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Firm-Sponsored General Training

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This article analyzes firm and worker's incentives to invest in general and specific training when these are separable in the production technology and wages are determined by the outside-option principle. It is shown that firms pay for general training, while workers receive the full return on it, and firms and workers share both the costs and benefits of specific training. The case of delayed general training is also studied. When general training is delayed, it is shown that the strategic complementarity between specific and general training increases the worker's incentives to invest in specific training.

I. Introduction

In standard human capital theory as developed by Becker (1964), there is a sharp distinction between general and specific training. Training is general when it is equally valuable with or without the relationship (e.g., when it increases productivity in more than one firm), and it is specific when its value is greater within the context of a relationship (e.g., when it increases productivity within a single firm). According to Becker's human capital theory, in a competitive labor market the analysis of general investment is straightforward. Workers capture the full return on their general training, which implies that firms should not pay for general training.[1] In contrast, specific training, combined with an incomplete contract, creates quasi-rents that are not divided ex post according to the parties' ex ante contractual terms. Since parties share the returns on specific

I would like to express my gratitude to participants in the Central Bank of Chile regular seminar and to Alex Galetovic for his insightful comments. Contact the author at fbalmace@dii.uchile.cl.

[1] There is one caveat here: workers must have free access to the credit markets.

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investment ex post, there is underinvestment in specific training. In contrast to Becker's human capital theory and consistent with the empirical evidence, this article shows that firms pay for general training and workers receive the full return on it, while firms and workers share the costs and benefits of specific training.[2]

Becker's result is consistent with several wage determination processes that are in agreement with plausible bargaining games like Rubinstein's alternating-offer game. To visualize this, suppose that the worker and the firm receive a per-period payoff while bargaining continues (what is known as the inside option) equal to what they can get outside the relationship, which is forfeited once agreement is reached. Then, as discounting goes to zero, the perfect equilibrium outcome gives each party the inside option plus half the surplus generated within the relationship, which in this case is the total output minus the sum of the inside options. Becker's solution considers the no-trade payoffs as the inside options, which can be interpreted as a wage bargaining model in which the worker can work in another job during the negotiations and the firm can hire an equivalent worker, until they reach a wage settlement. In this case, investment in general training shifts the inside option but does not shift the surplus within the relationship, since total output and the inside option increase by the same amount with general training. Consequently, the firm never shares the returns of general training, and therefore it should not invest in general training.

Consider now an alternative scenario, assumed in this article, where bargaining and employment on the spot market are mutually exclusive. In this case, taking a job outside the firm or hiring a replacement worker terminates the bargaining process. Therefore, the no-trade payoff would be an outside, rather than an inside, option in bargaining terminology (see Sutton 1986). The outcome of the game with an outside option depends on which party can take the outside option if an offer is rejected in the previous round of bargaining. In the case where only the responder can take the outside option, which is the case on which this article is focused, there are three possible outcomes. The first possibility is one in which neither outside option is binding and thereby each party gets a share of the surplus created within the relationship (the surplus sharing outcome), which in this case is the total output. The second possibility is that only party *i*'s outside option is binding, in which case he receives his outside option, and the other party's payoff is the total surplus minus

[2] The evidence on firm-sponsored general training is vast: see, e.g., Loewenstein and Spletzer (1997), Acemoglu and Pischke (1998), and Balmaceda and Sevilla (2001). The most common examples are the German apprenticeship system, which is common in many countries today, and the temporary help agencies in the United States, which provide general training, such as computer skills, to new employees and bear the full monetary costs (Autor 2001).

party i's outside option. The third possibility occurs when both parties' outside options are binding, in which case the relationship terminates and each party gets his outside option.

When there is uncertainty about the surplus within the employment relationship, any of the three outcomes mentioned above have a positive probability of occurring, which implies a positive probability of the worker and firm sharing the returns on general training. Thus, the firm invests in general training. The intuition here is that the ex post bilateral monopoly created by specific training encourages the firm to pay for general training while creating incentives to invest in specific training at an inefficient level. In addition, the surplus-sharing outcome is more likely to occur the larger the investment in specific training. Hence, general and specific training are strategic complements even when they are separable in the production technology.

The strategic complementarity between specific and general training helps to alleviate the holdup problem. If a worker is paid her outside option (i.e., as much as she could get in another firm), the firm receives the full return on its investment in specific training. Given that a larger investment in general training increases the worker's outside productivity, additional general training makes the firm more likely to get the full return on its investment in specific training.

This result shows that (i) Becker's result is based on assumptions about wage bargaining that (although standard) are at odds with the results derived from alternative, but plausible, models of noncooperative bargaining. In particular, it is at odds with the outside-option principle considered in this article. And (ii) the friction caused by the presence of specific training is of a more fundamental nature than the information asymmetries used, for example, in Acemoglu and Pischke (1998).

I also discuss the consequences of delayed general training; that is, when both parties invest in specific training first and then the firm invests in general training. The idea that investment in general training is delayed is not at odds with the empirical evidence. For instance, Loewenstein and Spletzer (1997) find that delayed formal training seems to be the rule rather than the exception, and Bartel (1995), analyzing personnel records, finds that 47% of the individuals hired before 1980 have received some formal training by 1990.[3]

When general training is delayed, it is shown that the strategic complementarity between specific and general training increases the worker's

[3] A standard example of delayed general training is MBA graduate education. Often a company will pay part of the tuition of a current worker. Furthermore, casual evidence suggests that the longer a worker has been with a company (more specific training accumulated), the more likely it is that the firm will pay for part of an MBA. These facts support the existence of complementarity between specific and general training.

incentives to invest in specific training. The reason is that if the worker moves first in choosing specific training, this allows him to commit to a higher level of specific training than he would choose in a simultaneous move game. This encourages the firm to invest more in general training, which the worker desires because this assures at least a fraction of the benefits, or even all the benefits, if his outside option is binding. It is also shown that if the expected payoffs of both parties are supermodular, delayed general training results in larger investment in general and specific training, and in higher total welfare.

This article borrows ideas from and is related to the extensive literature on the holdup problem. DeMeza and Lockwood (1998) use an incomplete contract model to show that if parties bargain on the ex post division of surplus under the outside-option principle used in this article, asset ownership may adversely affect incentives to invest. My analysis, while borrowing from their paper, differs because of its focus on cooperative investments and considers the interaction between specific and general investments.[4]

Cooperative investments of the type considered here have received little attention. MacLeod and Malcomson (1993a, 1993b) deal with cooperative investments by only one party. They do so by means of a contract that specifies a trade price, a nontrade price, and an outside-option price, and in which the outside option of the noninvesting party is always binding. Since specific investment does not affect the outside option, the investor gets the full return on his investment and therefore invests at the efficient level.

Che and Hausch (1999) offer the most complete treatment of cooperative investments. Their main finding establishes that when parties are not allowed to rule out subsequent renegotiation and specific investments are sufficiently cooperative, an intermediate range of bargaining powers exists for which contracting has no value; that is, contracting offers the parties no advantage over spot contracting. In fact, they show that when

[4] There are several other papers that focus on noncooperative investments. Chung (1991), Aghion, Dewatripont, and Rey (1994), and Noldeke and Schmidt (1998) propose contracts that while incomplete still may induce efficient investments. These papers have in common that at the renegotiation stage one party holds all the bargaining power. That party, by essentially becoming the residual claimant, has the incentive to invest efficiently. Edlin and Reichelstein (1996) assume that parties write a contract that specifies a fixed trade price and quantity and that after realizing the gains from the trade the parties renegotiate to reach the ex post efficient quantity, with the bargaining surplus divided between them according to their relative bargaining power. They show that by itself this renegotiation process leads to underinvestment, but also that there is an additional incentive for each party to improve his disagreement outcome. Hence, under certain conditions, a more suitable initial contract can provide the parties with the right incentives to invest at the efficient level.

investment is purely cooperative, contracting becomes worthless for the entire range.

There are other articles showing that firms pay for general training, but they assume different types of frictions. Acemoglu and Pischke (1998, 1999) argue that labor market imperfections may explain why firms pay for general training. They show that when labor market imperfections distort the wage structure within the firm, pushing it away from the competitive benchmark and favoring unskilled workers, it will be profitable for firms to provide workers with general training. This is because labor market imperfections make general skills specific in the sense that trained workers do not get their full marginal product when they switch to another job. Chang and Wang (1996) and Katz and Ziderman (1990) make a very similar point in a slightly different context. Assuming that investment in general training is unobserved by potential employers and noncontractible—so potential employers do not know trained workers' marginal product—they show that trained workers' outside offers do not fully reflect their productivity. Thus, there is underinvestment in human capital, and, in equilibrium, investment in general training is positively related to the probability of a worker staying with the same employer in the second period. Finally, Kessler and Lülfelsmann (2001), on work done independently, also address cooperative specific investments coupled with general investments in a competitive labor market and derive similar results. They do not, however, consider delayed general training.

The rest of the article is structured as follows. The next section, Section II, presents the model. Section III derives the first-best training levels. In Section IV, it is shown that general and specific training are strategic complements and that firms pay for general training. In Section V, the role of delayed general training is discussed. And finally, Section VI offers some concluding remarks.

II. The Model

I consider a two-period model between a firm (f) and worker (l), both of whom are risk neutral. At the beginning of period 1, which is viewed as the early stage of the worker's career, the firm and the worker negotiate a one-period contract for the supply of one unit of labor, and the worker and firm undertake noncontractible relationship-specific investments denoted by s_l and s_f, respectively, and the firm also undertakes noncontractible general training, denoted by g.[5] The firm and the worker's cost per unit of either specific or general training is normalized to one. At the beginning of period 2, a productivity shock, denoted by η, which deter-

[5] It is assumed that the worker does not invest in general training to focus on the most interesting case in which the firm decides how much to invest in general training.

mines the surplus within the relationship (the total output) at $t = 2$ is realized. After the productivity shock is realized, the parties either negotiate a one-period contract for the supply of one unit of labor, or, alternatively, they may either refuse to trade or agree to trade with a third party instead. The wage determination procedure, which I discuss in detail below, is based on the outside-option principle found, for example, in Sutton (1986).

The output (joint surplus) in period 2 is $\mu(\boldsymbol{s}) + v(g) + \eta$, $\mu(0) = 0$, and $v(0) \equiv \bar{v} > 0$, where $\boldsymbol{s} \equiv (s_f, s_l)$.[6] The output in period 1 is given by $\bar{v}$, which is the productivity of an untrained worker. For trade with third parties, let $v(g)$ and $\pi \geq 0$ denote the worker and the firm's second period payoffs (outside options), respectively.

Notice that general and specific training are separable in the production technology and that general training has the same marginal product inside the firm as in the market; that is, g is completely general in Becker's sense. This is to ensure that our results do not depend on either the complementarity or substitutability of general and specific training.

Assumption 1. (i) For all $\boldsymbol{s} \in \Re^2_+$, $\mu(\boldsymbol{s})$ is bounded above, C^2, and strictly concave in $\boldsymbol{s}$; (ii) $\lim_{s_i \to 0} \mu_{s_i}(\boldsymbol{s}) \to \infty$ and $\lim_{s_i \to \infty} \mu_{s_i}(\boldsymbol{s}) \to 0$ for $i = f, l$; (iii) for all $g \geq 0$, $v(g)$ is bounded above, C^2, and strictly concave; and (iv) $\lim_{g \to 0} v_g(g) \to \infty$ and $\lim_{g \to \infty} v_g(g) \to 0$.[7]

Assumption 2. The productivity shock η is distributed $f[\underline{\eta}, \bar{\eta}]$ and is independent of σ, where $\sigma \equiv (s_f, s_l, g)$.

Because the firm and the worker are risk neutral, the potential surplus from continuing the relationship after shocks are realized is well defined and given by

$$S(\sigma, \eta) = \max\{\mu(\boldsymbol{s}) + v(g) + \eta, v(g) + \pi\}. \tag{1}$$

For the sake of simplicity, it is assumed that $\pi = 0$.[8]

We now turn to the issue of how the worker's compensation is determined after the shock η is realized. As emphasized in the introduction, the key difference between this article and Becker's is that here the no-trade payoffs for the firm and worker enter the bargaining process as outside options.

The bargaining between the firm and worker adopted here is Rubinstein's alternating-offer game, with the addition of outside options for both the firm and worker. Bargaining takes place over a number of periods. At the beginning of each period, the worker is chosen to be a proposer with probability α—the worker's bargaining power—and the firm with

[6] Bold denotes vectors.

[7] This assumption eliminates corner solutions.

[8] This assumption is consistent with a competitive labor market, since in the absence of specific training the firm has to pay a worker his marginal product.

probability $1 - \alpha$—the firm's bargaining power. If the proposer is the worker, he proposes a wage w. The firm can either accept or reject this offer; if it accepts, then the firm gets $\mu(s) + v(g) + \eta - w$, while if it rejects, then either the firm and worker gets zero and bargaining goes to the next round where the firm makes a proposal, or the firm chooses to terminate the bargaining process taking its outside option. If bargaining is terminated, the worker also gets his outside option, which is equal to $v(g)$, that is, the spot market wage. Note that only the responder is allowed to choose to terminate bargaining. This ensures a unique solution for the bargaining game. Furthermore, because complete information is assumed, the bargaining process ensures that trade is ex post efficient; that is, the firm-worker relationship continues whenever continuing the relationship generates more than separating; that is, $\mu(s) + v(g) + \eta \geq v(g)$. It follows from this and the outside-option principle that when neither outside option is binding, the surplus from continuing the relationship is divided according to each party's bargaining power (the surplus-sharing outcome); that is, the worker gets $\alpha[\mu(s) + v(g) + \eta]$ and the firm gets $(1 - \alpha)[\mu(s) + v(g) + \eta]$; when only the worker's outside option is binding, the worker gets his outside option and the firm gets the total surplus minus the worker's outside option; that is, $\mu(s) + v(g) + \eta - v(g)$; and when only the firm's outside option is binding, the worker gets the total surplus from continuing the relationship and the firm gets its outside option. Finally, when the worker and the firm's outside options are binding, they are better off terminating the relationship and each getting the outside option because what is generated by continuing the relationship is less than what can be generated if the firm and worker terminate their relationship.

Because the firm's outside option is zero and $v(g) \geq 0$ for all g, whenever the firm's outside option is binding it is optimal to terminate the relationship.[9] Thus the firm and the worker's payoffs are determined as follows:

$$u_f(\sigma) \equiv \begin{cases} (1-\alpha)[\mu(s)+v(g)+\eta] & \text{if } \alpha[\mu(s)+v(g)+\eta] \geq v(g), \\ \mu(s)+\eta & \text{if } \alpha[\mu(s)+v(g)+\eta] \leq v(g) < \mu(s)+v(g)+\eta, \\ 0 & \text{if } \mu(s)+v(g)+\eta < v(g), \end{cases} \tag{2}$$

[9] To visualize this, notice that the firm's outside option is binding when $(1 - \alpha)[\mu(s) + v(g) + \eta] < 0$. This implies that the surplus within the relationship $\mu(s) + v(g) + \eta$ is negative, which means that $\mu(s) + v(g) + \eta < v(g)$. That is, the surplus inside the relationship is lower than the surplus when the relationship is terminated.

and

$$u_l(\sigma) \equiv \begin{cases} \alpha[\mu(s)+v(g)+\eta] & \text{if } \alpha[\mu(s)+v(g)+\eta] \geq v(g), \\ v(g) & \text{if } \alpha[\mu(s)+v(g)+\eta] \leq v(g) < \mu(s)+v(g)+\eta, \\ v(g) & \text{if } \mu(s)+v(g)+\eta < v(g), \end{cases} \quad (3)$$

where $u_f(\sigma)$ denotes the firm's payoff and $u_l(\sigma)$ denotes the worker's payoff.[10]

III. A Benchmark: The First-Best Outcome

In this section the efficient investment level σ is determined. This requires that for every training level σ and state η, trade be at an efficient level; that is, separations take place if and only if $\mu(s) + v(g) + \eta < v(g)$.[11] Given efficient trading, the efficient investment further requires that σ maximizes the total expected gains from the employment relationship regardless of whether a separation occurs. That is, σ maximizes $S(\sigma)$, which is given by

$$\int_{-\mu}^{\bar{\eta}} (\mu + v + \eta) dF(\eta) + \int_{\underline{\eta}}^{-\mu} v dF(\eta) - s_f - s_l - g.$$

Assume that $S(\sigma)$ is strictly concave.[12] Given assumptions 1 and 2, this results in a unique maximizer $\sigma^* > 0$. Using the envelope theorem, the efficient investment level, denoted by σ^*, is determined by the following first-order conditions:

$$\mu_{s_f}(s^*)[1 - F(-\mu(s^*))] - 1 = 0,$$

$$\mu_{s_l}(s^*)[1 - F(-\mu(s^*))] - 1 = 0,$$

$$v_g(g^*) - 1 = 0,$$

where $F(-\mu(s^*))$ is the probability that a separation occurs.

Because g is completely general in Becker's sense, the probability of separation is independent of the level of general training. That is, the first-

[10] As was mentioned in the introduction, Becker's solution can be rationalized under Rubinstein alternating-offer game in which the no-trade payoffs are the outside options. In this case the firm's payoff is given by $(1 - \alpha)[\mu(s) + v(g) + \eta - v(g)]$ and the worker's payoff is $\alpha[\mu(s) + v(g) + \eta - v(g)] + v(g)$. Note that in this case general training does not affect the surplus from the relationship.

[11] In what follows, the arguments within the different functions are omitted where there is no room for confusion.

[12] For instance, this holds when $\mu(\bullet)$ and $v(\bullet)$ are strictly concave and $F(\eta)$ is concave. See, e.g., MacLeod and Malcomsom (1993a) and Che and Hausch (1999) for a similar assumption.

order condition for general training implies that the probability of separation is independent of the level of general training. Notice also that the first-order conditions for relationship-specific investments imply that changes in specific investments affect the probability of a match through states for which the gains from matching are exactly counterweighed by the gains from separation, and that the efficient specific investment levels are independent of the investment in general training.

Assume from hereafter that $\underline{\eta} < -\mu(\mathbf{s}^*)$; that is, when the efficient investment level is undertaken it is efficient to separate when shock η is sufficiently negative.

IV. Firm-Sponsored General Training

The first point to be made is that the firm and worker's choices of investment are interdependent since (as is clear from eqq. [2] and [3] above) the firm's choice of (s_f, g) may depend on s_l and vice versa. The worker and firm payoffs depend on the realized state. When $\eta \geq (1-\alpha)v/\alpha - \mu$, neither outside option is binding, and thereby the worker's payoff is share α of surplus within the relationship $\mu + v + \eta$, while the firm's payoff is a share $1-\alpha$ of the surplus $\mu + v + \eta$; when $-\mu \leq \eta < (1-\alpha)v/\alpha - \mu$, the worker's outside option is binding and thereby he gets v and the firm gets $\mu + v + \eta - v$; and when $\eta < -\mu$, what is generated within the relationship is lower than what can be generated outside of it, and thereby the working relationship is terminated and the firm and the worker get their outside options 0 and v, respectively. Given this, the firm's period 2 expected payoff is given by

$$U_f(\sigma) \equiv \int_{[(1-\alpha)v]/\alpha-\mu}^{\bar{\eta}} (1-\alpha)(\mu + v + \eta)dF(\eta) + \int_{-\mu}^{[(1-\alpha)v]/\alpha-\mu} (\mu + \eta)dF(\eta),$$

while the worker's period 2 expected payoff is given by

$$U_l(\sigma) \equiv \int_{[(1-\alpha)v]/\alpha-\mu}^{\bar{\eta}} \alpha(\mu + \eta)dF(\eta) + \int_{\underline{\eta}}^{[(1-\alpha)v]/\alpha-\mu} v\,dF(\eta). \quad (4)$$

Thus, the firm chooses (s_f, g) to maximize $U_f(\sigma) - s_f - g$ and the worker chooses s_l to maximize $U_l(\sigma) - s_l$.

Assuming that the second-order conditions are satisfied, the optimal investment under spot contracting, denoted by σ^s, is determined by the following first-order conditions:

$$\mu_{s_f}(\mathbf{s}^s)[1 - F(-\mu(\mathbf{s}^s))] - \alpha\mu_{s_f}(\mathbf{s}^s)\left[1 - F\left(\frac{(1-\alpha)v(g^s)}{\alpha} - \mu(\mathbf{s}^s)\right)\right] - 1 = 0, \quad (5)$$

$$v_g(g^s) - v_g(g^s)\left[\alpha + (1-\alpha)F\left(\frac{(1-\alpha)v(g^s)}{\alpha} - \mu(\boldsymbol{s}^s)\right)\right] - 1 = 0, \qquad (6)$$

$$\alpha\mu_{s_l}(\boldsymbol{s}^s)\left[1 - F\left(\frac{(1-\alpha)v(g^s)}{\alpha} - \mu(\boldsymbol{s}^s)\right)\right] - 1 = 0. \qquad (7)$$

Notice first that the first-order condition for s_f shows that the marginal return on s_f is equal to the marginal return when efficient investments are undertaken minus a positive term, which is the probability that the surplus-sharing outcome occurs, $1 - F((1-\alpha)v/\alpha - \mu)$, weighted by the marginal return on this investment times the worker's bargaining power. Second, the first-order condition for g also shows that the marginal return on g is equal to the marginal return when an efficient investment in general training is undertaken minus a positive term. This positive term captures the fact that the firm obtains $1-\alpha$ of the marginal return on general training when the worker's outside option is nonbinding, and that when it is binding the firm pays the worker his outside option and thereby does not obtain any return on general training. The first-order condition for s_l captures the fact that the worker gets only a fraction α of the marginal return on his investment in specific training s_l when the worker's outside option is nonbinding, and shows nothing when it is binding because his outside option is independent of the investment in specific training.

It is also interesting to notice that contrary to the first-order condition when efficient training is undertaken, here the three first-order conditions depend on both general and specific training. This means, as mentioned earlier, that the optimal training levels are interrelated and that the probability of separation depends on both general and specific training. How they are interrelated depends on whether the different types of training are strategic substitutes or strategic complements.

Fortunately, it readily follows from the firm's first-order condition for general training that general and specific training are strategic complements even though they are assumed to be separable in the production technology. The reason for this is that there is a positive probability that the worker and firm will share the surplus within the relationship and that the probability of this occurring increases with s_i for $i = f, l$. This leads to the following result.

LEMMA 1. General and specific training are strategic complements.[13]

Proof. $\partial U_f^s(\sigma)/\partial g \partial s_i = v_g \mu_{s_i} f((1-\alpha)v/\alpha - \mu) > 0$ for all $\boldsymbol{s}$ and g and $i = f, l$.

This result implies that general training has a positive effect on the

[13] This result holds if general and specific investments are technological substitutes as long as this substitution is not too strong.

firm's incentive to undertake specific investments. To better understand this effect, assume, for simplicity, that the firm cannot or does not invest in general training and that $\alpha[\mu(s) + \bar{v} + \eta] \geq \bar{v}$; that is, surplus sharing always occurs, and therefore the firm and the worker share the benefits of specific training. Clearly, in this scenario the firm has an incentive to underinvest in specific training. Next assume that the firm can commit to invest in general training, then there is a set of states under which $\mu(s) + v(g) + \eta \geq v(g)$ and $\alpha(\mu(s) + v(g) + \eta) < v(g)$. This implies that there is a set of states under which the firm's payoff is given by $\mu(s) + \eta$; that is, the firm gets the full marginal return on its investment in those states and therefore the firm has an incentive to invest at an efficient level.

While general training induces the firm to invest more in specific training, it does not provide enough incentive to overcome the probability that the parties will share the returns on specific training. Hence, the parties never reach efficient training levels. The following proposition states this formally.

PROPOSITION 2. The equilibrium investment denoted by σ^s is as follows: if specific investments are strategic complements, then $s_f^s < s_f^*$, $s_l < s_l^*$, and $0 < g^s < g^*$; while if they are strategic substitutes, then either $s_f^s \geq s_f^*$ and $s_l < s_l^*$ or $s_f^s < s_f^*$ and $s_l \geq s_l^*$ or $s_f^s < s_f^*$ and $s_l < s_l^*$ and $0 < g^s < g^*$.

Proof. See the appendix.

This proposition establishes two things: first, the firm invests in general training, but at a suboptimal level; and second, when the firm and the worker's specific training are strategic complements there is underinvestment in every type of training, while when they are strategic substitutes, there could be overinvestment in either the worker or the firm's specific training but not in both. Thus, a competitive market never provides enough incentives to induce both the firm and worker to undertake efficient training levels.

The fact that the firm invests in general training does not necessarily mean that there is firm-sponsored general training because the firm may recoup its investment costs in the first period by lowering the first-period wage. Hence, in order to have firm-sponsored general training the firm cannot be able to lower the first-period wage below the worker's marginal product.

In the first period, firms compete for workers in a Bertrand-like fashion with the well-known result that in equilibrium firms have zero expected profits. This implies that $\bar{v} - w_1 + U_f(\sigma^s) - g^s - s_f^s$ must be equal to zero, where $\bar{v} - w_1 - g^s - s_f^s$ is the first-period profit and $U_f(\sigma^s)$ is the second-period expected profit. Hence, the first-period wage is given by $w_1 = \bar{v} + U_f(\sigma^s) - g^s - s_f^s$.

Notice that $U_f(\sigma^s) - g^s - s_f^s \geq 0$, since the firm can always ensure a payoff of at least zero by investing zero in general and specific training and hiring an untrained worker or closing down. Thus, the first-period wage is equal to the worker's marginal productivity as an untrained worker plus the firm's expected profit from its investment on training. Thus the firm cannot recoup its investment by paying the worker less than his marginal product as an untrained worker. In addition, the firm and the worker share the costs and benefits of specific training since the firm's second-period profit is nonnegative.

This discussion is summarized in the next proposition.

PROPOSITION 3. The firm pays for general training and the firm and worker share the costs and benefits of specific training.

This proposition is in contrast to Becker's human capital theory and is consistent with the stylized fact that there is firm-sponsored general training. Thus, what seems to be puzzling evidence in support of human capital theory is no longer so when a different wage determination process is assumed as the one considered here.

Before ending this section two remarks are in order. First the existence of firm-sponsored general training seems to rest heavily on the presence of specific investments. However, what is really needed for that is a positive probability that the surplus-sharing outcome occurs. Thus, if the support of the distribution for η when $s^s = 0$ is such that there is a positive probability that $\eta \geq (1 - \alpha) v(g)/\alpha$, firm-sponsored general training occurs. Yet, this condition is rather ad hoc because it depends only on the support of η.

Second, inside and outside options have been treated independently, although they may coexist. Workers may pursue casual employment while bargaining, but taking an alternative established job may terminate negotiations. The results are robust for the introduction of inside options that are different from zero and depend on investment levels as long as the surplus generated within the relationship (the output minus the inside options) increases with both general and specific training.

V. Delayed General Training

In this section, I discuss the case in which general training is delayed. This is motivated by the evidence found by Loewenstein and Spletzer (1997), who find using the National Longitudinal Survey of Youth and the Current Population Survey that high-tenure workers are more likely to have ever received training while on their current job than are workers with lower tenure, and Bartel (1995), who, analyzing personnel records, finds that 47% of the individuals hired before 1980 have received some formal training by 1990.[14]

Assume that the firm undertakes general training right after the firm and worker undertake their investments in specific training and right

[14] This, however, is no evidence that firms invest first in specific training; it only shows that general training is delayed.

before the shock η is realized. Under this assumption it is easy to show that the first-order conditions for the firm's specific and general training do not change and thereby they are equal to conditions (5) and (6), while the worker's first-order condition for specific training becomes

$$\alpha\mu_{s_l}\left[1-F\left(\frac{(1-\alpha)v}{\alpha}-\mu\right)\right]+v_g\frac{\partial g}{\partial s_l}\left[\alpha+(1-\alpha)F\left(\frac{(1-\alpha)v}{\alpha}-\mu\right)\right]-1=0. \tag{8}$$

Note that this first-order condition has two terms: the first is the worker's marginal return on specific training under simultaneous specific and general training (eq. [7]), and the second captures the effect of delayed general training. The first term, as mentioned earlier, captures the fact that the worker gets only a fraction α of the marginal return on his investment in specific training s_l when his outside option is nonbinding, and captures nothing when it is binding because his outside option is independent of the investment in specific training.

The effect of delayed general training depends exclusively on the sign of $\partial g/\partial s_l$, which is positive when general training and the worker's specific training are strategic complements and negative otherwise. Because the first-order condition for general training does not change when this is delayed, the result in lemma 4 implies that general and specific training are strategic complements. Thus, delayed general training increases the worker's marginal return on general training and, therefore, the worker's incentive to invest in specific training. A larger investment in specific training results in a higher probability that the surplus-sharing outcome occurs and therefore in a higher probability that the firm reaps ex post the benefits of general training. This induces the worker to invest more in specific training because he will always get at least a fraction α of the return on general training—and sometimes all of it, when his outside option is binding.

Whether this extra incentive results in a larger investment level σ and in a larger welfare depends on whether specific investments are strategic complements or substitutes. In what follows it is assumed that they are strategic complements. This holds, for example, when $\mu(\boldsymbol{s})$ is weakly supermodular on $\boldsymbol{s}$; that is, if the marginal return on s_i (weakly) increases as s_j increases for $i, j = f, l$, and $i \neq j$.

PROPOSITION 4. Assume that $\mu(\boldsymbol{s})$ is (weakly) supermodular. Then, the optimal investment as well as the total surplus under delayed general training are larger than those under simultaneously chosen general training.

Proof. It readily follows from theorem 7 in Milgrom and Roberts (1990).

The intuition behind this can be easily grasped in figures 1, 2, and 3.

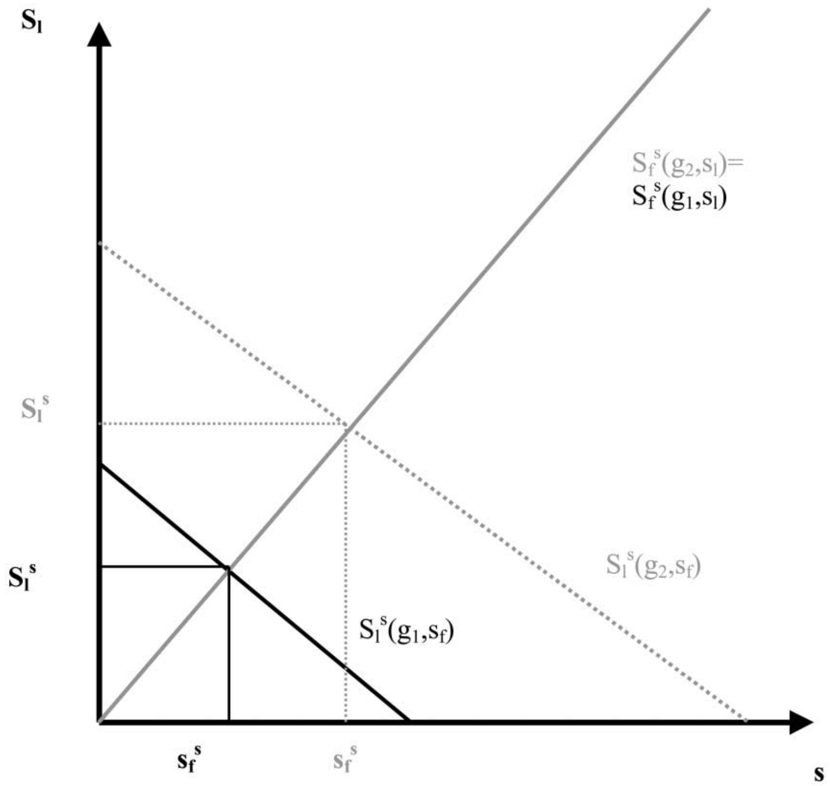

FIG. 1.—Supermodular firm's payoff and submodular worker's payoff: delayed versus simultaneous general training. Dotted line = delayed general training; black line = simultaneous general training.

From figure 3, we can see that when the expected payoff functions are both submodular, the reaction functions are downward sloping, and thus welfare may decrease because the firm's investment in specific training may be lower than when training is done simultaneously. Meanwhile, if the firm's expected payoff function is supermodular (figs. 1 and 2), then the firm's reaction function is upward sloping. Because the worker's reaction function is larger in the presence of delayed general training and general and specific training are strategic complements, the equilibrium investment levels are higher in the presence of delayed general training. Hence, welfare is greater under delayed general training.

VI. Conclusions and Final Remarks

In this article it has been shown that firm-sponsored general training arises naturally when general and specific training are separable in the production technology and wages are determined by bargaining and the

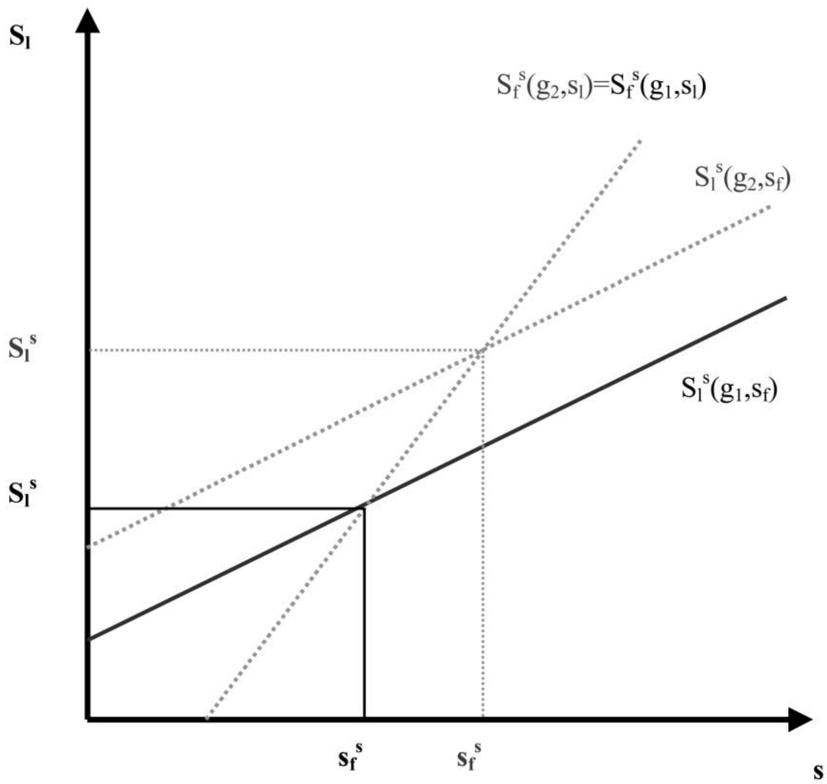

FIG. 2.—Supermodular firm's and worker's payoff: delayed versus simultaneous general training. Dotted line = delayed general training; black line = simultaneous general training.

outside-option principle. This implies that the friction caused by the presence of specific human capital is of a more basic nature than, for example, the information asymmetries in Acemoglu and Pischke (1998), Chang and Wang (1996), and Katz and Ziderman (1990). Further, delaying the firm's general training decision increases the worker's incentive to undertake specific training and increases the total surplus from the employment relationship when both the firm and worker's specific training are strategic complements. That is, delaying general training brings efficiency gains.

There are two questions that arise naturally concerning the timing of training investments. These are: What happens when first the firm invests in general training, and then both sides make specific investments? and Does the efficiency gain occur only when general training is delayed, or would the reverse order lead to a similar result? A full answer to these questions will require a paper in its own right (see Balmaceda 2003). Yet in the particular context of this article an answer can be provided. Delaying the investment in specific training instead of delaying the investment in

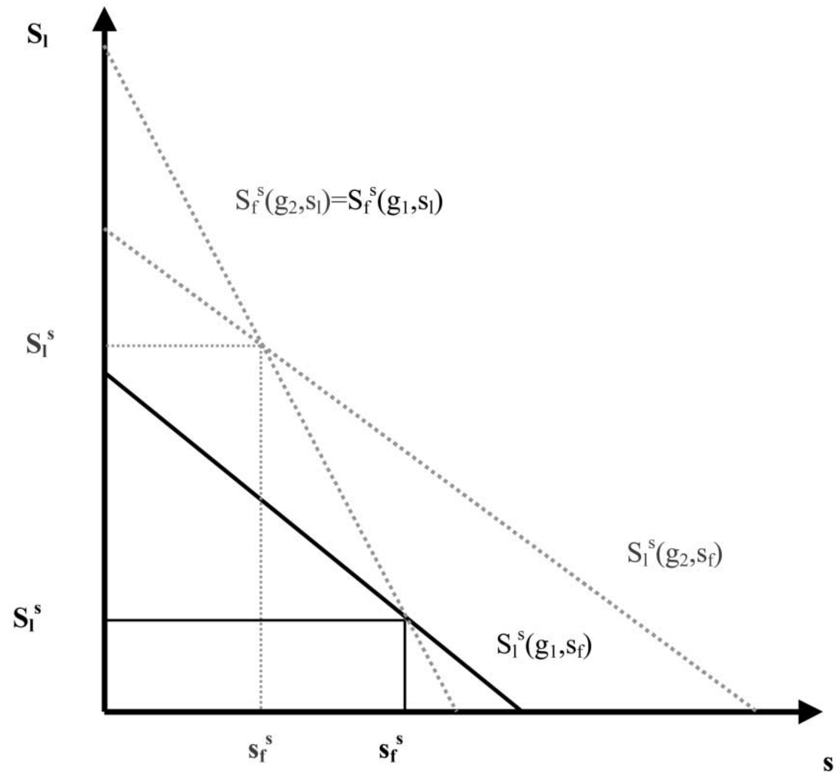

FIG. 3.—Submodular firm's and worker's payoff: delayed versus simultaneous general training. Dotted line = delayed general training; black line = simultaneous general training.

general training implies that an additional term on the firm's specific training first-order condition equal to $\partial U_f(\sigma)/\partial s_l \times \partial s_l/\partial g$ arises.[15] Because general and specific training are strategic complements independent of the timing of investments—that is, $\partial s_l/\partial g$ is positive, and the firm's expected payoff increases with the worker investment in specific training—that is, $\partial U_f(\sigma)/\partial s_l$ is positive, delaying the investment in specific training provides the firm with better incentives to invest in specific training. For a larger investment in general training results in a lower probability that the surplus-sharing outcome occurs and therefore in a higher probability that the firm reaps ex post the benefits of specific training. This implies that when specific investments are strategic complements, the optimal investment as well as total surplus are larger than those under simultaneously chosen general and specific investments.

Finally, in a previous version of this article, the role of long-term con-

[15] Note that $\partial U_f(\sigma)/\partial s_l = \mu_{s_l}(s)[1 - F(-\mu(s))] > 0$ for all $s \in \Re^2_+$.

tracting was studied. There, it was shown that many of the commonly observed contractual provisions that provide workers with incentives to invest in specific training also encourage firms to invest in both general and specific training. In particular, wage floor contracts like minimum wage provisions and up-or-out rules were studied. It was shown that when specific investments are strategic complements, wage floor contracts induce the firm and worker to undertake more general and specific training than spot contracting does, yet they result in inefficient separations. Mainly this is because wage floors above the worker's outside option make the firm more likely to get the full return on its investment since the worker gets paid the wage floor in several states.

Appendix

$$\mu_{s_f}(s^s)[1 - F(-\mu(s^s))] - \alpha\mu_{s_f}(s^s)\left[1 - F\left(\frac{(1-\alpha)v(g^s)}{\alpha} - \mu(s^s)\right)\right] - 1 = 0, \quad \text{(A1)}$$

$$v_g(g^s)(1-\alpha)\left[1 - F\left(\frac{(1-\alpha)v(g^s)}{\alpha} - \mu(s^s)\right)\right] - 1 = 0, \quad \text{(A2)}$$

$$\mu_{s_l}(s^s)[1 - F(-\mu(s^s))] - \mu_{s_l}(s^s)\left[1 - \alpha + \alpha F\left(\frac{(1-\alpha)v(g^s)}{\alpha} - \mu(s^s)\right) - F(-\mu(s^s))\right] - 1 = 0. \quad \text{(A3)}$$

Let us define $S_i^*(s_j, g)$ as the efficient best-response of party i to the specific investment of party j and $S_i^s(s_j, g)$ as the spot-contracting best-response of party i to the specific investment of party j. Also, let us define $G^*(\mathbf{s})$ as the efficient best-response of the firm to the specific investments and $G^s(\mathbf{s})$ as the spot-contracting best-response of the firm to the specific investments.

Comparing the first-order conditions for efficient investments with those from spot contracting, it is clear that $S_i^*(s_j, g) \geq S_i^s(s_j, g)$ for all (s_j, g) and $G^*(\mathbf{s}) \geq G^s(\mathbf{s})$ for all $\mathbf{s}$. A simple inspection of the first-order conditions for s_f and g reveals that this is the case, while for s_l this follows from the fact that the second term in the first-order condition given in equation (A3) is decreasing in α and at $\alpha = 1$ this term becomes equal to zero. Investments are positive because of Inada's conditions on $\mu(\mathbf{s})$ and $v(g)$.

Notice that for all $s_f \geq S_f^*(s_l, g)$, $\partial U_f^s(\sigma)/\partial s_f \leq \partial S(\sigma)/\partial s_f$, which implies that, unless $S_f^*(s_l^s, g^s) = 0$, $s_f^s < S_f^*(s_l^s, g^s)$. Similarly, $s_l \geq S_l^*(s_f, g)$, $\partial U_l^s(\sigma)/\partial s_l \leq \partial S(\sigma)/\partial s_l$, which implies that, unless $S_l^*(s_f^s, g^s) = 0$, $s_l^s < S_l^*(s_f^s, g^s)$ and $s_f \geq$

$S_f^*(s_l, g)$, $\partial U_f^s(\sigma)/\partial g \leq \partial S(\sigma)/\partial g$, which implies that, unless $G^*(s_l^s, g^s) = 0$, $g^s < G^*(s_l^s, g^s)$. This does not necessarily imply that $\sigma^s < \sigma^*$, although strict inequality must hold for at least one component.

When the three reaction functions are upward sloping, that is, if s_f and s_l are strategic complements, then this implies that $\sigma^s < \sigma^*$, while when $S_i^s(s_j, g)$ is downward sloping for $i = f, l$, then $g^s < g^*$ since $G^s(\mathbf{s})$ is upward sloping, $s_i^s \lesseqqgtr s_i^*$ for $i = f, l$ and either $s_f^s < s_f^*$, $s_l^s < s_l^*$, or $s_f^s < s_f^*$ and $s_l^s < s_l^*$.

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