

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

Anke S. Kessler and Christoph Lülfesmann

University of Bonn

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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 reconsiders 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: Human Capital Formation, General and Specific Training, Hold-up Problem

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Corresponding address: Department of Economics, University of Bonn, Adenauerallee 24-42, 53113 Bonn, Germany.

Phone: +49-(228) 73 39 39, *Fax:* +49-(228) 73 92 39.

E-mail: kessler@wipol.uni-bonn.de, clmann@wiwi.uni-bonn.de.

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1 Introduction

Based on the transferability of the acquired skills, human capital theory distinguishes between investments in general-usage and specific human capital. As pointed out by Becker (1964), this distinction is important if these investments take the form of employer-provided training. While the returns to specific training can be realized only in an ongoing relationship with the training firm, general training increases the productivity of a worker in many firms besides those providing it. Becker's theory separately addresses these phenomena and draws two main conclusions. First, employers will share the returns and the cost of investments in firm-specific skills with their employees. Second, in a competitive labor market firms will not invest into general skills of their employees due to their inability to collect the returns from such investments. Therefore, workers must pay the full cost of general training.

Yet, there is a range of evidence indicating that firms voluntarily bear the cost of training, even if the acquired skills are largely general in nature. This is particularly apparent in countries with institutionalized apprenticeship systems. In Germany, for example, participants in the system (secondary school graduates) engage in part-time schooling and on-the-job training and receive upon completion a nation-wide accepted certificate that helps to make their skills marketable throughout the profession. Franz and Soskice (1995) estimate that German employers paid a net cost per apprentice of about DEM 12.300 in 1985. Using 1991 survey data on training firms in Germany, von Bardeleben, Beicht and Fehr (1995) conclude that even under the most conservative assumptions, the net cost of an apprentice in a larger German firm exceeds DEM 7.500.¹

The present paper reconsiders Becker's seminal arguments in a framework where firms can provide both general and specific training. To this end, we employ a simple model that preserves two essential characteristics of the standard theory: a) the labor market is frictionless in the sense that a worker always receives the full return from general training and b) he obtains a share of the return from specific training. Our main result is that employers may still voluntarily provide a positive amount of general training or alternatively, be willing to share the costs of such training with their employees if cost-sharing arrangements are feasible. As a first step to this conclusion, we find that general and specific investments cannot be separately analyzed. Rather, the presence

¹Interestingly, this study also estimates net training costs be negative for small firms, especially those with part-time trainers (see Section 3 for a discussion). For further evidence on firm-sponsored general training, see Soskice (1994) and Harhoff and Kane (1997) for Germany, and Ryan (1980) and Bishop (1991) for the US.

of the relationship-specific rent that is generated through a workers's specific skills makes the parties' returns from either type of investment interdependent even if (as we posit) there is no technological link between them. The idea of our approach can be outlined as follows. If a firm can provide only general training, it has no incentives to invest since the employee can recover the full return on his human capital in the absence of market imperfections. If, in contrast, the firm can also expend investments in relationship-specific skills, this will create a wedge between the worker's productivity if he leaves his current employer and his productivity if employment continues beyond the training period. Once training is completed, firm and worker are then in a bilateral monopoly position.

Now suppose that they divide the surplus from continued employment in the ensuing wage negotiations with their external market opportunities acting as outside options. Then, although the (above market) rent depends only on the worker's specific skills, the way in which is shared also depends on his general skills. In particular, as long as the external market opportunity of the worker (which fully reflects his marginal product from general training) is binding, negotiations will lead to the going market wage so that the rent from specific human capital accrues entirely to the firm. If this rent is sufficiently large relative to the return on general human capital, however, or if the worker's bargaining power is sufficiently high, his share of the surplus from continued employment will be above what he can realize on the external market. As a consequence, the worker captures part of the rent from specific skills and a 'Hold-up' problem [Williamson (1985), Grout (1984)] arises. While hold-up discourages specific training, it at the same time improves the firm's incentives to provide general training: although external wages rise one-to-one with a worker's productivity from general skills, the wage he obtains if he stays with the training firm rises by less than that if surplus sharing (hold-up) occurs. Moreover, the higher the level of specific training, the larger the resulting cap which further encourages the firm to invest into general training.

As we will see, the reverse also holds, i.e., general skills enhance the firm's provision of specific training relative to a scenario where general training is not taken into consideration. Intuitively, in situations where workers' outside wage is binding for given investment levels, the employer reaps the full return from specific investments at the margin because each worker's equilibrium wage then coincides with his marginal product from general training. As a consequence, her investment incentives in specific training increase as compared to a setting without general training where the workers outside wages pose a weaker constraint in bargaining. Hence, general and specific

human capital may be *complementary* from the firm's point of view even though their returns (or provision costs) are technologically disconnected. For this reason, we also find that the parties will agree on a general training level in excess of the first best if this investment can be contracted upon in advance. Since general and specific training are complements, a higher level 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. Finally, we argue that extending our framework to allow for (equilibrium) turnover or the possibility of long-term contractual arrangements qualitatively leaves these conclusions unaffected.

The present paper is related to a number of contributions in the literature. First, we adopt our theoretical approach from previous work on specific investments and the 'hold-up' problem.² In particular, our analysis draws on MacLeod and Malcomson (1993a, 1995) who provide a natural framework to study both general and specific investments in bilateral trade relationships. To formalize how the rent generated through specific investments is shared among the parties, the authors develop a bargaining game where negotiation and trade takes place over time. This property not only reflects the long-term nature of employment relationships well but also allows for the possibility of renegotiating an existing contract. The equilibrium outcome follows the outside option principle which will be of importance for our findings as well. This principle has been derived in a version of the Rubinstein game where at one party can take an outside option [Shaked and Sutton (1984)] and states that outside options act as a lower bound to party's payoffs in negotiations but otherwise do not affect the outcome. MacLeod and Malcomson (1993a, 1993b) use this model to investigate under which conditions simple contractual arrangements can induce efficient investments. In particular, it is shown that a long-term contract which specifies a fixed price (wage) and possibly in addition a fee paid in case of termination (a redundancy payment) will induce one party to expend efficient specific investments, even if those also benefit the other party as is the case with firm-sponsored specific training. However, they do not consider a situation where the firm provides general training, which is the focus of our analysis.³ We will briefly discuss their results on long term contracting and the implementability of efficient (specific) investments in Section 2.3 below.

Second, a number of recent papers have analyzed human capital accumulation in the context of employment relationships and propose several reasons for why we observe

²See among others, Grout (1984), Hart and Moore (1998) and Edlin and Reichelstein (1996).

³MacLeod and Malcomson (1993a) also study general investment by both parties but these are 'selfish' in the sense that they do not affect the external market opportunity of the other party.

firm-sponsored general training. This literature mainly focuses on general training and disregards specific investments. One explanation is based on asymmetric information between the training firm and potential future employees. Katz and Ziderman (1990) suggest that the firm may be willing to invest in a worker's general skills if his level of training is unobserved by the market.⁴ Acemoglu and Pischke (1998) study a model where the training firm obtains superior information on the worker's ability during the training period. The informational disadvantage of firms in the external labor market gives rise to adverse selection, i.e., the equilibrium market wage falls short of the marginal product of highly skilled workers. As a result, a training firm enjoys some monopsony power over its workers and is able to capture (part of) the return from general training. 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. Acemoglu and Pischke (1999) motivate the prevalence of employer-financed general training by the existence of market frictions that compress the structure of wages in the sense that the outside wage is below the marginal product from general skills and that this wedge increases in the level of training provided. The authors show that such wage compression can endogenously emerge in economies with minimum wages, wage-setting unions, or worker moral hazard. Finally, they note that firm-sponsored investments in general training is encouraged if general and specific skills are complements in a firm's production function. A related argument has been put forward by Franz and Soskice (1995) who recognize that employers may provide general training if general and specific investments are complements in the firm's investment cost function.

The remainder of the paper proceeds as follows. Section 2.1 develops the basic model with general and specific investments which is analyzed in Section 2.2. The following Section 2.3. briefly considers the implications of labor turnover and the possibility of long-term contracting. In Section 3 we discuss our results and their implications and relate them to empirical evidence. A final Section 4 concludes.

⁴See also Chiang and Chiang (1990) and Chang and Wang (1995).

2 A Model of General and Specific Training

2.1 The Basic Framework

Consider the following simple model of human capital accumulation in the labor market. There are two risk-neutral parties: a worker and a firm operating in a competitive labor market.⁵ Time is divided into a training period $t = 1$ and a subsequent employment period $t = 2$ and there is no discounting. In each period t , the worker can supply one unit of labor at personal cost $c > 0$ to produce an output of v_t measured in monetary terms. The wage he receives for his work is denoted by w_t . In the first period, the worker is unskilled but may be trained by the firm in both general and firm-specific skills. The firm's total outlays for general and specific training are denoted by $g \in [0, \bar{g}] \subset \mathbb{R}$ and $s \in [0, \bar{s}] \subset \mathbb{R}$, respectively. Throughout the analysis, we assume that the amount of specific training s which the worker receives on the job cannot be contractually specified. Training in general skills g , in contrast, may or may not be contractible, depending for example on whether there is a formal apprenticeship program in which the parties participate or not.

For simplicity, we let the productivity of an unskilled worker in $t = 1$ be independent of the amount of training he receives and be equal to $v_1 = \underline{v}_1 \geq c$. The output v_2 of a skilled worker in $t = 2$ is determined by the firm's investments in general and specific training, g and s , as well as a random parameter θ which may be interpreted as the worker's ability or as a industry-wide shock that affects market conditions. θ becomes known to both parties after the first period and is distributed according to a continuously differentiable distribution function $F(\theta)$ over a bounded support $[\underline{\theta}, \bar{\theta}]$. Let $\sigma = (s, g, \theta) \in \Sigma$ be the state of the world in $t = 2$. To make our point as strong as possible, we disregard in what follows the possibility of technological complementarities between general and specific training. Thus, the productivity of a skilled worker is additively separable in g and s ,

$$v_2(s, g, \theta) = v^S(s, \theta) + v^G(g, \theta), \quad \forall \sigma \in \Sigma \quad (1)$$

where v^S and v^G are the components of v_2 that can be attributed to the acquisition of firm specific and general skills, respectively.

⁵Restricting attention to a single worker-firm pair is done for expositional convenience only and inconsequential for the results that follow. It is formally justified if there is a sufficiently large number of firms in the market and all firms have access to the same technology that is linear in the number of workers they employ.

Assumption 1. The function $v_2(\cdot)$ is continuously differentiable, strictly concave and increasing in (s, g) . Furthermore, for all $\sigma \in \Sigma$,

- a) $\lim_{i \rightarrow 0} \partial v_2(s, g, \theta) / \partial i = \infty$ and $\lim_{i \rightarrow \bar{i}} \partial v_2(s, g, \theta) / \partial i = 0$, $i \in \{s, g\}$,
- b) $\inf_{\sigma} v_2(s, g, \theta) = \underline{v}_2 \geq c$ and $v_2(0, g, \theta) = v^G(g, \theta)$.

Part a) of Assumption 1 implies that it is always socially optimal to have a positive amount of training. Part b) ensures that subsequent employment (whether with the current employer or with another firm on the external labor market) is always efficient. Moreover, in the absence of specific investments, all productivity is general in nature. Given the state σ at the beginning of period 2, worker and firm negotiate on the second-period wage in a way to be detailed below. 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 . By definition, the worker's general skills are perfectly marketable while his specific skills lose their value in case of a separation. Thus, another firm hiring the worker (or the firm hiring another skilled worker) would value his output at $v^G(g, \theta)$.

Assumption 2. There is perfect competition on the external labor market in both periods and the state $\sigma = (s, g, \theta)$ is commonly observable. Hence, $w^E = v^G(g, \theta)$ for all $\sigma \in \Sigma$.

The sequence of events is summarized in Figure 1. In stage 0, the firm offers a wage contract w_1 to the worker that governs the training period. If feasible, the contract may also specify how much training in general skills g he is to receive. Once hired the worker produces \underline{v}_1 , and the firm decides in stage 1 on training outlays s and g . In stage 2, first period payoffs $\pi_1 = \underline{v}_1 - w_1 - s - g$ and $u_1 = w_1 - c$ are realized. The random parameter θ (e.g., the worker's ability) becomes known in stage 3. The second-period wage w_2 is negotiated in stage 4. If employment continues, the worker produces v_2 and the parties' second-period payoffs are $\pi_2 = v_2 - w_2$ and $u_2 = w_2 - c$. If the relationship is terminated, either party can take up its external market opportunity. The payoffs in this case are denoted by u^E and π^E , respectively.

For future reference, let us briefly calculate the efficient levels of training. To this end, recall that since $\underline{v}_t \geq c$, the worker should be hired in $t = 1$ and continued to be employed by the firm in $t = 2$, irrespective of its training outlays s and g .⁶ The

⁶The assumption that the worker should always stay with the training firm will be relaxed in Section 2.3. below which addresses the possibility of efficient separation in $t = 2$.

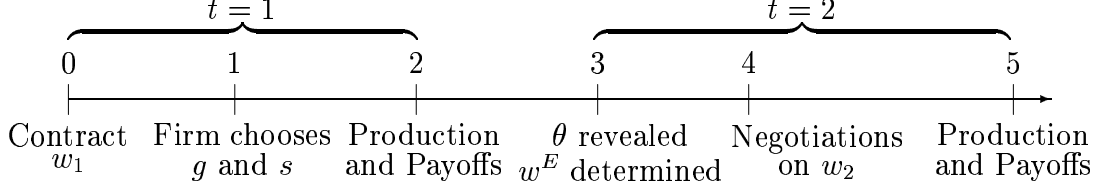


Figure 1: Sequence of Events

first-best amount of training each worker receives is thus uniquely defined by

$$(s^{FB}, g^{FB}) = \arg \max_{(s,g) \geq 0} \int_{\theta \in [\underline{\theta}, \bar{\theta}]} [v_2(s, g, \theta) - c] dF(\theta) + (\bar{v} - c) - s - g.$$

Using (1), the corresponding first-order conditions are

$$\int_{\theta \in [\underline{\theta}, \bar{\theta}]} \frac{\partial v^S(s^{FB}, \theta)}{\partial s} dF(\theta) = 1, \quad (2)$$

$$\int_{\theta \in [\underline{\theta}, \bar{\theta}]} \frac{\partial v^G(g^{FB}, \theta)}{\partial g} dF(\theta) = 1. \quad (3)$$

equating the expected marginal return from each type of training with its marginal cost. As one would expect, g^{FB} and s^{FB} are determined independently from each other due to the separability of $v_2(\cdot)$.

It remains to describe the outcome of the negotiations between the firm and a worker on the second-period wage w_2 . Recall that those take place under symmetric information since the state is known to both parties in stage 4. Clearly, if an agreement is reached and the relationship continues, the net surplus to be divided in negotiations is equal to second period net production $v_2 - c > 0$. However, each party can terminate the relationship and take up its external market opportunity in which case the payoff to the firm and the worker is π^E and u^E , respectively. In the subsequent analysis, we assume that negotiations can be formalized by a bargaining solution which ensures efficiency and is characterized by the outside option principle.

Assumption 3. Let $\alpha \in (0, 1)$ be a parameter that measures the relative bargaining power of the worker. The second period equilibrium payoffs $\hat{\pi}_2$ and \hat{u}_2 in the negotiation

game are unique and satisfy $\hat{\pi}_2 + \hat{u}_2 = v_2(s, g, \theta) - c$, $\forall \sigma \in \Sigma$ where

$$\hat{u}_2 = \begin{cases} \alpha[v_2(\cdot) - c] & \text{for } \alpha[v_2(\cdot) - c] \geq u^E \\ u^E & \text{otherwise,} \end{cases}$$

and $\hat{\pi}_2 = \begin{cases} (1 - \alpha)[v_2(\cdot) - c] & \text{for } (1 - \alpha)[v_2(\cdot) - c] \geq \pi^E \\ \pi^E & \text{otherwise.} \end{cases}$

Thus, worker and firm share the surplus from continued employment $v_2 - c > 0$ according to their relative bargaining power with their external market opportunities acting as an outside option, i.e., they constitute a lower bound on each parties' payoff but otherwise do not affect the outcome. This formulation is consistent with several extensive-form bargaining games that have been developed in the context of labor markets [Shaked and Sutton (1984), MacLeod and Malcomson (1993a, 1995)].⁷ It can further be simplified by noting that $\pi^E = 0$ because competition on the external labor market ensures that the firm hiring another worker always has to pay him his full marginal product [Assumption 2]. Due to $v_2(\cdot) - c > 0$ from Assumption 1, the firm's share of the surplus from continued employment always weekly exceeds the profit from taken up its external market opportunity. We can thus disregard the firm's outside option in what follows and characterize the negotiation outcome in terms of the second period equilibrium wage \hat{w}_2 which, using $u_2 = w_2 - c$ and $u^E = w^E - c$, is given by

$$\hat{w}_2 = \begin{cases} c + \alpha[v_2(\cdot) - c] & \text{for } c + \alpha[v_2(\cdot) - c] \geq w^E \\ w^E & \text{otherwise.} \end{cases} \quad (4)$$

Two characteristics of \hat{w}_2 are notable. First, the employee always receives at least his marginal product from general skills, $w^E = v^G(g, \theta)$. Second, 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 (outside option principle). As the literature on non-cooperative bargaining has shown, this property will prevail if a quit (or layoff) effectively terminates the negotiations and

⁷More specifically, the unique subgame perfect equilibrium of the game studied by Shaked and Sutton (which is based on the Rubinstein bargaining game) coincides in the limit were discounting is negligible with the outcome in Assumption 3 for $\alpha = 1/2$. Arbitrary values of α can be introduced into the alternating-offers game by assuming that nature chooses which player makes an offer in each bargaining round with constant probability [see Binmore (1987)]. Using this variant of the Rubinstein game, MacLeod and Malcomson (1993a, 1995) develop a model of contract (re-)negotiation where trade occurs over time rather than at a single date, thus reflecting the long-term nature of employment relationships very well. Under our specification (and assuming $c > 0$ so that the worker is not willing to work in the absence of a contract), the unique subgame perfect equilibrium in their model if the time interval between offers vanishes again coincides with the outcome in Assumption 3.

forges all future gains from cooperation so that the worker cannot credibly threaten to quit in such a situation.⁸

General Investments in Human Capital

Let us first investigate a situation where the firm cannot or does not invest into relationship specific skills of the worker by setting $s \equiv 0$. Because all training is then general, the employee is as valuable inside the existing relationship as on the external labor market: competition among firms ensures that the worker is paid his full marginal product $v^G(g, \theta)$, irrespective of whether the relationship is continued or the worker seeks outside employment. By (4), negotiations will lead to a second-period wage of $\hat{w}_2 = w^E$: surplus sharing never occurs simply because there is no rent in excess of what can be obtained in the market. The firm's second period profit is thus $\hat{\pi}_2 = 0$ and the worker's utility is $\hat{u}_2 = v_2(0, g, \theta) - c = v^G(g, \theta) - c$. The expected overall returns from the relationship are then given by $E[\pi(0, g)] = \underline{v} - w_1 - g$ and $E(u) = w_1 - c + E_\theta[v^G(g, \theta)] - c$, respectively. The following proposition is immediate and replicates Becker's (1975) seminal argument.

Proposition 1. *Suppose the firm does not invest into specific skills of the employee, i.e., $s \equiv 0$. Then, the equilibrium level of general training g^* and the first period wage \hat{w}_1 satisfy*

- a) $g^* = 0$ and $\hat{w}_1 = \underline{v}$ if g cannot be contracted upon,
- b) $g^* = \min\{g^{FB}, \underline{v}\}$ and $\hat{w}_1 = \max\{\underline{v} - g^{FB}, 0\}$ if the initial contract offer can include g but the worker is wealth constrained.

The employer never pays for training in general skills because she cannot recover any returns from such training in the second period. If its training expenditures are non-contractible, this implies that no general human capital investments are made in equilibrium. Likewise, if the firm can offer initial contracts (w_1, g) , any outlays in general training have to be borne entirely by the employee by receiving a first-period wage below his productivity. Expressed differently, if we let γ be the worker's cost share and express the first-period wage as $\hat{w}_1 = \bar{w}_1 - \gamma g$ where \bar{w}_1 is the wage component that is independent of g , then $\bar{w}_1 = \underline{v}$ and $\gamma = 1$: the worker is paid his first-period marginal product and finances the full cost of his training out of his pay. First-best

⁸See, e.g., Osborne and Rubinstein (1990). Malcomson (1997) provides an extensive discussion of how market opportunities can enter the negotiation outcome and when they take the form of outside options. This point is discussed in more detail in Section 3.

investments thus become feasible if and only if productivity during the training period is sufficiently high. Otherwise, however, underinvestment prevails.⁹

2.2 Investment in General and Specific Training

We now return to the possibility of investment in the acquisition of firm-specific skills. To see how training in firm-specific skills alters equilibrium characteristics, reconsider the outcome of negotiations on second-period wage contracts. For $s > 0$, there is now a positive rent $v_2(s, g, \theta) - w^E = v_2(s, g, \theta) - v^G(g, \theta) = v^S(s, \theta) > 0$ to be divided between worker and firm. While this rent depends solely on the level of specific training s , the way in which it is shared depends also on g as can be seen from (4). For $c + \alpha(v_2 - c) < w^E \Leftrightarrow v^S < (v^G - c)(1 - \alpha)/\alpha$, the worker's share of the surplus generated in the existing relationship falls short of what he can obtain on the external labor market: since his alternative market opportunity is binding, the negotiated second period wage is $\hat{w}_2 = w^E = v^G(g, \theta)$ and the rent from specific investments $v^S(\cdot)$ accrues entirely to the firm.

Conversely, the negotiated wage exceeds the outside market wage for $c + \alpha(v_2 - c) \geq w^E \Leftrightarrow v^S \geq (v^G - c)(1 - \alpha)/\alpha$. In those states, the worker captures part of the rent generated through specific human capital accumulation through his share α of the overall surplus. His equilibrium wage then satisfies $\hat{w}_2 > w^E = v^G(g, \theta)$. As already noted by Becker, specific training investments imply that worker and firm are in a bilateral monopoly position after those investments have been made: if the worker quits and takes on 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 laid off and he would therefore be unable to recoup any specific investments on this own part. As is well known, once worker and firm share the rent from specific investments, the 'Hold-up Problem' [Williamson (1985), Grout (1984)] arises and the firm will underinvest. 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: whenever 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, let $\Theta(s, g) = \{\theta \in [\underline{\theta}, \bar{\theta}] : v^S(s, \theta) \geq (v^G(g, \theta) - c)(1 - \alpha)/\alpha\}$ denote the set

⁹As stated in the proposition, this line of reasoning requires the worker not to have access to the capital market. Once he can borrow against future wage income, the efficient amount of general training is provided in equilibrium.

of states in which rent sharing occurs. Inserting the expression for \hat{w}_2 from (4) into the firm's expected profit from the relationship, the latter can be written as

$$E[\pi(s, g, \theta)] = \underline{v} - w_1 + \int_{\theta \in \Theta} (1 - \alpha) [v_2(s, g, \theta) - c] dF(\theta) + \int_{\theta \notin \Theta} [v_2(s, g, \theta) - v^G(g, \theta)] dF(\theta) - g - s. \quad (5)$$

Let us first focus on a situation where g is not contractible so that the employer would not be willing to provide general training for $s \equiv 0$. If specific investments are allowed for, the firm chooses (s, g) so as to maximize (5), subject to the non-negativity constraints $g \geq 0$ and $s \geq 0$. As is easily seen, the latter constraint is never binding and can be ignored. Substituting for $v_2(s, g, \theta) = v^S(s, \theta) + v^G(g, \theta)$, the first-order conditions that characterize equilibrium training outlays (s^*, g^*) are

$$\int_{\theta \in [\underline{\theta}, \bar{\theta}]} \frac{\partial v^S(s^*, \theta)}{\partial s} dF(\theta) - \alpha \int_{\theta \in \Theta(\cdot)} \frac{\partial v^S(s^*, \theta)}{\partial s} dF(\theta) = 1, \quad (6)$$

and

$$(1 - \alpha) \int_{\theta \in \Theta(\cdot)} \frac{\partial v^G(g^*, \theta)}{\partial g} dF(\theta) \leq 1, \quad = 1 \text{ for } g^* > 0, \quad (7)$$

where $\Theta(\cdot)$ is evaluated at (s^*, g^*) .¹⁰ Hence,

Proposition 2. *Suppose the firm can train the worker in specific and general skills and training expenditures are non-contractible. Then, its equilibrium training outlays (s^*, g^*) are characterized by*

a) $s^* < s^{FB}$ and $0 < g^* < g^{FB}$ if $v^S(s^{FB}, \theta) > (\underline{v} - c) \frac{1-\alpha}{\alpha}$ for some realization of $\theta \in [\underline{\theta}, \bar{\theta}]$,

b) $s^* = s^{FB}$ and $g^* = 0$ otherwise.

Thus, the firm invests in general training if and only if hold-up with respect to specific training occurs with positive probability.

Under our assumptions on $v_2(\cdot)$, the claim follows directly by comparing (6) with (2) and by inspection of (7). A formal proof is therefore omitted. The intuition for this

¹⁰It is straightforward to verify that $E[\pi(s, g)]$ is concave in (s, g) . Equilibrium training outlays (s^*, g^*) are therefore unique and fully determined by (6) and (7).

finding has already been laid out in the preceding discussion. If hold-up occurs in some states of the world, the employee captures a fraction α 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 part of its expenditures on general training on the margin. This is true even though rent sharing implies that its joint profit from both types of training decreases relative to a situation where the employee's alternative market opportunity is binding. Expressed differently, the firm captures part of its general training outlays *although* the worker always receives at least his marginal product from general training.¹¹ Hold-up with respect to specific investments ($s^* < s^{FB}$) can only be avoided if, given efficient specific and no general training, the external wage of a worker with no marketable skills, $w^E = \underline{v}$, is sufficiently high so as to make the worker's outside market opportunity binding in every state of the world, i.e., $\Theta(s^{FB}, 0) = \emptyset$, or equivalently, $v^S(s^{FB}, \theta) \leq (\underline{v} - c) \frac{1-\alpha}{\alpha}$ for all realizations of θ . Otherwise, however, hold-up will occur and it is optimal for the employer to provide a positive amount of general training. Finally, note that for $s^* > 0$, the firm expects to realize a positive second-period profit. On a competitive labor market, those future profits will be competed away by means of first-period wage payments. Formally, we have $E_\theta \pi(s^*, g^*, \theta) = 0 \Rightarrow \hat{w}_1 > \underline{v}$, i.e., the firm's rents from human capital accumulation are captured by the worker through a rise in his first period wage.

At first glance, the statement in Proposition 2 may lead one to conclude that a firm's investment in general human capital negatively distorts the accumulation of specific human capital relative to a situation where general training is absent, $g \equiv 0$. The following result asserts that this conclusion is misleading:

Proposition 3. *The firm's expected profit function (5) is supermodular in s and g . Therefore, general and specific training are complementary from the firm's point of view and its optimal investments into specific human capital $s^*(g)$ are nondecreasing in the level of general human capital g (and vice versa).*

Again, this finding has a simple explanation. Employees with a high level of general training receive higher external wage offers than those with fewer or no general skills. The outside market opportunity of workers with more general training will therefore bind more frequently, *ceteris paribus*. Although the firm has to match the external wage in those states, it at the same time reaps the full marginal return from its specific

¹¹It is important to observe that this property of our model differs from the existing literature where wages are 'compressed' and workers receive less than the marginal productivity associated with their general skills. See Section 3 for a discussion.

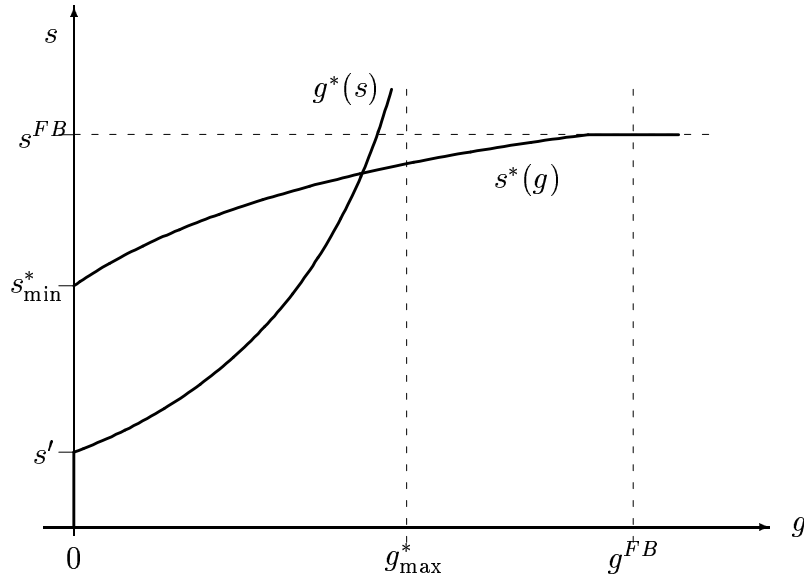


Figure 2: Training Outlays

training outlays (rent sharing does not occur) and its incentives to provide specific training rise. In other words, general training alleviates the hold-up problem that arises from the parties' lock-in in a bilateral monopoly situation.

Figure 2 illustrates the above arguments. It depicts the firm's optimally chosen expenditures in specific training s^* (respectively general training g^*) as a function of a given level of g (respectively s). If the worker had no general training, the firm would provide specific training of $s^*(0) = s_{\min}^*$ which solves (6), evaluated at $\Theta(s_{\min}^*, 0)$. The specific training outlays $s^*(g)$ increase thereafter until g is so high that surplus sharing no longer occurs so that the firm invests efficiently, independent of g . Conversely, no general training would be provided if $s = 0$ and this continues to be optimal up to some $s = s'$ at which point surplus sharing occurs with positive probability, i.e., $\Theta(s, 0)$ is non-empty for $s \geq s'$. From then on, the provision of general training $g^*(s)$ increases because the likelihood of a surplus sharing outcome increases in s , ceteris paribus. If this probability is equal to one, g^* is maximal and given by $g_{\max}^* < g^{FB}$ which solves (7) for $\Theta = [\underline{\theta}, \bar{\theta}]$. The equilibrium outlays (s^*, g^*) characterized in Proposition 2 can be found at the intersection of both curves. As long as $\hat{s}_{\min} < s^{FB} \Leftrightarrow \Theta(s^{FB}, 0) \neq \emptyset$, the intersection point is characterized by $g^* > 0$. Otherwise, we have $\hat{s}_{\min} = s^{FB}$ which implies $s' > s^{FB}$ by definition of s' so that the curves intersect on the axis where $g^* = 0$. Also note that the effect of a drop in the worker's bargaining power does not

necessarily encourage firm-sponsored general training: a reduction in α reduces the probability that surplus sharing occurs, thus shifting $s^*(g)$ upwards. Since $g^*(s)$ also shifts upwards by the same token, however, the composite effect is ambiguous.

Let us now turn to the case where g is contractible so that the firm can offer an initial contract (w_1, g) . For a precontracted level of general training g , the firm's expenditures on specific training $s^*(g)$ are determined by (6) and its associated expected profit is (5) evaluated at $(s^*(g), g)$. Clearly, feasible (i.e., individually rational) contracts (w_1, g) must satisfy $E[\pi(s^*(g), g, \theta)] \geq 0$ and $w_1 \geq 0$.¹² Thus, a necessary and sufficient condition for a first-best amount of general training to be part of a feasible arrangement is that $E[\pi(s^*(g^{FB}), g^{FB})]$ is non-negative at $w_1 = 0$. Assuming this to be the case in what follows, we can ask whether firm and worker will agree on a contract that prescribes general training to be at its efficient level g^{FB} . If we decompose $w_1 = \bar{w}_1 - \gamma g^{FB}$ again, we find using (1) and (5),

$$\bar{w}_1 = \bar{v} + \int_{\theta} v^S(s^*(g^{FB}), \theta) dF(\theta) - \alpha \int_{\theta \in \Theta} v^S(s^*(g^{FB}), \theta) dF(\theta) - s^*(g^{FB}) > \bar{v}$$

and $\gamma = 1 - (1 - \alpha) \int_{\theta \in \Theta} [v^G(g^{FB}, \theta) - c] dF(\theta) / g^{FB}$. (8)

We see that the presence of specific training facilitates an agreement on first-best general training for two reasons. First, the firm's second-period rent that is generated by the firm-specific skills of the employee raises first period wages, thereby relaxing the worker's liquidity constraint. Second, the share of general training outlays borne by the worker is strictly less than one if the last term in (8) does not vanish, i.e., if $\Theta(s^*(g^{FB}), g^{FB})$ is non-empty. From our previous analysis, this condition is equivalent to $s^*(g^{FB}) < s^{FB}$ or

$$v^S(s^{FB}, \theta) > (v^G(g^{FB}, \theta) - c) \frac{1 - \alpha}{\alpha} \quad \text{for some } \theta \in [\underline{\theta}, \bar{\theta}]. \quad (9)$$

The argument here is essentially the same as in Proposition 2. If hold-up with respect to specific training prevails, the firm captures part of the surplus from general training and is therefore willing to bear a positive share of those expenses. In this case, though, the equilibrium contract does not prescribe a first-best amount of general training:

¹²Recall that the worker is wealth constrained by assumption so first-period wages cannot be negative.

Proposition 4. *Suppose the firm can train the worker in general and specific skills and the amount of general training can be contracted upon. If (9) holds, equilibrium training outlays satisfy $s^* < s^{FB}$ and $g^* > g^{FB}$. In this case, the worker does not bear the full cost of his general training. Otherwise, $(s^*, g^*) = (s^{FB}, g^{FB})$ and the worker's share of general training expenditures is equal to one.*

The result states that worker and firm do not necessarily agree on the first-best level of g even though such a contract is feasible. Rather, they may well decide on a inefficiently *high* provision of general training. Although perhaps surprising, this finding is easily explained: suppose at a precontracted level of general training g^{FB} , the firm's (unilaterally chosen) expenditures on training in specific skills fall short of s^{FB} . Obviously, a small increase in g above g^{FB} has only a second order effect on the returns to general training. Since general and specific training are complementary from the firm's point of view, however, it improves the firm's incentives to engage in specific training. By Proposition 3, raising g has a positive first-order effect on the joint surplus from specific human capital accumulation. Thus, the worker optimally receives 'too much' general training in order to reduce a prevailing hold-up problem with respect to the firm's specific human capital investments.

2.3 Extensions

This section briefly considers two natural extensions of the basic model: the possibility of (equilibrium) labor turnover and the implications of long-term contracts.

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: the joint surplus in an ongoing relationship always exceeded the corresponding surplus after separation due to the firm-specific skills of the employee.¹³ Firm and worker therefore could always find a second-period wage scheme that made a continuation profitable for both parties. The possibility of equilibrium labor turnover can be incorporated into our basic model in a simple way. Suppose that in addition to the employee-specific (or industry-wide) shock θ , there is another purely match specific shock $\lambda \geq 0$ that is observed by both parties and positively affects the parties' payoff if they terminate the relationship and take up their outside market opportunities in period 2. For example, the worker may learn that he dislikes his colleagues or that his spouse has found employment in another state. Alternatively,

¹³Recall from Assumption 1 that $v_2(s, g, \theta)$ is increasing in s and $v(0, g, \theta) = v^G(g, \theta)$, $\forall g, \theta$.

the firm may discover that the worker is unable to adapt to its corporate culture. Irrespective of which party experiences the shock λ , separation in $t = 2$ is then efficient if and only if $v_2(s, g, \theta) < w^E + \lambda$ or, equivalently, $v^S(s, \theta) < \lambda$ after using (1) and $w^E = v^G(g, \theta)$. In such a situation, firm and worker can do no better than taking up their respective outside opportunities, i.e., the worker optimally quits or is laid off, respectively. In states where $v^S(s, \theta) \geq \lambda$ so that continuation is efficient, the outcome of wage negotiations as described in Assumption 3 remains valid with π^E or U^E adjusted for λ . Clearly, the external market opportunities will bind more often, thereby reducing the likelihood of a rent-sharing outcome. By our previous arguments, the amount of general training that the firm is willing to provide on its own account in equilibrium will thus be lower, ceteris paribus.¹⁴ As long as the firm's specific investments are sufficiently high so that rent-sharing (hold-up) occurs with positive probability, however, we will still have $g^* > 0$. Finally, note that the effect of λ on the firm's equilibrium outlays in specific training is ambiguous. On the one hand, the return from specific training falls if the relationship is terminated with positive probability since specific skills are valued only within an existing match. On the other hand, the firm has to share the rent from its specific investments less frequently because the likelihood that surplus-sharing occurs is reduced.

Long-term Contracts

Since employment contracts frequently expand beyond a short time horizon, it is important to study long-term arrangements and their effects on the formation of human capital.¹⁵ For concreteness, let us consider long-term contracts offered in stage 0 that take the form (w_1, w_2) , specifying a fixed wage w_t if the worker is employed in period t . Also, let us for the moment confine attention to the case where separation is never efficient, i.e., employment should always continue beyond the training period. Under this assumption, the parties can find a second period wage w_2 such that

$$c \leq w_2 \leq \inf_{\theta} v_2(s^{FB}, g^{FB}, \theta) \tag{C1}$$

so that employment in $t = 2$ would be preferred by both to no employment at all if the firm invested efficiently. Clearly, a contract (w_1, w_2) satisfying (C1) is not sufficient to ensure first-best investments: as long as contracting is on an at-will basis, the worker could still take up his external market opportunity in $t = 2$ and would optimally do so whenever $w^E > w_2$. Since the return from both general and specific training is lost to

¹⁴As is easily seen, the first-best general training outlays g^{FB} are unaffected by the possibility of efficient separation because general skills increase the value of a worker irrespective of whether he stays with his current employer or not.

¹⁵See Malcomson (1997) for a comprehensive survey.

the firm if the worker quits, it would underinvest (see below). Suppose now, however, that the contract can (in addition to w_t) stipulate a breach penalty P paid by worker to the firm that becomes due once the worker quits and switches to an outside employer at the beginning of the post-training period. Clearly, a sufficiently high penalty could – if enforceable – serve to protect the firm’s training outlays. In particular, for a breach penalty $P \geq \sup_{\theta} v^G(g^{FB}, \theta) - w_2$, the worker never takes up outside employment since the fine he would have pay in this case exceeds the highest possible external market wage (provided his general training does not exceed g^{FB}).¹⁶ As long as the fixed wage w_2 satisfies (C1), the firm obtains the full return from its investments at the margin. Moreover, the first-period wage w_1 can be adjusted to ensure non-negative profits. The firm would thus invest efficiently both in general and specific skills.

In view of their simplicity and apparent advantages, one might thus ask why such breach penalties are rarely observed in employment relationships where training is likely to play an important role. One obvious reason is that courts are reluctant to enforce breach penalties that *de facto* represent an exclusive dealing clause, thereby eroding the at-will nature of employment contracts. This will be particularly so if the breach remedy P necessary to ensure efficient investments is much larger than the actual damages of the firm arising from breach [Malcomson (1997)]. Another more fundamental explanation may lie in the fact that for the penalty to be effective, it must be contingent on the identity of the breaching party. If P had to be paid irrespective of who was responsible for separation, the firm would become eligible for the payment if it took a unilateral action, i.e., dismissed the employee. As a result, the worker would be (inefficiently) laid off in some states and the firm would underinvest. But it may be quite impossible for an outsider to determine who was responsible for the termination of the relationship, e.g., quits and layoffs may be indistinguishable.

If (contingent) breach penalties are not enforceable, it is less straightforward to achieve efficient investments. To see this, note that for the firm never to lay the worker off, the initially agreed upon second period wage must satisfy $w_2 \leq \inf_{\theta} v_2(s^{FB}, g^{FB}, \theta)$. Similarly, for the worker never to quit, we must have $w_2 \geq \sup_{\theta} v^G(g^{FB}, \theta)$. Taken together, these two inequalities can only hold if

$$\inf_{\theta} v_2(s^{FB}, g^{FB}, \theta) \geq \sup_{\theta} v^G(g^{FB}, \theta), \quad (\text{C2})$$

i.e., the smallest conceivable surplus inside the relationship must exceed the highest

¹⁶This reasoning requires the legal system to allow for such penalties in employment contracts. Also, the worker must be able to pay the penalty if necessary.

conceivable wage on the external labor market, given efficient investments.¹⁷ As long as there is some uncertainty in second-period productivity of a skilled worker, (C2) is quite restrictive: the difficulty lies in the fact that (efficient) voluntary continuation of the relationship has to be ensured, i.e., it must be possible to find the fixed second-period wage such that a quit or a layoff is never unilaterally optimal for either party. Of course, there may be little reason to suppose that one party actually would terminate the relationship if separation is not efficient. In other words, firm and worker could jointly agree to renegotiate w_2 if either outside option is binding.

The possibility that contracts are renegotiated by mutual consent is well recognized in the literature studying long-term arrangements as a way to resolve the hold-up problem. Since the formulation of wage negotiations in $t = 2$ given in (4) does not cover the case of a precontracted wage w_2 , a formal analysis of renegotiations is beyond the scope of the present paper. However, some insights as to what can be achieved in such a situation can be gained by drawing on the work of MacLeod and Malcomson (1993a, 1993b). Building on the Rubinstein/Stahl extensive-form bargaining game, the authors develop a model that allows for contract renegotiation. Essentially, they find that a contract is never renegotiated if both parties prefer continuing their relationship under the initial terms to taking up their external market opportunities or to no employment at all. Otherwise, the outcome is qualitatively the same as the formulation in Assumption 3, i.e., if continued employment requires renegotiation, the parties share the surplus from trade with their external market opportunities acting as outside options.¹⁸ In a setting where all the firm's investments are specific, MacLeod and Malcomson (1993b) then show that a simple long term contract (w_1, w_2) which sets w_2 sufficiently low that the workers external market opportunity is always binding [e.g., $w_2 \in (c, \underline{v}_2)$] will induce the firm to invest efficiently. Intuitively, since w_2 is always renegotiated to the market wage w^E , surplus sharing never occurs. Hence, the firm captures the full return from specific training and optimally sets $s = s^{FB}$. Yet, it is clear that the firm would not be willing to sponsor any general training in this case because the full return from general skills accrues to the worker (see Proposition 2). Only if g is contractible, therefore, this contractual arrangement can potentially implement first-best training levels.¹⁹

¹⁷To see why the condition must also hold if non-contingent breach penalties P are feasible, note that if either party can unilaterally trigger breach, the relevant inequalities are $P \leq \inf_{\theta} v^2(s^{FB}, g^{FB}, \theta) - w_2$ and $w_2 \geq \sup v^G(g^{FB}, \theta) - P$, again implying (C2).

¹⁸Thus, no initial contract would correspond to a precontracted second-period wage of $w_2 = 0$ where the worker would always prefer to terminate the relationship. In this case, the equilibrium outcome of the MacLeod/Malcomson game is identical to the outcome in Assumption 3 (see also their paper).

¹⁹MacLeod and Malcomson also consider general investments. Contrary to our specification, they assume that a) those are incurred by the worker and b) they do not affect second-period output but

If g cannot be contracted upon in advance (or feasible first-period wages do not cover g^{FB} if the worker is wealth constrained) and contingent breach-penalties are unfeasible, however, the analysis in Section 2.2 suggests that it is generally impossible to induce efficient training once contracts are open to renegotiation. The reason is straightforward: employers are only willing to sponsor (part of) their employees' general training if surplus sharing occurs; yet, surplus sharing hampers an efficient accumulation of relationship-specific human capital. Thus, for first-best firm-sponsored training to be implementable, the contract must a) make the worker's second period wage non-responsive to the external market wage (so that the firm has first-best incentives with respect to providing general training) and b) at the same time prevent surplus-sharing (so that the firm invests efficiently in specific training). In essence, a) and b) require that the second-period wage is independent of the firm's training outlays. In light of the renegotiation outcome described above, this means that it is possible to precontract a wage w_2 which is never renegotiated.²⁰ Thus, renegotiation further impedes the possibility of inducing efficient training, at least under the simple contractual arrangements we consider.

Before concluding this section, one should also observe that first-best firm-sponsored general training is even more difficult to achieve if it may be optimal for the parties to separate. Intuitively, if the worker (efficiently) quits, the training firm does not recover any surplus from her general investments. Since it does not take into account the positive externality general investments have on the worker's outside productivity, underinvestment prevails. This argument holds even if contingent breach penalties are feasible: if the fee is small so that the worker quits in spite of the penalty, the employer obtains no return from her general investments. Conversely, if the fee is large so efficient separation requires renegotiation, the employer receives only a fraction of the marginal returns as long as the worker has some bargaining power. Again, the firm does not fully internalize the externality generated by its training outlays.²¹

rather the worker's disutility from working. Thus, general investments have no direct effect on the firm's payoff from employment and can be termed 'selfish'. Still, their line of argument equally applies to our case of 'cooperative' investments incurred by the firm provided that g is contractible and can be financed by the worker. Observe that this contract continues to induce $s = s^{FB}$ if separation is efficient with some probability.

²⁰This condition even more restrictive than (C2). Suppose for example that the firm invests less than (s^{FB}, g^{FB}) so that $\inf_{\theta} v_2(s^{FB}, g^{FB}, \theta) \geq w_2 \geq \sup_{\theta} v^G(g^{FB}, \theta)$ no longer ensures voluntary continuation. Then, w_2 is renegotiated and surplus sharing will occur. Note that the surplus share that the firm reaps in renegotiations may exceed $v_2(s^{FB}, g^{FB}, \theta) - w_2$, thus making such a deviation profitable.

²¹In a model with labor market frictions, Acemoglu (1997) shows that this result even applies when general investments are contractible. In his model, the employee is randomly matched with another

3 Discussion

In his seminal work, Becker (1964) drew the important distinction between general and specific investments in human capital. If the skills a worker acquires through on-the-job training are purely general, he argued, the wage on the external labor market will reflect the full marginal product from this training. Thus, workers capture the entire return from their general human capital in a competitive labor market. Conversely, training in perfectly specific skills has no effect on the worker's productivity in other firms and the wage that an employee could get elsewhere would thus be independent of the amount of training he received. As a consequence, the return to specific human capital is shared between employees and firms. Becker concluded that employees must bear all the costs of their general training whereas the costs of specific training are shared between workers and firms.²² As noted earlier, however, the first prediction is at odds with empirical work on firm-sponsored formal training programs whose content is general in nature. The present framework reconciles Becker's theory with empirical evidence in a framework that preserves its two main characteristics: a) the worker always receives the full return from general training and b) obtains a share of the return (rent) generated by specific training. The sole difference lies in the fact that we do not consider each type of human capital investment separately but rather allow for both general and specific training to be provided at the same time.²³ Once this possibility is taken into account, the sharp conclusion that firms should never pay for investments in general training no longer applies. Moreover, this result does not rely on general and specific skills being complements in production (or training) as the previous analysis has shown.

A body of recent research has suggested several reasons of why and under which circumstances firms may be willing to contribute to the costs of general training. One prominent explanation is based on informational asymmetries between the training firm and potential future employers.²⁴ If the outside market is not as well informed as the

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 occurs. 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 ignore the externality when contracting on general training, and underinvestment prevails.

²²For a formal analysis on how the costs of specific investments are shared, see Hashimoto (1981).

²³Note that our model is formally equivalent to the Becker's framework and yields identical predictions for $s \equiv 0$ and $g \equiv 0$, respectively.

²⁴See Katz and Zidermann (1990), Chiang and Chiang (1990), Chang and Wang (1996), and Acemoglu and Pischke (1998). For an analysis of what long-term (apprenticeship) contracts can achieve

current employer about a worker's level of training or his other relevant characteristics, the worker's general skills are no longer perfectly marketable and in essence become specific skills. A analogous line of reasoning applies if there are labor market frictions created by search or hiring costs [Acemoglu (1997)]. In both cases, workers receive less than their marginal product from (general) training on average which improves firms' investment incentives. Acemoglu and Pischke (1999) note further labor market imperfections where wages are below marginal product and rise less steeply than productivity so that the wedge between marginal product and (outside) wage is higher, the more trained a worker is.²⁵ A similar mechanism is at work in our framework: although external wages are *equal* to worker's marginal product from general training, the wage he obtains if he stays with the training firm rises by less than his productivity. Furthermore, the resulting gap is an increasing function of his level of specific training.

Observe that this property of our model critically depends on the outcome of wage bargaining formulated in Assumption 3, namely, that the bargaining solution is characterized by the outside option principle. Implicit in this formulation is the assumption that the default payoff each party receives in the course of bargaining is zero or, more importantly, independent of investments. In other words, the default payoffs in case of a disagreement during negotiations are unaffected by what the parties' can obtain on the external market. While the distinction between outside market opportunity and default payoff is irrelevant for the firm (its profit on a competitive market is zero anyway) it matters for the worker: suppose his default payoff while bargaining is identical to what he could obtain if he were to quit permanently, i.e., equal to $w^E - c$. Then, the gain from reaching an agreement would no longer be $v_2(s, g, \theta) - c$ but rather $v_2(s, g, \theta) - c - (w^E - c) = v^S(s, \theta)$ and would thus be unaffected by general training outlays g . If the parties share this gain according to their relative bargaining powers, equilibrium payoffs would be $\hat{u}_2 = w^E - c + \alpha v^S(\cdot)$ and $\hat{\pi}_2 = (1 - \alpha)v^S(\cdot)$. As the latter is independent of g , the firm would have no incentive to invest in general skills.²⁶ Notice that for the employee's default payoff to be $w^E - c$, he must be able to take on a temporary job in the process of negotiations that pays the same wage w^E as an permanent job on the external labor market. If there are search or relocation costs

in this context, see Malcomson et al. (1999).

²⁵Apart from informational asymmetries, the authors study three situations where such a 'compressed' wage structure is likely to arise: union wage setting, minimum wages, and worker moral hazard.

²⁶Formally, the additively separable structure of marginal products would be fully reflected in the worker's post-training wage. There would be no interaction between the two types of skill and Becker's original argument would fully carry over to a situation where both general and specific training is provided.

associated with finding an equally good job outside the current relationship, however, the worker will optimally bear those only if the new job is expected to last for some time. In particular, as the time spent in negotiations (the time interval between offers) becomes very small, such turnover costs - even if they are arbitrarily low - are worth incurring only if the outside job is permanent.²⁷ The external market opportunity, if taken up, therefore terminates the relationship and must be represented as an outside option. In this sense, our arguments rest on the (implicit) presence of labor market frictions even if we can allow those to be arbitrarily small so that the wage a worker can obtain in the external labor market formally coincides with the marginal product of his (general) skills.

On the empirical side, our approach yields a number of predictions of which some are similar to those of the existing literature. For example, since equilibrium turnover is lower the higher the level of firm-specific skills, one would expect lower turnover rates in industries where specific investments are very viable. Proposition 3 then implies a negative correlation between *both* types of training and equilibrium turnover although low turnover rates *per se* do not improve a firm's incentives to provide general training as has sometimes been suggested [Blinder and Krueger (1996)]. Also, surplus sharing implies that the post-training wage increases by less than a worker's productivity. Both predictions are in line with empirical evidence²⁸ but stand in contrast to the classical theory (where turnover should be independent of the level of general training and wages grow at the same rate as productivity). Yet, they are also implied by, e.g., models where informational asymmetries between current and future employer encourage firm-sponsored general training. While asymmetric information is certainly a relevant phenomenon, it is perhaps less so in countries with formal training programs like Germany where apprentices receive upon completion a nation-wide accepted certificate which acknowledges their skill and overall training success.²⁹

²⁷See Malcomson (1997) for the same argument and a further discussion along those lines. Binmore, Shaked and Sutton (1989) provide experimental evidence on the relevance of the outside option principle. Using data on the UK manufacturing industry from 1972-1982, Scaramozzino (1991) finds clear evidence that external market wages act as outside options.

²⁸A positive correlation between general training and retention rates has for example been found in Blinder and Krueger (1986) and Soskice (1994). Blanchflower, Oswald and Sanfey (1996) find that an increase in profit per worker 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, suggesting that surplus-sharing between firm and employer is prevalent.

²⁹The certificate reduces uncertainty in particular with respect to the amount of training received. In contrast, the unknown characteristic in Acemoglu and Pischke (1998) is the ability of the apprentice of which standardized exams may provide only a very noisy signal. Also, the presence of adverse selection is supported by the empirical analysis the authors conduct: they compare the salaries of two groups

Supporting evidence that can only be accounted for by the interaction of general and specific training may lie in the significant differences in training expenses across sectors of the German economy. Franz and Soskice (1995) estimate the average yearly net training cost 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 per worker in the crafts and artisan sector (“Handwerk”). Similar results are found in von Bardeleben, Beicht and Feher (1995) who estimate that large firms with more than 500 employees have positive net training costs of about DM 7500 per employee, while the costs for the smallest firms with less than 10 employees [usually from the Handwerk sector] are close to zero or may even be negative.

These patterns are somewhat surprising because the formal structure of apprenticeship programs in the two sectors is more or less the same, and it is not immediate why informational asymmetries or search costs should systematically differ between industrial and crafts sector. However, it seems quite plausible that firm-specific training is of considerable importance in large enterprises which are characterized by complex internal structures. In fact, Franz and Soskice (1995, p.220) 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.” Our findings 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 (1994) 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 for-

of employees who left their training firm, one group being drafted to the military, the other group either quitting voluntarily or having been laid off by the previous employer. The findings indicate 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.

mal 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.

Our results are also consistent with the positive correlation between general training and retention rates in an international context. Recall that the equilibrium level of general training in our model depends (among other things) on its contractibility. If one reasonably assumes that the amount of training is more easily enforceable in Germany with its institutionalized training structure than in countries 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.³⁰

Finally, our analysis can account for the fact that employers frequently sponsor general training of their employees only simultaneously with or after a period of in-house training.³¹ If in-house training is partly relationship-specific, it may take some time until a worker's specific skills generate sufficient additional surplus until his outside wage falls short of the negotiated equilibrium wage inside the current relationship which is a prerequisite for general training to be viable. Expressed differently, if general investments would be provided prior to the specific training, outside employers could poach the worker upon completion of the general training period, and then train him in firm-specific skills themselves. In such a situation, the firm recovers no return from general investments in the first period, and would rationally postpone its participation in general training until a sufficient level of specific human capital has been accumulated.

³⁰Of course, lower turnover rates in Germany are also likely to be due to inflexibilities in the German labor market that do not arise from specific training.

³¹Yu (1999) conducts a survey of evening MBA students at the HAAS business school at UC Berkeley. About 80 percent of the students had partial to full tuition (which amounts to \$ 19,000-\$24,000 annually) paid for by the companies for which they work. He finds that the number of years an employee had worked for the company (as a proxy for the amount of firm-specific training the worker has acquired) has a significant positive impact on the percentage of firm-sponsored education.

4 Concluding Remarks

This paper has studied a situation where the firm can invest in general as well as firm-specific human capital. Our main result was that these types of investments interact even if no technological link exists. Specifically, specific training not only renders the provision of general training viable for an employer, but the reverse also holds: the higher the level of a worker's general human capital, the larger are the firm's incentives to train him in specific skills. The finding therefore indicates that specific and general training are 'incentive' complements from the employer's point of view. As a consequence, employers may be willing sponsor general training even in competitive labor markets where outside wages fully reflect a worker's marginal product from his general human capital.

We have argued that there is not only evidence that firms sponsor general human capital accumulation of their workers, but also evidence suggesting a complementarity in the provision of general and specific training. Whether this complementarity can be attributed to purely technological reasons or to the interaction we posit in the present paper is an empirical question which future research needs to address. We should emphasize, though, that our model does not preclude the possibility of a technological link between both types of training, be it on the output or on the cost side of production. The positive incentive effect that we have isolated in our analysis should be present irrespective of whether general and specific training are technological complements or substitutes.

Appendix

Proof of Proposition 3

By definition, $E[\pi(s, g)]$ is supermodular in (s, g) if and only if $\partial E[\pi(s, g')]/\partial s \geq \partial E[\pi(s, g)]/\partial s$ for all s and $g' > g$. Using (6), this condition is equivalent to

$$g' > g \Rightarrow \int_{\theta \in \Theta'} \frac{\partial v^S(s^*, \theta)}{\partial s} dF(\theta) \leq \int_{\theta \in \Theta} \frac{\partial v^S(s^*, \theta)}{\partial s} dF(\theta), \quad \forall s, \quad (10)$$

where $\Theta' \equiv \Theta(s, g')$ and $\Theta \equiv \Theta(s, g)$. Since $g' > g \Rightarrow v^G(g', \theta) > v^G(g, \theta)$ for all values of θ , we have $\theta \in \Theta' \Rightarrow \theta \in \Theta \Leftrightarrow \Theta' \subseteq \Theta$, which together with $\partial v^S(s^*, \theta)/\partial s > 0$ implies (10). Also observe that the inequality in (10) is strict whenever either $\Theta \neq \emptyset$ or $\Theta' \neq [\underline{\theta}, \bar{\theta}]$. \square

Proof of Proposition 4

The equilibrium contract (\hat{w}_1, g^*) when g is contractible maximizes expected surplus $S(g, s) \equiv E_\theta [v_2(s, g, \theta)] - c + (\bar{v} - c) - s - g$ subject to $s = s^*(g)$, $w_1 \geq 0$ and $E[\pi(s, g)] \geq 0$. Assume in what follows that one can find a w_1 such that neither of the two individual rationality constraints is binding at g^{FB} and $s^*(g^{FB})$ so that $g^* = g^{FB}$ is a feasible arrangement. Under this assumption, we show that $g^* \geq g^{FB}$ and $s^* \leq s^{FB}$ with strict inequality if and only if (9) holds.

Suppose first by way of contradiction that (9) is satisfied but $g^* \leq g^{FB}$. Now consider a contract $g' = g^* + dg$ with $dg > 0$. Using (6), the change in expected surplus for dg small is

$$dS = \left[\int_{\theta} \frac{\partial v^G(g^*, \theta)}{\partial g} dF(\theta) - 1 \right] dg + \left[\alpha \int_{\theta \in \Theta} \frac{\partial v^S(s^*, \theta)}{\partial s} dF(\theta) \right] \frac{\partial s^*(g)}{\partial g} dg.$$

Note that by (3), the first term in brackets is non-negative for any $g^* \leq g^{FB}$. Likewise, under condition (9), $\Theta(s^{FB}, g^*)$ is non-empty for any $g^* \leq g^{FB}$. (6) then implies $s^*(g^*) < s^{FB}$ so that the second term is strictly positive. Furthermore, $\partial s^*/\partial g > 0$ for $\Theta(s^*(g), g) \neq \emptyset \Leftrightarrow s^* < s^{FB}$ from the proof of Proposition 3. Thus, $dS > 0$, contradicting our presumption that g^* is part of an equilibrium contract (an analogous argument can be applied to show that we must have $s^* < s^{FB}$ in equilibrium). The corresponding value of γ can be obtained by evaluating (8) at g^* . Since $\Theta(s^*, g^*)$ is non-empty, we have $\gamma < 1$.

Finally, suppose (9) is not satisfied, i.e., $\Theta(s^{FB}, g^{FB}) = \emptyset$. Together with (6), this implies $s^*(g^{FB}) = s^{FB}$. Hence, the level of general training that maximizes $S(s, g)$ subject to $s = s^*(g)$ is equal to g^{FB} which is feasible by assumption. The claim $\gamma = 1$ follows immediately from (8) and $\Theta(s^{FB}, g^{FB}) = \emptyset$ which completes the proof. \square

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