We proceed as follows. Section 2 develops and analyzes the basic model with general and specific investments. Section 3 provides a brief discussion on the effects of labor turnover, and explores long-term contracting. Section 4 briefly relates our results to empirical findings, and Section 5 concludes.

2 A Simple Model of General and Specific Training

2.1 The Basic Framework

Consider a labor market with a large number of firms and workers. Firms have access to a technology that is linear in the number of workers they employ. There are two periods. At the beginning of period one, workers enter the labor market and can be hired by firms. In this period, the firms can invest into general and specific skills of

[8] Proposition 5 in MacLeod and Malcomson (1993a) deals with general investment by both parties. These investments, however, are 'selfish' in the sense that they do not affect the outside option value of the other agent, respectively.

their agents. At the end of period one, workers may remain with their initial employers or change jobs. If they stay, their value for the firm in period two depends both on the general and on specific skills that they have previously acquired. If they decide to quit or the firm lays them off, they enter the external labor market at the beginning of period two. In this case, their marginal product solely depends on their general skills.

Because we suppose the firm's technology is linear, we can confine ourselves for the most part of the analysis to the employment relationship between a single worker and a single firm. At the beginning of period 1, firms offer worker wage contracts w_1 that cover the first period. In this period, the firms can invest into general and specific training of their workers. The firm's outlays for training are denoted by g and s, respectively. For simplicity, we assume that the output each worker produces in the expected first period output is $v_1 = \underline{v}$ independent of the training received. In the second period, workers are skilled. Their output v_2 is determined by the firm's investments in general and specific training g and s, and a random parameter $\theta \in \Theta$ that is drawn by nature at the beginning of period 2. We interpret θ as a macroeconomic shock that affects market conditions.[9] We assume that θ is distributed according to a continuously differentiable distribution function $F(\theta)$ over a a bounded support $[\underline{\theta}, \bar{\theta}]$. To make our point as strong as possible, we disregard in what follows the possibility of technological complementarities between general and specific training. Thus, suppose that the output of a skilled worker is additively seperable in g and s,

$$v_2(s, g, \theta) = v^S(s, \theta) + v^G(g, \theta), \qquad \forall\, \theta \in \Theta \tag{1}$$

where $v^S(\cdot)$ and $v^G(\cdot)$ are the components of v_2 that can be attributed to the acquisition of firm specific and general skills, respectively. We assume that the functions $v^S(\cdot)$ and $v^G(\cdot)$ are non-negative, twice continously differentiable and well behaved in s and g, respectively. In particular, they are increasing and stricly concave, and satisfy the Inada conditions. Furthermore, the expected second-period output of a worker who has not received any training is in expectation equal to the first-period output of an unskilled worker, i.e. $v^S(0, \theta) = 0 \ \forall \ \theta \in \Theta$ and $E_\theta v^G(0, \theta) = \underline{v}$. After θ has become known, worker and firm can negotiate the second-period wage w_2. Both parties are free to terminate their relationship at that time, i.e. the worker may decide to quit or the firm may decide to lay the worker off. In either case, the parties have access to the external labor market. The wage determined in this market is denoted by w^E.

[9] In Section 3.1, we allow for firm- or match-specific shocks.

We formalize the wage negotiations as an alternating-offer bargaining game which is in detail explained below. If the parties decide to continue their relationship, the worker produces an output given by (1). In case of a separation, however, only a worker's general skills are valuable. Thus, a firm hiring another worker values his output at $v^G(g,\theta)$. Throughout our analysis, we will assume that θ as well as the trining levels g and S are commonly observable. Thus, competition among firms will ensure a wage of $w^E = v^G(g,\theta)$ on the external labor market.

We complete the description of the model with summarizing the sequence of events. At the beginning of the first period, firms decide on the number of workers they hire and offer wage contracts w_1 to those they employ. Next, they decide on the training s and g the workers receive. At the end of period 1, the state of the world θ is drawn by nature. At the beginning of period 2, firms enter into negotiations with their existing workers on the second-period wage w_2. Both workers and firms are free to terminate the relationship at that time. Next, firms can make offers w^E to the workers who are in the second- hand labor market.[10] When training firm and workers continue their relationship, each worker produces v_2.

Efficient Investments

The efficient amount of training each worker receives is represented by

$$(g^*, s^*) \in \text{ argmax }_{(g,s)} \int_{\theta\in\Theta} v_2(s,g,\theta)dF(\theta) - g - s.$$

Sustituting $v_2(s,g,\theta) = v^G(g,\theta) + v^S(s,\theta)$, the first-order conditions are

$$\int_{\theta\in\Theta} \frac{\partial v^G(g^e,\theta)}{\partial g} dF(\theta) = 1 \tag{2}$$

$$\text{and} \qquad \int_{\theta\in\Theta} \frac{\partial v^S(s^e,\theta)}{\partial g} dF(\theta) = 1. \tag{3}$$

Due to the separability of $v(\cdot)$, g^* and s^* are determined independently. Recall that we have assumed $v^S(\cdot) \geq 0$ for all s and θ. Thus, it is always efficient to continue an existing employment relationship in period 2. This assumption will be relaxed in Section 3.1. below where we introduce firm-specific or match-specific shocks that may

[10] This timing assumption is innocuous. Notice that, in our framework, it is irrelevant whether employees bargain with outside employers only after unsuccessful negotiations with their training firm, or whether outside firms engage in poaching. In either case, an alternative firm cannot offer more than $v^G(g,\theta)$.

make separation efficient. Note, however, that g^* remains unaffected by this possibility since general investments increase the value of a worker irrespective of whether he stays with his current employer of seeks outside employment. The efficient amount of specific training, in contrast, decreases because specific skills are valued only within an existing match. Thus, s^* will generally be lower if the relationship is (optimally) terminated with positive probability.[11]

Wage Negotiations

As mentioned above, the negotiations between the firm and a worker on the second period wage are formalized as an alternating offers bargaining game in the spirit of Rubinstein (1982). There is an infinite number possible rounds and we suppose that the discount factor is $\delta \to 1$. Since there are alternative opportunities for both players on the external labor market, we need to specify how they enter the bargaining process. In what follows, we assume that negotiating and taking up alternative alternatives are mutually exclusive, which in the present context of an employment relationship means that a quit or layoff decision terminates the negotiations. Following a proposal w_2 by one party, the other party can either accept, reject, or terminate the relationship by taking up the outside option. If accepted, the payoffs of worker and firm are $\Pi = v_2(\cdot) - w_2$ and $U = w_2$, respectively. In case of a rejection, both parties obtain zero and bargaining moves on to the next round. Finally, if one player terminates the relationship, both parties obtain their payoffs from taking up an ouside market opportunitiy, $\Pi_2^E = 0$ and w_2^E, respectively.

As is well known, the above game has a unique subgame perfect equilibrium for any $\delta < 1$. This equilibrium establishes the so-called 'outside option principle' [see Shaked and Sutton (1984), Sutton (1986)] which asserts that an outside options constitutes a

[11] Formally, suppose that $v_2 = v_2(g, s, \theta, \lambda)$ where $\lambda \in \Lambda$ is the realization of a firm- or match-specific shock. Let $\hat{\lambda}(g, s, \theta)$ be a realization characterized by $v_2(g, s, \theta, \hat{\lambda}) = w^E(g, \theta)$. Then, the parties separate in equilibrium if and only if $\lambda < \hat{\lambda}(\cdot)$, and efficient investments maximize

$$\int_{\lambda \geq \hat{\lambda}(g,s,\theta)} \int_{\theta} v_2(g, s, \theta, \lambda) dF(\theta) dF(\lambda) + \int_{\lambda < \hat{\lambda}(g,s,\theta)} \int_{\theta} v^G(g, \theta) dF(\theta) - g - s. \tag{4}$$

The first-order conditions for efficient specific investments then becomes

$$\int_{\lambda \geq \hat{\lambda}(g^*,s^*,\theta)} \int_{\theta \in \Theta} \frac{\partial v^S(s^*, \theta)}{\partial g} dF(\theta) = 1. \tag{5}$$

while g^* remains unchanged.

lower bound on an agent's payoff, but otherwise does not affect the bargaining outcome. For $\delta \to 1$, the second period wage is given by

$$w_2^* = \begin{cases} v_2(\cdot)/2 & \text{for} \quad w^E \leq v_2/2 \\ w^E & \text{otherwise.} \end{cases} \tag{6}$$

An important implication of the wage negotiations as formalized above is therefore that that surplus sharing can occur:[12] if the worker prefers his equilibrium wage in the absence of an outside opportunity to the wage he can obtain in the external labor market, the latter does not influence the bargaining outcome. As Shaked and Sutton (1984) have noted, the worker cannot credibly threaten to quit in this case which leaves his payoff unaffected. In contrast, if the agent's market valuation exceeds the equilibrium wage in the absense of external markets, his outside option binds and the firm must pay him exactly w^E.

General Investments in Human Capital

Let us first assume that the firm does not invest into relationship specific skills of its workers by setting $s \equiv 0$. In such a situation, a worker is as valuable inside the existing relationsip as on the external labor market: his second period output is $v^G(g, \theta)$ and remains the same irrespective of whether the relationship is continued or the employee seeks outside employment. Since $w^E = v(g, \theta)$ on the competitive external labor market there are no rents generated inside an ongoing relationship in period 2. By inspection of (6), the wage negotiations lead to a second period wage of $w_2 = w^E$: surplus sharing never occurs simply because there is no surplus in excess of what can be obtained in the market. Expressed differently, because all investments are general, competition among firms ensures that the worker is paid his full marginal product in all states of the world. The firm's second period profit is thus $\Pi_2 = 0$ and the worker's utility is $U_2 = v(g, 0, \theta) = r(g, \theta)$. The expected overall returns from the relationship are given by

$$\begin{aligned} E[\Pi] &= \underline{v} - w_1 - g \qquad \text{and} \\ E[U] &= w_1 + \int_{\theta \in \Theta} v(g, \theta) dF(\theta), \end{aligned}$$

[12] Binmore (1987) considers a variant of this bargaining game that allows it to incorporate asymmetric bargaining powers. In his version, the player who can make an offer is randomly drawn with an exogenous probability at the beginning of each round. The paper shows that the surplus share of a party then coincides with the probability that it is selected to make an offer. See also MacLeod and Malcomson (1993a, 1995).

respectively. The following proposition is immediate and replicates Becker's (1964) argument.

Proposition 1. *Suppose firms do not invest into specific human capital of their workers, i.e.* $s \equiv 0$. *Then,*

a) if g *cannot be contracted upon,* $g^e = 0$ *and* $w_1^* = \underline{v}$,

b) if g *is contractible, we have*

$$g^e = \min\{g^*, \underline{v}\} \qquad \text{and} \qquad w_1^* = \max\{\underline{v} - g^*, 0\}.$$

If the training level is non-contractible, the employer will not invest in general human capital because she cannot recover any returns from investments in the second period. Conversely, if it is possible to make the first-period salary contingent on the level of training, the employee sacrifices first-period wages in order to have the employer agree to positive training investments. If the agent's first-period productivity is high enough, first-best investments become feasible, while general training remains unfeasible if the employee is totally unproductive in the initial period.

Investment in General and Specific Training

We now return to the possibility of investment in the acquisition of firm specific skills. For the moment, let us assume that g is not contractible so that firms would not be willing to provide general training for $s = 0$. To see how training in firm specific skills changes equilibrium characteristics, reconsider the outcome of negotiations on second period wage contracts as given by (6). As long as $s > 0$, there is now a positive rent $v_2(s, g, \theta) - v^G(g, \theta) = v^S(s, \theta) > 0$ to be shared between the worker and the firm. While this rent depends only on the level of specific training s, the way in which it is shared depends also on g. If $v^S(s, \theta)$ is relatively low, the worker's share of rents generated in the existing relationship is lower than the wage he can obtain on the external labor market. Hence, his alternative market opportunity is binding and the negotiated second period wage is $w_2 = v^G(g, \theta)$. In this case, the firm's second-period profit is $\Pi_2 = v(s, g, \theta) - w_2 = v^S(s, \theta)$: the entire surplus from specific training accrues to the firm.

Conversely, the wage negotiated in equilibrium will exceed the wage that the worker can obtain on the external labor market if $v^S(s, \theta)$ is sufficiently high. As a result, the

worker captures a fraction 1/2 of the *entire* surplus $v_2(s,g,\theta)$. His equilibrium wage in this case is $w_2 = v_2(s,g,\theta)/2 > v^G(g,\theta) = w^E$. As already noted in Becker's work, specific investments imply that worker and firm are in a bilateral monopoly position after those investments have been made: if the worker quits and takes another job, the firm's expenditures are wasted because no replacement worker would be equally proficient in the required task. Similarly, the specific skills are not marketable if the worker is layed off and he would therefore be unable to recoup any specific investments on this own part. This leads to surplus sharing and, hence, to underinvestment. This is the well known 'Hold-up Problem' [Williamson (1975)] that occurs whenever investments are specific to a relationship. The crucial point to recognize, however, is that the firm's hold-up with respect to its specific investments is beneficial with respect to its incentives to invest into general skills. While the worker receives part of the surplus from the firm's expenditures on specific training, the firm at the same time captures part of the return on general training.

Formally, the firm's expected profit from the relationship is

$$E[\Pi] = \underline{v} - w_1 + \int\limits_{\{\theta|\frac{1}{2}v_2 \geq v^G\}} \frac{1}{2} v_2(s,g,\theta) dF(\theta) + \int\limits_{\{\theta|\frac{1}{2}v_2 < v^G\}} \left[v_2(s,g,\theta) - v^G(g,\theta)\right] dF(\theta) - g - s \tag{7}$$

Assume first that g and s cannot be contracted upon. Sustituting $v^S(s,\theta) = v_2(s,g,\theta) - v^G(g,\theta)$ and rearranging, the first order conditions of (7) can be written as

$$\int_\theta \frac{\partial v^S(s,\theta)}{\partial s} dF(\theta) - \int\limits_{\{\theta|v^S \geq v^G\}} \frac{1}{2} \frac{\partial v^S(s,\theta)}{\partial s} dF(\theta) = 1,$$

and

$$\int\limits_{\{\theta|v^S \geq r\}} \frac{1}{2} \frac{\partial v^G(g,\theta)}{\partial g} dF(\theta) = 1,$$

where $v^S(\cdot)$ and $v^G(\cdot)$ are evaluated at s^e and g^e, respectively. Comparing the first order conditions with (2) and (3) yields

Proposition 2. *If training expenditures are non-contractible, firms invest in general training if and only if hold up with respect to specific training occurs with positive probability, i.e.*

$$g^e > 0 \quad \Leftrightarrow \quad s^e < s^*.$$

In particular, the equilibrium level of general training is generically positive unless the market value of an untrained worker, $\underline{v}$, exceeds $v^S(s^*, \theta)$ for any θ.

The intuition for this finding has already been laid out in the preceding discussion. If hold-up occurs in some states of the word, the employee captures part of the surplus from the firm's expenditures in his acquisition of specific skills. At the same time, however, the firm is also able to recover some of its expenditures on general training on the margin. This is true even though surplus sharing implies that its absolute profit from *both* types of training decreases relative to a situation where the employee's alternative market opportunity is binding. Note that hold-up with respect to specific investments (i.e., $s^e < s^*$) can only be avoided if, given efficient specific investments, the market wage of unskilled workers is so high that the agent's outside wage $\underline{v}$ binds in any state of the world. For reasonable specifications of the functional forms, it is thus very likely that hold-up will occur, and the employer provides general training.

One should be prompted to believe that investments in general human capital negatively distort the accumulation of specific training relative to a situation where general-training investments are absent, $g = 0$. Perhaps surprisingly, though, the following proposition asserts that this intuition is misleading:

Proposition 3. *General and specific capital are incentive complements. Therefore, the firm invests more in specific training the higher its provision of general human capital.*

The intuition for this result is again very simple. Suppose that the firm cannot (or does not) invest in general human capital, and assume for simplicity that $v^G(0, \theta) = 0$.[13] Then, $w^E < v_2(0, s, \theta)$ for any $s > 0$ and surplus-sharing always occurs. Accordingly, the firm reaps half of the marginal returns on its training outlays in *every* state of the world. Conversely, suppose now that the firm invests a positive amount of general human capital. Now, $v_2(\cdot)/2 < v^G(g, \theta)$ for a positive measure of states, where the agent's equilibrium wage coincides with his outside option payoff. Since the firm's marginal return from specific investments in these states becomes $\partial v^S(s, \theta)/\partial s$ rather than $[\partial v^S(s, \theta)/\partial s]/2$, it will provide a higher level of specific training. In other words,

[13] If $v^G(g, \theta)$ is positive in some states, the employee's outside option may still be binding for some small amounts of specific investments, $s < \bar{s}$. Although general training does not affect the employer's return from specific training for those investment levels, note that $\bar{s}(g)$ increases in g such that smaller general investments narrow the interval $[0, \bar{s}(g)]$ where surplus-sharing arises.

the presence of general training alleviates the hold-up problem that arises from the parties' lock-in in a bilateral monopoly situation.

Now consider the case where g is contractible so that the first period wage contract can specify a fraction α of the general training expeditures borne by the worker. The firm's problem is again given by (7) with $w_1 = \bar{w} - \alpha g$. The equilibrium level of g is then determined by

$$\int\limits_{\{\theta | v^S \geq v^G\}} \frac{1}{2} \frac{\partial v^G(g,\theta)}{\partial g} dF(\theta) = 1 - \alpha.$$

Define

$$\alpha^e = 1 - \int\limits_{\{\theta | v^S \geq v^G\}} \frac{1}{2} \frac{\partial v^G(g^e,\theta)}{\partial g} dF(\theta),$$

where $v^G(\cdot)$ and $v^S(\cdot)$ are evaluated at g^* and s^e, respectively. By inspection, setting $\alpha = \alpha^e$ yields $g^e = g^*$. Thus, if firm and worker agreed to a sharing rule α^*, the firm would invest the efficient level $g^e = g^*$ in general training. Observe that α^e is strictly less than one as long as the hold up problem with respect to specific training prevails, which implies that the firm will bear a positive fraction of those investments. As the proposition below shows, however, the parties will implement a sharing rule that leads to a strictly higher investment in general human capital.

Proposition 4. *If g is contractible, first period wage contracts specify $w_1 = E[\pi] - \alpha^* g$ where $1 > \alpha^* > \alpha^e$. Consequently, firms provide inefficiently high levels of general training in equilibrium, i.e. $g^e > g^*$.*

The reason for this overinvestment is intuitive. From the employer's point of view, general and specific investments are complements, and a higher level of general training leads to a higher level of specific investments. Since g is contractible, the parties will therefore not only agree on the first-best level of general training, but pushing those investments farther in order to enhance the employer's incentives to engage in specific training [note that the worker's share α does not have to influence his first-period wage since w_1 allows for an additional degree of freedom].[14] On the other hand, it still

[14] Our result is interesting in consideration of the fact that German employers often complain about their excessive commitments to general training: once a firm participates in the government sponsored formal training program, the apprentice twice a week attends a vocational school.

remains valid that the worker does not pay for the whole amount of the employer's investments: a share parameter $\alpha = 1$ would make investments costless for the employer and therefore trigger an unreasonably high amount of general investments as well as absolute transfers from the worker.

3 Extensions

This section considers two natural extensions of the basic framework. We first allow for (equilibrium) labor turnover that has been ruled out so far. Thereafter, we study the implications of long-term wage contracts.

3.1 Idiosyncratic Shocks - Layoffs and Quits

In our previous discussion, there was no reason for a firm to lay off workers or for employees to quit their jobs. Since the joint surplus in an ongoing relationship was assumed to be weakly larger than that after separation [recall that $v_2(g, s, \theta) \geq v^G(g, \theta) \forall\, \theta$ by our previous assumptions], employer and worker could always implement a second-period wage scheme that made a continuation profitable for both parties. Though we found that the occurence of surplus-sharing is important for the investment in general human capital by the employer, one may ask whether the presence of specific investments is really nessessary to generate this property in an extended framework where firms are subject to idiosyncratic shocks. For example, the values of an ongoing relationship may differ across firms or across firm-worker pairs, and there may be rents which can be shared between the parties. In particular, a continuation of the current relationship may be so viable that the outside market does not affect the bargaining between employer and worker, which may in turn create incentive to invest in general human capital. Notwithstanding this argument, however, we will show that idiosyncratic shocks do not affect our previous conclusions on the necessity of relationship-specific investments as an explanation for the prevalence of employer-sponsored general training in non-frictional labor markets.

We can incorporate the possibility of labor turnover into our basic framework in a simple way. Suppose that in addition to the (employee-specific or industry-wide) shock θ, there is another *idiosyncratic* shock λ that affects the joint surplus from continuing

the relationship in period 2. To simplify the exposition, assume that these shocks are uncorrelated across the firms in the economy. With probability $\gamma > 0$, the potential second-period surplus $v_2(s, g, \theta)$ takes a high realization $v(s, g, \theta, \lambda^+)$. Conversely, a smaller surplus $v_2(g, s, \theta, \lambda^-)$ is realized with probability $(1 - \gamma)$. In what follows, we will emphasize that the exact implications of idiosyncratic shocks depend on which of two alternative interpretations is employed. In a first interpretation, the firm is subject to a negative productivity shock which is not relationship-specific. Alternatively, the parties may learn that their match is not optimal, while the firm's productivity may still be high with another worker. We will show that both kinds of shocks affect the employer's incentives to invest in general human capital in fundamentally different ways. For the purpose of our discussion, it is convenient to dismiss s in this subsection.

Firm-specific productivity shocks

In this case, λ affects the productivity of a firm j in the second-period match with any possible agent. Hence, $v_2^j = v^j(g, \theta, \lambda^j)$ if the firm is matched with any worker with training level g. After the end of period 1, a fraction γ of firms has a high productivity $v_2(g, \theta, \lambda^+)$, while a fraction $(1 - \gamma)$ suffers from a low-productivity parameter λ^-. Imagine first that there is no boundary on the number of workers employed by a firm. Then, all low-productivity firms will leave the market, while competition drives the equilibrium wage of worker g to $v_2(g, \theta, \lambda^+)$. Second, suppose that each firm can employ just one worker, and there is no market entry of new firms. Then, no firm will be driven out of the market in equilibrium, and the equilibrium profits of highly productive firms may depend on the general training of the agent they employ. As a consequence, the vector of equilibrium profits may depend on the composition of workers' general skills in the market. Nonetheless, however, the expected profit of any firm is unaffected by its own training provision if a large number of firms are present, and free-rider behavior leads any firm to non-investment in general human capital. It is immediate that the presence of market entry does not affect these results. Since general investments drive no wedge between the attainable surplus within and outside the relationship, it cannot pay for an employer to engage in general training even when firm-specific shocks render it possible that the firm becomes more profitable than a portion of its market competitors.

Match-specific shocks

We now interpret λ as a shock that is idiosyncratic to a specific employer-worker pair. For example, the parties may simply learn after the first period that they like (λ^+) or dislike each other (λ^-). As before, it may now be efficient to terminate the current relationship, and switch to a new matching partner. Let us again consider a frictionless competitive economy where workers can switch costlessly, and each agent faces uncertainty whether he will match well with an outside partner. Fix any agent's expectation expectation as $E[\lambda] \in [\lambda^+, \lambda^-]$.[15] Therefore, employer-worker pairs with an unsuccessful match separate and the equilibrium wage in new matches is $\tilde{w}_2 = v_2(g, \theta, E[\lambda])$, while successful pairs continue their relationship at a wage rate $w_2 = \max\{\tilde{w}_2, v_2(g, \theta, \lambda^+)/2\}$. As a result, we now observe a spread of wages across identical workers: while a fraction $(1 - \gamma)$ quits and obtains the outside wage $\tilde{w}_2$, workers in successful matches may obtain a premium above this market wage. As a consequence, and in contrast to the outcome under firm-specific shocks, an employer now invests in general human capital since rent-sharing with her former apprentice arises with positive probability. The equilibrium level of those investments increases in γ (for $\gamma = 1$, the results from our basic model fully apply) as well as in the size of the positive match-specific shock, λ^+. We can thus conclude that general training will be provided even though the employer does not invest in s. This outcome, however, does not invalidate our claim that specific investments are necessary to explain for this investment. To see this, recall our assumption that formerly unmatched parties have an expectation $E[\lambda]$ on the success of their relationship. We motivated this assumption with the argument that a new pair has not yet found out its pair-specific λ at the time where they agree upon their relationship. On the other hand, this information is available to any pair that was matched in the first period. Exactly for this reason, one must consider the first-period relationship between an employer and a worker as a special case of a relationship-specific investment (without monetary costs): in order to find out whether their match is beneficial, the parties have to lock in to create the potential for a surplus above market valuations.

[15] If there is perfect information on the vector $[\lambda_{ij}]$ of all firm-worker pairs, workers in an unsuccessful match simply change to an employer with positive match-specific productivity component, and shocks have no effect on the identity of firms in the market nor on equilibrium wages when a perfect match is feasible for each pair. If not, we again find that market entry of firms will guarantee perfect matches. In either case, the effect of match-specific shocks on general investments is the same as when a firm-specific productivity shock occurs.

3.2 Long-term Contracts

Employment contracts frequently expand beyond a short time horizon.[16] It is therefore interesting to examine long-term arrangements and to scrutinize their effects on the formation of human capital. In the previous sections, we found that the employer invests in general training only if the parties share the overall surplus from the relationship, so that an efficient accumulation of relationship-specific capital cannot be attained. Therefore, a long-term scheme is helpful if it makes the worker's wage non-responsive to his outside option (which leads the employer to invest efficiently in general human capital), and prevents profit-sharing in order to encourage the employer's incentives to invest in specific training.

The incomplete-contracting literature has proposed long-term contractual arrangements as a way to resolve hold-up problems.[17] In a scenario where the employer can provide investments which do not affect the employee's outside option payoff, McLeod and Malcomson (1993a)[18] find that a long-term wage in combination with a breach penalty induces the firm to invest efficiently.[19] We will first show that a similar remedy applies to the present model even though we consider a situation where the agent's outside payoff is responsive to the firm's general investments. Suppose that the parties initially agree upon a long-term wage w^L for the post-training period. In addition, they stipulate a 'breach penalty' p_B (from agent to employer) that becomes due if the agent switches to an outside employer, while the agent is not obliged to any payment if he discontinues to work after a termination of the current relationship. To see how this arrangement works, consider a breach penalty $p_B \geq v^G(g^*, \bar{\theta})$. Consequently, the agent will never unilaterally exercise his outside option because the breach payment

[16] See Malcomson (1997) for a good survey.

[17] For the purpose of this section, we extend the bargaining game we have utilized so far: specifically, we add a prestage and posit that each party can commit whether it wants to bargain or not. The game then proceeds to the bargaining stages only after both parties agreed. The inclusion of this additional stage has no effect if the parties do not write a long-term contract. In the present section where we admit long-term contracts, it serves to preclude renegotiation if and only if both parties prefer to continue their relationship under the initial terms of contracts rather than to separate. It thus has the convenient property that initial contracts are not renegotiated if the parties face a constant- sum game before they have to decide whether to work together in the second period. Note that McLeod and Malcomson (1993, 1995) constructed a bargaining game that leads to the same outcome.

[18] See their Proposition 7.

[19] In their paper, the employer pays the employee a (possibly large) amount of money if the agent takes his outside option. Therefore, the employee always has an incentive to quit, and renegotiation ensures that the employer obtains the whole surplus from the relationship minus the constant breach penalty.

exceeds his highest possible surplus from quitting. In addition, the parties agree upon a second-period wage $w^L \leq \max\{0, v^G(0, \underline{\theta}) + v^S(0, \underline{\theta})\}$. Under this wage agreement, both worker and firm always obtain a non-negative (continuation) surplus. Therefore, the precontracted wage will never be renegotiated and the employer invests efficiently because his payoff amounts to total surplus minus a constant in every state of the world.

In view of their simplicity, one might thus ask why breach penalties are rarely observed even in employment relationships where training is likely to play an important role. This incompleteness may be attributed to the fact that breach penalties require a relatively high degree of verifiability. In particular, the firm has to produce legal evidence that not only the labor relationship discontinued, but also that the agent took an outside job. To see that this distinction is crucial for the efficiency of the long-term scheme we described above, suppose that breach penalty and termination fee coincide, and the agent has to provide a payment to his previous employer even if he does not engage in an outside relationship. Then, the employer has strong incentives to underinvest because she now becomes eligible for a payment if she takes a *unilateral* action, i.e., dismisses the employee. While it certainly is innocuous to assume that courts can verify whether an employee works or not [otherwise, employment contract could never be enforced at least in a static framework], it is presumably hard to distinguish between outside employment and a worker's withdrawal from the labor market. For instance, the employee might move to another city or even another country which may make it prohibitively costly for the firm to provide legal evidence on an outside employment. Perhaps even more importantly, courts will refuse to enforce contracts that in effect force the employee to retire when a labor relationship ends.[20]

Therefore, it is important to examine the efficiency properties of long-term contracts that do not require this verifiability assumption. The simplest long-term scheme to consider is an initial agreement on the wage to be paid in the second period, w^L. By our earlier arguments, the firm will potentially invest efficiently only if this contract is never renegotiated. Since the agent can never credibly insist on renegotiation as long as $w^L \geq v^G(g^*, \bar{\theta})$, we must ask whether it can indeed be optimal for a firm to expend efficient investments (g^*, s^*) under a long-term wage contract from that range.

[20] In contrast, the law admits labor contracts that prevent employees from exploiting their acquired knowledge in competing firms. In reality, though, it is often very hard to decide whether the worker uses his previously acquired general human capital in a new relationship or not.

It is useful to state the following two conditions.

Condition 1: $E_\theta[v^G(g^*,\theta)+v^S(s^*,\theta)]-g^*-s^* > v^G(g^*,\bar{\theta})$.

Condition 1 states that the firm's expected profits from efficient investments are non-negative if the agent obtains a salary $w^L = v^G(g^*,\bar{\theta})$.[21]

Condition 2: $v^G(g^*,\underline{\theta})+v^S(s^*,\underline{\theta}) \geq v^G(g^*,\bar{\theta})$.

Suppose that the employer exerted efficient investments. If condition 2 applies, her continuation payoff under a wage contract $w^L = v^G(g^*,\bar{\theta})$ is positive. Note that Condition 1 encompasses Condition 2 if the parties do not face a substantial amount of uncertainty. Conditions 1 and 2 can be interpreted as the firm's participation (or individual rationality constraints) before and after it expended efficient investments. If Condition 1 is violated, the firm would suffer from a negative expected profit when investing efficiently, and can always do better by refraining from any investments. Similarly, a violation of Condition 2 implies that firm's gross-of-wages utility falls short of the precontracted wage payments in unfavorable states of the world. In this case, a continuation of the relationship requires a reduction of the initially contracted wage, and renegotiations become unavoidable.

We can now state:

Proposition 5. *Suppose that investments are non-contractible, and that Conditions 1 and 2 apply. Then, a long-term initial wage contract $w^L = v^G(g^*,\bar{\theta})$ implements efficient specific as well as general investments (at least) if either*

(1) the firm's bargaining power in renegotiations is sufficiently small; or

(2) the net return on efficient specific investments is sufficiently large.

Morever, if (g^*,s^*) can be implemented, the precontracted wage w^L is not renegotiated in equilibrium, and the agent's salary (generically) exceeds the market wage.

Proof: See appendix.

The proposition has interesting economic implications. When specific investments are taken into consideration, it is likely that efficiency can be attained by a long-term

[21] One can easily verify that Condition 1 does not apply if specific investments have no value.

contract which does not entail any termination fees or exit clauses.[22] Since specific investments drive a wedge between the attainable payoff inside and outside the current relationship, it is possible to agree upon a second-period wage that is not renegotiated even if both parties are in principle free to refuse a continuation under the precontracted terms. If conditions 1 and 2 apply and the firm chooses the efficient investment levels (g^*, s^*), it never has a credible threat to dismiss the worker at wage w^L while the worker's wage strictly exceeds his maximal remuneration in an outside firm. For this reason, the combination (g^*, s^*) constitutes at least a local maximum in the employer's optimization program. This local maximum coincides with the global optimum if her bargaining power is sufficiently small, or if the return on specific investments is sufficiently large. While we prove these findings in the appendix, it is useful to provide an intuitive explanation. Suppose there is no uncertainty. If the firm sufficiently underinvests relative to the first best, she can threaten not to pay the precontracted salary w^L which may significantly exceed the agent's market wage. Accordingly, the parties then bargain over a continuation of their relationship, and the employer obtains a payoff weakly smaller than her Nash-payoff $\gamma[v^G(g) + v^S(s)] - s - g$. This surplus, in turn, cannot exceed $\gamma v^G(g^*) - s$ because $v^G(g) + v^S(s) < v^G(g^*) = w^L$ is necessary for a credible threat. Since the employer reaps $v^S(s^*) - s^* - g^*$ if she invests efficiently, it is now easy to see that underinvestment cannot be beneficial if her bargaining power is small. Even more importantly, a long-term wage contract leads to efficiency if specific investments have a strong effect on the overall return from the relationship.[23]

Before concluding this section, we should note that none of the previous schemes is able to implement efficient investments if it can be optimal for the parties to separate. This outcome has an intuitive reasoning: when a long-term contract specifies only w^L, the agent immediately quits if this is efficient, and the employer then does not recover any surplus from her general investments. Since the training firm does not take into account the positive externality general investments have on the agent's surplus,

[22]Note that we can easily incorporate specific self-investments of the worker and still obtain a first-best result. Since the worker obtains a fixed wage w^L under the optimal contract, he will invest efficiently since he accrues the marginal surplus.

[23]The parties might combine w^L with a termination fee p_0 which becomes due when the relationship ends after the first period. Then, one can show that Conditions 1 and 2 still remain necessary (and do not become sufficient) prerequisites for the feasibility of efficient investments. However, a proper combination of long-term wage and termination fee may now render a first best feasible even if efficiency is unattainable under an initial contract specifying only w^L. Moreover, one can show that the optimal p_0 is a positive payment from employer to worker, while the agent's equilibrium wage is some $w^L > v^G(g^*, \bar{\theta})$.

underinvestment prevails. Alternatively, when the parties agreed upon a termination fee or breach penalty, the agent has to compensate his previous employer in case he terminates the relationship. If the fee is sufficiently small, no renegotiation is required. The agent pays the precontracted penalty, and the employer again obtains no marginal return on her general investments. Conversely, if the fee is large, the parties separate only after they renegotiated their initial contract. Whenever the employer does not have the entire bargaining power in these renegotiations, she receives just a certain fraction of marginal returns, and still underinvests in general human capital because again she does not fully internalize the externality generated by her training.[24] However, a long-term scheme comprising a termination fee generically implements efficient specific investments if g is contractible: an initial contract then prescribes g^*, and the employee becomes eligible for a termination *bonus* p_0 when the relationship ends. If the bonus is large enough, his outside option payoff always binds and he receives $v^G(g^*, \theta) + p_0$ whether or not the relationship continues. Accordingly, the employer's equilibrium payoff becomes $v^S(s, \theta) - s - g^* - p_0$ in every state where a continuation is efficient [and $-p_0 - s - g^*$ otherwise]. The training firm thus accrues the whole marginal surplus from its specific investments, and efficiency prevails. Interestingly, Malcomson (1997, p. 1941) notes that employers in many European countries are required to make redundancy payments or have to seek approval from government agencies until they can lay off workers. These costs seem to be especially high in Germany, i.e., in a country where institutional features easily allow for a verifiability of general training. Our analysis suggests that the presence of these payments is efficiency enhancing since it induces the employer to expend optimal investments in relationship-specific capital.

4 Discussion

A closer look at actual labor turnover rates may provide a natural test for the theory we have developed in this paper. In previous work, turnover rates have been largely treated as exogenous, country-specific characteristics [see, e.g., Hashimoto and

[24] Acemoglu (1997) shows in a model with frictional labour market that this result even applies when general investments are contractible. In his model, the employee is randomly matched with another firm after an exogenous breakdown of the current relationship. Since there is a lock-in effect with this new employer for a certain period, surplus-sharing applies. If worker and previous employer cannot ex ante agree upon contracts with potential second-period employers that prescribe side payments in case that the worker changes his job, the parties will rationally ignore this externality when contracting on general investment, and underinvestment prevails.

Yu (1980), Blinder and Krueger (1996), Acemoglu and Pischke (1999)], and it has been found that lower turnover rates are correlated with higher training investments. By contrast, our integrated analysis of general and specific investments allows it to revert the causality chain: by the definition of firm-specific skills, there must be a negative relationship between specific investments and turnover simply because these investments increase marginal returns only if the relationship is continued. Therefore, one would expect lower turnover rates in industries where specific investments are very viable.

Features from the German labor market may confirm this prediction. To show this, note that there are significant differences in training expenses across sectors of the German economy. Franz and Soskice (1995) estimate the average yearly net training cost of employers per apprentice at about DM 15000 in the industrial sector which largely consists of medium and large scale enterprises, and at only about DM 7000 in the crafts and artisan sector ("Handwerk"). Similar results are found in Acemoglu and Pischke (1997) who [using data from an empirical study conducted by von Bardeleben, Beicht and Feher (1995)] estimate that large firms with more than 500 employees have positive training costs of about DM 7500, while the costs for the smallest firms with less than 10 employees [usually from the *Handwerk* sector] are close to zero. These patterns are interesting because the formal structure of apprenticeship programs in the two sectors is more or less the same. Since we see no obvious argument why informational asymmetries or search costs should systematically differ between industrial and crafts sector, it seems very plausible that firm-specific training is of considerable importance in large enterprices which are characterized by complex internal structures. In fact, Franz and Soskice note that *"[w]ith the type of modern patterns of work organization which seem increasingly widespread in Germany, the requirements of a skilled worker [in the industrial sector] have radically changed. By contrast to the traditional craftsman or to a tradesman in a Fordist company who had a set of standardized skills which they could use in many different environments, the modern skilled employee plays a complex interactive role in the production, maintenance, organization of new processes, and so on."* [Franz and Soskice (1995), p.220]. The results of our paper suggest that differences in employer-sponsored training between the industrial and the crafts sector of the German economy can be traced back to the differences in the viability of specific training. This view is also confirmed by the observation that retention rates after the completion of the apprenticeship program vary significantly with firm size: Soskice (1995) reports that the retention rates in small firms with 5-9 employees are about

0.56, while they increase in firm size and reach a rate of 0.87 for companies with more than 1000 employees. This sample also exhibits a relation between the employer's willingness to invest in general training and firm size: while about 41 percent of firms of less than 50 employees [and even 65 percent of firms with 5-9 workers] do not participate in formal training programs which to a large degree increase the general-usage skills of the trainee, the fraction of non-training firms continuously shrinks and becomes negligible for firms with more than 500 employees. This finding is in line with our theoretical results, where a high relevance of specific training leads not only to low turnover rates, but goes hand in hand with a more pronounced provision of firm-sponsored general training.

Similarly, we would predict a positive correlation between general training and retention rates in an international context. Recall that the equilibrium level of general training in (not exclusively) our theory depends on its contractibility. Following reasonable arguments in the literature and supposing that verifiability in Germany with its institutionalized training structure is much higher than in a country like the United States, one would expect a higher equilibrium level of employer-sponsored general training in Germany relative to the United States. Since general and specific training are incentive complements for the employer, we would thus predict higher turnover rates in the United States than in Germany, a hypothesis which is strongly supported by the data. For example, Topel and Ward (1992) and Soskice (1994) find that the average number of jobs held by US American employees during the first ten years of their job careers is about five, but only one or two in Germany [Soskice (1994), Acemoglu and Pischke (1997)].

Finally, our results indicate the occurence of tenure effects and are therefore consistent with findings in the theoretical [see, e.g., Acemoglu (1997) and Acemoglu and Pischke (1999)] as well as empirical work [Altonji and Shakotko (1987), Topel (1991)]. Interestingly, Blanchflower, Oswald and Sanfrey (1996) find that a training-induced profit increase from general training raises wages only at a rate of at most 0.3, and Loewenstein and Spletzer (1998) estimate that a worker's return on employer-sponsored specific and general training is very similar. These results suggest that rent-sharing between employer and agent concerns the overall surplus from their relationship, and that the agent's bargaining power is in some intermediate range where rent- sharing

indeed takes place according to our theoretical predictions.[25]

5 Conclusion

We have shown that employers will devote own resources to general training of their employees even in a competitive economy without (exogenous) market friction. To this end, we analyzed a setting where the firm can invest in general as well as firm-specific human capital. As the most important result, we showed that these types of investments interact even if no technological link exists. The feasibility of specific investments not only renders the provision of general investments viable for an employer, but the reverse also holds: the higher the level of general investments, the larger are the firm's incentives to provide specific training. Our theoretical results thus show that specific and general training are 'incentive' complements from the employer's point of view. Moreover, they may also conform with empirical evidence: according to our findings, we would predict that turnover rates decrease in general training since those investments positively affect the employer's outlays in specific training. One should therefore expect a systematic difference in turnover rates between countries in which general investments are contractible (and therefore provided at a high level) and countries in which the degree of contractibility is low. We argued that Germany's institutional dual system of vocational training is a good example for a system with verifiable general training, while the U.S. is not. Indeed, empirical studies overwhelmingly find that training expenses are much higher in Germany, whereas labor turnover is low relative to the US. While we have to leave a closer exploration of these and related issues to future research, we hope that the incorporation of specific investments into an analysis of human capital formation opens new avenues for a range of empirically testable hypotheses.

[25] We should note that our framework does not explain empirical findings from Acemoglu and Pischke (1997): they compare the subsequent salaries of two groups of employees who left their training firm. While individuals from one group were drafted to the military and therefore discontinued the relationship for exogenous reasons, the other group of individuals either quit voluntarily, or was laid off by their previous employers. The results in Acemoglu and Pischke suggest that the first group had significantly higher earnings than the second, which confirms their hypothesis that workers without exogenous reason to quit are considered as inferior in the labor market. Our model cannot adequately account for these differences, which emphasizes the importance of adverse selection phenomena as a complementary explanation for the prevalence of general training.

Appendix

Proof of Proposition 5:

Notice first that a long-term wage contract $w^L \geq v^G(g^*, \bar{\theta})$ is necessary for the implementability of efficient investments. Suppose not. Then, after the employer expended (g^*, s^*), the worker prefers to take his outside option rather than continuing the relationship with his training firm in some states of the world. In these states, renegotiations arise and the employer's marginal investment incentives are smaller than efficient. Next, note that Conditions 1 and 2 are also necessary to avoid renegotiations. If condition 1 is violated, the employer's ex ante expected profit for efficient investments is negative. If condition 2 does not apply, she cannot credibly commit to disburse w^L in every state of the world, and renegotiations again render efficiency unfeasible.

Thus, consider $w^L = v^G(g^*, \bar{\theta})$ and suppose that conditions 1 and 2 apply. Define $\Theta(g, s)$ as the set of states of the world where

$$v^G(g, \theta) + v^S(s, \theta) - v^G(g^*, \bar{\theta}) \geq 0 \quad \forall \ \theta \in \Theta(g, s) \tag{8}$$

for given investments (g, s). Conversely, let $\tilde{\Theta}(g, s)$ be the set of states where the inequality in (8) is reversed. Note that, for any (g, s), the long-term wage rate $w^L = v^G(g^*, \bar{\theta})$ becomes the agent's equilibrium remuneration if and only if $\theta \in \Theta(g, s)$. For any θ from the complementary set $\tilde{\Theta}(g, s)$, the parties will renegotiate their initial contract and the worker's continuation wage is $\max\{v^G(g, \theta), [v^G(g, \theta)+v^S(s, \theta)](1-\gamma)\}$.

If the employer expends some investment combination (g, s) for which the set $\tilde{\Theta}(g^*, s^*)$ is empty, her surplus in every state θ is

$$\Pi(g^*, s^*, \theta) = v^S(s^*, \theta) + v^G(g^*, \theta) - g^* - s^* - w^L. \tag{9}$$

Accordingly, (g^*, s^*) constitutes a local optimum of the firm's optimization program for the subset of investments (g, s) that lead to an empty set $\tilde{\Theta}(g, s)$.

We now have to check whether the employer may have an interest to choose some other investment combination $(\hat{g}, \hat{s})$ for which the set $\tilde{\Theta}(\hat{g}, \hat{s})$ has a positive measure. For any such investment tuple and states from this set, the employer's payoff becomes

$$\Pi(\hat{s}, \hat{g}, \theta \in \tilde{\Theta}(g, s)) = \min\{v^S(\hat{s}, \theta), [v^G(\hat{g}, \theta) + v^S(\hat{s}, \theta)]\gamma\} - \hat{s} - \hat{g}, \tag{10}$$

while it is easy to check that her payoff in states from the complementary set $\theta \in \tilde{\Theta}$ is strictly smaller than $\Pi(g^*, s^*, \theta)$. Analyzing (10), it is immediate that a deviation cannot be profitable if γ is sufficiently small, which proves part (i) of the proposition.

Consider now a deviation $(\hat{g}, \hat{s})$ for which $\tilde{\Theta}(\cdot)$ is non-empty (i.e., it comprises at least states with small θ). If the employer's payoff when expending efficient investments is larger than that for *any* such investment combination $(\hat{s}, \hat{g})$ in *any* state $\theta \in \tilde{\Theta}(\hat{g}, \hat{s})$, we have another sufficient condition for efficiency. This condition is fulfilled iff

$$\begin{aligned} &\Pi(g^*, s^*, \theta \in \tilde{\Theta}(\hat{g}, \hat{s}) \geq \Pi(\hat{g}, \hat{s}, \theta \in \tilde{\Theta}(\hat{g}, \hat{s})) \quad \Longleftrightarrow \\ &v^S(s^*, \theta) + v^G(g^*, \theta) - g^* - s^* - w^L \geq \min\{v^S(\hat{s}, \theta), [v^G(\hat{g}, \theta) + v^S(\hat{s}, \theta)]\gamma\} - \hat{g} - \hat{s} \end{aligned} \tag{11}$$

At a given investment pair $(\hat{g}, \hat{s})$, $\theta \in \tilde{\Theta}(\hat{g}, \hat{s})$ requires the validity of the (necessary) condition

$$v^G(\hat{g}, \theta) + v^S(\hat{s}, \theta) < w^L. \tag{12}$$

Therefore, we can utilize

$$\min\{v^S(\hat{s}, \theta), [v^G(\hat{g}, \theta) + v^S(\hat{s}, \theta)]\gamma\} \leq v^G(g^*, \bar{\theta}) \equiv w^L \quad \forall \quad \theta \in \tilde{\Theta}(\hat{g}, \hat{s}). \tag{13}$$

Replacing the term with minimum operator in (11) by w^L and rearranging, a sufficient condition for the validity of (11) is

$$V^S(\theta) \equiv v^S(s^*, \theta) - s^* \geq (1 + \gamma)v^G(g^*, \bar{\theta}) + v^G(g^*, \theta) + g^* - (\hat{g} + \hat{s}) \quad \forall\, \theta \in \tilde{\Theta}(\hat{g}, \hat{s}). \tag{14}$$

Accordingly, if $V^S(s^*, \theta)$ is sufficiently large, an initial wage contract w^L implements (g^*, s^*). $\square$

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