Termination restrictions and investment in general training

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Abstract

Conditional separation payments efficiently increase firms' investment in general training if the latter is not directly contractible. Since training is vested in the worker on separation, a firm's return to training is zero when a match ends or, more generally, when the firm's outside return is binding. Large enough conditional separation penalties ensure that, independently from outside opportunities, the ex post situation is one of bilateral monopoly. This allows the firm to capture a positive share of the return to the general component of training in all states of nature. A fixed wage contract and large enough separation penalties ensure the firm's investment decision is fully efficient if training is general in Becker's (1964) sense.

JEL Classification: D23, J24, J65.

Keywords: General training, incomplete contracting, consensual separation.

*E-mail: G.Fella@qmw.ac.uk. I am grateful for the helpful comments of Giuseppe Bertola, Steve Pischke, Coen Teulings, two referees and seminar participants at Ente "Luigi Einaudi", EUI, University of Keele and University of Warwick.

1 Introduction

There are numerous examples of employment contracts in which one or both sides of the relationship have to obtain the consent of their counterpart in order to terminate the contract. In professional sports, for example, the system of transfer fees prevents players from terminating their contract ahead of time unless the clubs involved in the transfer agree on a suitable payment to the club of origin as compensation for early termination. Some US firms such as IBM, Eli Lilly, NUMMI contractually commit to a zero-firing policy that effectively prevents them from laying off workers unless by mutual consent. The institution of lifetime employment in Japan has the same effect. In Germany, firms cannot legally carry out mass redundancies unless they agree with workers' representatives on a social plan covering procedures and compensation packages.

A number of authors (e.g. Bean [1997] and Nickell [1998]) have conjectured that job security provisions may increase workers' contribution to firms' value and firms' incentives to train. Bishop (1991) reports that the likelihood and amount of formal training are higher at firms where firing a worker is more difficult. The existence of a possible link between termination restrictions and incentives to train is also suggested by the recent debate on the abolition of transfer fees for football players playing for European clubs. FIFA, the international football governing body, has vociferously argued that the abolition of the transfer-fee system would seriously undermine clubs' incentives to train young players[1].

[1]See, for example, "Crunch game for the transfer system," *Financial Times,* 27 October 2000.

An important feature of the termination restrictions described above is that they are conditional on which party initiates separation. In other words termination penalties can be and are conditioned on which party provides a signal - sends a letter of resignation/dismissal or accepts another job - showing an intent to end the current relationship. Conversely, unconditional termination restrictions are uncommon in employment contracts.

This paper provides a theoretical foundation for the link between conditional termination restrictions and firms' investment in general training. It demonstrates that if training is non-contractible firms' incentives to invest are maximized, within the class of simple contracts considered, when *conditional* termination penalties are so large that all separations are consensual. In fact, under a fixed wage contract and consensual separation the firm's choice of investment is efficient if training is general in Becker's (1964) sense.

The model is an extension of MacLeod and Malcomson's (1993) framework in which renegotiable contracts featuring a fixed wage and severance pay can be stipulated ex ante. The crucial difference is that conditional, and not only unconditional, termination penalties are allowed.

To understand the intuition behind the result consider the case in which it is more surprising: a competitive labour market. In his seminal contribution, Becker (1964) argues - under the implicit assumption that training is contractible - that in a competitive labour market investment in general human capital would take place cooperatively. The employer would choose the jointly optimal level of investment and the worker would fully pay[2] for

[2]In line with the existing literature (e.g. Acemoglu and Pischke [1999]), we say that a *worker fully*

it by accepting a lower entry wage. If training is non-contractible, though, investment cannot take place cooperatively. Bygones being bygones, a firm's incentives to provide training are driven only by the firm's future private returns and not by the worker having accepted a lower wage during training. Since in a competitive market the worker would capture the full return to general human capital, firms would have no incentive to invest in non-contractible general training and all such investment would take place off the job. Furthermore, no investment would take place off the job if workers were borrowing constrained.

Consider instead an ex ante contract with the following provisions: 1) if production takes place after the training phase, the worker receives a contract wage w_c; 2) separation can take place only if both parties sign a publicly verifiable document stating their agreement to end the employment relationship. By locking both parties in the relationship, the latter provision transforms a competitive situation into an ex post bilateral monopoly.

Assume for simplicity that the disagreement payoffs are such that it is strictly optimal for both parties to produce while bargaining over renegotiation of their contract. If employment takes place the firm captures the full marginal return to training whichever the level of w_c. On the other hand, given transferable utility, the Coase theorem implies that separation takes place if and only if it is efficient. Since neither party can credibly threat to unilaterally terminate or to disrupt production while bargaining, the respective threat points are given by the parties' payoffs from producing at w_c. Therefore, in case

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pays for the training if a trainee's wage falls by the full cost of training, relative to the wage of an identical worker receiving no training. If this is not the case, the *firm pays for* (all or part of) *the training.*

of separation the worker receives w_c plus a share of the surplus from agreeing to separate while the firm receives the remainder of the joint separation payoff. The surplus is the difference between the joint payoff from separation and that from continuation. If training is general in Becker's sense its marginal return is the same inside and outside the match and marginal changes in training leave the surplus from separation unaffected. Hence, the worker's *marginal* return to training is zero in all states of nature and the firm invests efficiently, being full residual claimant. In the absence of termination penalties, instead, the firm would have no incentive to invest as the worker would always receive the full marginal return.

Of course, if the post-training wage w_c is above a trained worker's marginal product, the worker fully pays for the training by accepting a wage below her marginal product during the training phase[3]. On the other hand, the worker could agree to a contract featuring w_c below her marginal product when trained, rather than paying upfront through a lower entry wage.

Consensual separation clauses are hardly observed in practice. Yet, large enough conditional separation payments achieve the same effect of obliging the parties to bargain over the terms of separation. Furthermore, if labour markets are not competitive, quit penalties are not necessary, under mild conditions, to ensure consensual separation as long as the contract wage is large enough for workers always to prefer being employed at such a wage than quitting. This is consistent with the observation that quit penalties are not common in employment contracts.

[3]This is Becker's classic result, but with non-contractibility.

Conversely, if capital markets are imperfect and the required contract wage and the associated initial side-payment are so high that workers' borrowing constraints become binding, an optimal contract features a lower contract wage and higher (positive) quit penalties compared to the case in which borrowing is unconstrained. Contracts for professional sports players, which often feature quit penalties, seem a case in point. The size of payoffs for successful professional players is such that only a very large contract wage could ensure that players would never want to quit the training club absent quit penalties. As this would require very large entry fees, our model predicts that, if borrowing constraints bind, this is one category of workers for which consensual separation should be achieved through quit penalties rather than high ex post wages alone.

The efficiency result highlighted above revolves around two features of the optimal contract discussed: a fixed wage component and conditional termination penalties. That fixed price contracts provide high incentives to (self-)invest is a well known result in contract theory. The same insight underlies Acemoglu and Pischke's (1999) result that imperfectly competitive labour markets and other sources of wage compression give firms incentives to invest in general training even if they have to bear part or the full cost. By decoupling the external wage structure from the internal one, conditional termination payments allow for contractual wage compression, through the fixed wage, independently from the degree of labour market competition. Furthermore, with positive turnover wage compression is not sufficient to induce efficient investment in general training if the latter is non-contractible. Large enough conditional termination penalties lock the parties in a bilateral monopoly situation even in case of separation and allow firms to capture a positive *marginal* return to training also in case of separation.

An extensive literature, going back to Grout (1984) and Williamson (1985), has analysed the inefficiency of investment when, because of contract incompleteness, the latter can be held up by the non-investing party. More recently, a number of authors have proposed simple contractual solutions to address the hold up problem. In particular, Hart and Moore (1988) and MacLeod and Malcomson (1993) have highlighted the role of *unconditional* breach penalties and/or outside market opportunities in ensuring efficient investment despite the possibility of ex post renegotiation. These papers, though, restrict attention to pure selfish investments and pure cooperative investments[4]. General training, is a hybrid form of cooperative investment. It increases the current firm's (the investor's) revenues while the match survives, while it is vested in the worker on separation. We show that when general training is provided by firms, unconditional separation payments are not very useful in improving incentives to invest. This paper is closest Feess and Muehlheusser (2003), who show that a reduction in transfer fees for football transfers may reduce clubs' incentives to train young players. Investment is contractible in their model and the only source of underinvestment is the spillover onto future clubs. Kanemoto and MacLeod (1989) show that the Japanese lifetime employment system together with higher pay for lifetime jobs creates a tournament for lifetime jobs and induces efficient worker's investment in firm-specific human capital.

[4]A pure selfish investment generates direct benefits for the investor, but not for her counterpart. Viceversa a pure cooperative investment offers no direct benefits for the investor. Che and Hausch (1999) show that an incomplete contract is worse than no contract when investment is sufficiently cooperative. Crucial to their result is that the ex post level of trade is not a binary variable.

The paper is organized as follows. An example in section 2 illustrates the main result. Section 3 introduces the model. Section 4 characterizes the post-investment payoffs. Section 5 contains the model's main results and section 6 concludes.

2 An illustrative example

Consider a competitive labour market with free entry and exit of firms. Workers are born untrained and live for two periods. There is no discounting. Firms with unfilled vacancies compete in offering employment contracts. If a firm is matched to an untrained worker, it has to decide how much to invest in the worker's general human capital. The training phase lasts one period. At the end of the training phase, uncertainty about the productivity of the match is resolved and the firm and worker decide whether to stay together and produce in the second period or to separate and reenter the market. Going back to the market involves a (lump-sum) switching cost $m \geq 0$ for the worker, but no cost for the firm. The social marginal product of a worker with a positive stock h of general training is $f(h)$ and the marginal product of an untrained worker is normalized to zero. The cost of providing h units of skill is $c(h)$. $f(.)$ and $c(.)$ satisfy the standard regularity conditions that ensure a unique, internal optimum. Hence, the first-best training level h^*, satisfies $f'(h^*) = c'(h^*)$.

Uncertainty about the productivity of a match takes the following form. With probability $(1-\delta)$ the worker's productivity at the current firm is $f(h)$, the same as with any other employer. With the complementary probability δ, the worker's productivity at the current firm is $f(h) - z$, with $z > m$, and separation is efficient.

Consider the decentralized level of training when both parties can terminate the match at will. The reservation payoffs for a worker with skill level h and for her employer are respectively $f(h) - m$ and zero. The parties receive exactly their reservation payoff when this is higher than their current payoff from the match[5]. Hence, the worker, but not the firm, captures the full marginal return to training when either reservation payoff is binding. Therefore, a contract that gives the firm positive incentives to train has to ensure that both reservation payoffs are non-binding with positive probability. For example, if w_c is the contractual post-training wage, it has to be $f\left(h^P\right) \geq w_c \geq f\left(h^P\right) - m$, where h^P is the training level maximizing the firm's expected payoff from training

$$\pi^e(h, w_c) = (1 - \delta)[f(h) - w_c] - c(h). \tag{1}$$

Consider the lowest wage $w_c = f\left(h^P\right) - m$ the worker accepts at the beginning of the second period. If the firm invests in training, equation (1) becomes $\pi^e\left(h^P, w_c\right) = (1 - \delta)m - c\left(h^P\right)$, which is positive only if the switching cost m is large enough. If switching costs are low relative to the cost of training, $\pi^e\left(h^P, w_c\right) < 0$ and Becker's (1964) result obtains. It is never optimal for the firm to invest in general training as ex post the worker can threat to quit and the firm cannot recoup training costs.

Even if switching costs are large enough for the firm's ex post profits to be non-negative for some $w_c \geq f\left(h^P\right) - m$, the decentralized training level maximizing (1) is strictly lower

[5]This is trivially true if the parties separate. If the match survives a rational agent just matches the counterpart's outside alternative.

than the first best level h^* as, when separation is efficient, the firm fires the worker (its reservation payoff is binding) and the worker, not the firm, captures the return to training.

Consider now the decentralized level of training when all separations can take place only by mutual consent. Effectively, such an arrangement implies an infinite layoff penalty for the firm and an infinite quit penalty for the worker. Whatever the post-training wage w_c and the productivity realization, both reservation payoffs are non-binding with probability one. If continuation of the match is efficient, renegotiating the wage contract is not Pareto optimal. Hence, the contract is not renegotiated, the parties trade at w_c and the firm's payoff is $f(h) - w_c$. If separation is efficient, instead, there is a strictly positive surplus $f(h) - m - (f(h) - z) = z - m$ to be made by reaching an agreement on separation. Therefore, it is jointly optimal to renegotiate the separation clause and share the surplus from separation.

Both parties can threat not to accept separation, in which case trade takes place at w_c and the firm obtains $f(h) - z - w_c$. Assuming that the worker receives a fraction $0 \leq \alpha \leq 1$ of the surplus from separation, agreement on separation will be reached with the parties receiving their disagreement payoff plus their share of the surplus. The firm's separation payoff is then $-F = f(h) - z - w_c + (1-\alpha)(z-m)$, where F, the negotiated transfer from the firm to the worker, is increasing in the worker's ex post bargaining power α. Therefore the firm's expected payoff from training is

$$\pi^e(h, w_c) = f(h) - w_c - \delta[(1-\alpha)m + \alpha z] - c(h). \tag{2}$$

Clearly, (2) is maximized at the first-best training level h^*.

It remains to verify that the contract is consistent with free entry of firms, or

$$w_e = \pi^e(h, w_c) = f(h^*) - w_c - \delta[(1-\alpha)m + \alpha z] - c(h^*), \tag{3}$$

where w_e is any (entry) wage payment the worker receives upon signing the contract.

Consider the role of each type of termination restrictions separately.

1. *Quits can only be consensual but the firm can lay the worker off at will.* Since the worker is locked in, the contract wage just needs to ensure that it is not optimal for the firm to lay the worker off at any moment after w_e has been exchanged; i.e. $\pi^e(h^*, w_c) \geq 0$ and $f(h^*) - z - w_c \geq 0$. Such a wage clearly exists.

   As $\pi^e(h^*, w_c) \geq 0$ equation (3) is satisfied with $w_e \geq 0$. The firm, not the worker, pays for the cost of training upfront, since the worker receives a post-training wage below her marginal product. Depending on how low the post training wage w_c is, equilibrium may require $w_e > 0$ to dissipate the firm's post-training rent. Hence, the worker may receive a wage above her marginal product during the training phase.

2. *Layoffs can only be consensual but the worker can quit at will.* Since the firm is locked in, it is always optimal for the firm to invest h^* as long as $w_c > 0$ and the worker does not quit. Therefore, assuming the worker's payoff from relocation is positive, the contract wage only needs to ensure that the worker never wants to quit

or

$$w_c \geq f(h^*) - m. \tag{4}$$

If mobility is costless - $m = 0$ - inequality (4) implies the firm's post-training profits are non-positive and the entry wage in equation (3) has to be negative to compensate the firm for the cost of training $c(h^*)$ and for the termination payment F. Therefore, w_e is decreasing in the training cost, the probability of separation δ and the negotiated termination payment F. Only if m is positive and large enough there exists a wage w_c such that the worker has no incentive to quit yet the firm's ex post rent $f(h^*) - w_c$ is large enough to cover the cost of training. Since now the entry wage has also to exhaust the firm's rent, equation (3) may be satisfied with $w_e \geq 0$[6].

The above two results imply that, if relocation costs are small, the post training wage is close to workers' marginal product and, in the absence of quit penalties, workers have to bear a, possibly significant, fraction of training costs. If workers are borrowing constrained and mobility costs are low then quit rather than layoff payments are necessary for firms to invest efficiently.

Many attempts at measuring the impact of training on wages (e.g. Mincer (1988), Brown (1989), Barron, Berger and Black (1997)) revolve around the relationship between

[6] Therefore, if workers can quit at will the paper's prediction about who pays for trainining is the same as, for example, Acemoglu and Pischke (1999). Workers must receive less than their marginal product after training, for firms to pay for, rather than just provide, training. Equivalently, match-specific quasi-rents have to be significant for firms to bear a significant part of the cost of general training.

training and wage growth. For this reason, it is useful to derive such relationship for case 2 above, which is the relevant one for the majority of labour markets. Equations (3) and (4) imply a lower bound for wage growth

$$w_c - w_e > f(h) + c(h) - m(2-\delta) + \delta\alpha(z-m). \tag{5}$$

The first three terms are common to all models of general training[7], as they just embody the constraints that training cannot reduce ex ante profits and the post-training wage has to exceed the worker's reservation wage. The lower bound on wage growth equals a linear combination of productivity growth and the cost of training minus a term which depends on the maximum mark down from post-training marginal product the firm can extract thanks to labour market frictions or other sources of specificity. Higher levels of training result in higher wage growth, as long as mobility costs, here assumed constant, do not increase too fast with training. As argued by Acemoglu and Pischke (1999), large enough mobility costs are necessary to explain why productivity growth significantly exceeds wage growth, as documented in Barron et al. (1997). Inequality (5) also sheds light on why the positive relationship between wage growth and training found in national data (e.g. Parent (1999)) may not hold across countries. For example, Harhoff and Kane (1997) provide evidence of similar wage-tenure profile for German apprentices and U.S. high school graduates despite the well known larger provision of general training by German firms. The two phenomena are easily reconciled once one recognizes that, for

[7] The magnitudes, but not the sign, of the weights on these terms are sensitive to alternative hypothesis on ex ante bargaining power.

given training level, mobility costs are likely to be significantly higher in Germany given an average unemployment duration of nearly three quarters as opposed to one quarter in the U.S.

The last term in (5) captures the fact that *if entry wages are flexible*, layoff payments increase wage growth as workers have to prepay for the future benefit. Therefore, our model predicts that, to the extent that layoff costs are below the level for which all layoffs are consensual, they increase wage growth both through this direct effect and through the impact of the higher stock of training h on the first two terms[8]. Again, testing this prediction of the model requires controlling for the mobility cost function.

3 The model

Consider the following partial equilibrium set up. There are two classes of risk-neutral agents: firms and workers. Workers are endowed with one indivisible unit of labour and enjoy no utility from leisure. Upon meeting, a firm and a worker play the following game. In stage I, they agree on an employment contract. In stage II the firm invests in the worker's general human capital h at some strictly increasing and strictly convex cost $c(h)$ with $c(0) = 0$. In stage III, uncertainty about the productivity of the match and the parties' respective market returns is resolved.

More formally, denote by $s \in \Sigma$ the realization of the state of nature in stage III. μ is the cumulative density for contingencies $s \in \Sigma$. The productivity of the match and the

[8]The same would hold true if the entry wage could not fall below some positive level $w_e > 0$. In such a case, equation (4) implies $w_c - w_e > f(h) - m - w_e$, which is still incresing in h.

firm's flow revenues are $f(h,s)$. The flow outside returns in state s are exogenously given to a matched pair and are denoted respectively by $u(h,s)$ for a worker and $z(h,s)$ for a firm. No further information accrues after the third stage and the state of a match is completely described by $\varepsilon = \{s, h\}$.

Since training is vested in the worker, the firm's outside payoff is independent from the current worker's human capital or $z_h(\varepsilon) = 0$. Furthermore, $f(\varepsilon)$ and $u(\varepsilon)$ are assumed to be differentiable, strictly increasing and strictly concave in h and to satisfy the Inada conditions and $\int f_h(\varepsilon)\, d\mu, \int u_h(\varepsilon)\, d\mu < \infty$. This ensures that the optimization problem is well-behaved. It also implies that training has a general component as it increases $u(\varepsilon)$, the worker's payoff outside the current relationship.

Information is fully symmetric within a match. At stage III the firm and worker decide whether to separate and look for new partners, trade under the terms of the agreed contract or renegotiate the existing contract. The initial contract can be renegotiated only by mutual consent. Time is continuous and the horizon is assumed to be finite and normalized to one. For simplicity we assume that there is no discounting[9]. The firm has no fixed costs.

It is assumed that ε is observable only by the firm-worker pair. Therefore, contracts that condition on either the level of investment h or the state of nature s are not enforceable. On the other hand, third parties can observe whether or not trade occurs and

[9]Neither the absence of discounting, nor the finiteness of the horizon are necessary for the main result. The only substantive restriction associated with the finite horizon assumption is to rule out multiple, non-stationary equilibria of the kind studied in Haller and Holden (1990) and Fernandez and Glazer (1991) when a contract wage is in place. Such equilibria would not survive equilibrium refinements requiring stationarity or, as discussed in MacLeod and Malcomson (1995), efficiency.

whether contractual payments are carried out. This implies fixed-wage contracts and termination penalties are feasible.

The crucial assumption that drives the result and distinguishes the paper from MacLeod and Malcomson (1993) is that termination payments can be conditioned on who takes verifiable steps to end the relationship. A separation is deemed a dismissal if and only if the firm gives the worker written notice that it no longer wishes to continue the employment relationship. The end of the relationship is deemed a quit if the worker gives written notice that she no longer intends to continue in employment[10]. That is, neither party can claim the counterpart has unilaterally severed the relationship unless they can produce a written document, signed by the counterpart, proving their claim. This seems broadly consistent with existing practices in most countries. A separation is consensual if both parties sign a written document stating their agreement to terminate the relationship and exchange any termination payment specified in the document. Until one of these actions is taken the employment relationship is considered in existence.

Finally, lockouts are assumed to be illegal. Lockouts are indeed illegal in a number of countries. Furthermore, while lockouts might reduce ex ante efficiency in our set up, the parties could include a Pareto improving clause ruling them out if this were the case[11].

We restrict attention to a particular class of simple, realistic, employment contracts. We do not pursue the alternative route of looking for a mechanism (a complete contract) that can implement the efficient outcome subject to the constraints that agents cannot

[10]Alternatively, not showing up for work without providing a medical certificate could be interpreted as a signal that the worker has quit.

[11]I am grateful to a referee for pointing this out.

commit not to renegotiate and that ε is not observable by third parties[12]. Namely we assume that a contract can only specify an initial entry wage w_e, a contract wage w_c in case the match continues and termination payments conditional on which party initiates separation. In what follows we denote by F_c and Q_c the payments from the firm to the worker - measured as instantaneous flows - in case the worker is fired or quits respectively.

Before proceeding, it is appropriate to tackle one possible criticism concerning the enforceability of conditional termination payments. Carmichael (1983) has argued that "...a worker wanting to quit, for example, would simply behave badly enough to induce a fire." A symmetric situation applies for the firm. Yet, the possibility to burn money[13] - to destroy surplus as a way to increase the counterpart's bargaining cost - is conceptually different from the ability to label the separation in one's most preferred way - to oblige the other party to send a written notice of termination. Our result requires only that termination penalties can be conditioned on a verifiable document, not on the (bargaining) process that leads to such a document being signed. Different bargaining processes have different implications for the renegotiation of fixed wage contracts. While this may weaken the full efficiency result, it does not the paper's more general point concerning the efficiency-enhancing role of termination payments.

[12]Maskin and Tirole (1999) discuss these two alternative approaches to incomplete contracts: "...focus[ing] on simple institutions on *a priori* ground or study[ing] the implications of complete contract theory in structured environments."

[13]See Avery and Zemsky (1994) for a discussion of burning money as a bargaining threat.

4 Wages and employment determination

Given risk neutrality, as long as the entry wage w_e is unconstrained it can be adjusted to achieve any division of the ex ante gains from trade. So, we can concentrate on how contracts affect ex post payoffs and, through them, ex ante incentives to invest.

Be $v(\varepsilon) = \max\{f(\varepsilon), z(\varepsilon) + u(\varepsilon)\}$ the maximum joint return available to a firm-worker pair. The highest payoff the worker can obtain, which we will call the *firm's reservation concession*, is $\bar{\omega}(\varepsilon) = v(\varepsilon) - z(\varepsilon) + F_c$, as the firm can secure its reservation payoff $z(\varepsilon) - F_c$ by firing the worker. Viceversa, the *worker's reservation payoff* is $\underline{\omega}(\varepsilon) = u(\varepsilon) + Q_c$, the return to quitting unilaterally. If continuation is efficient, viz. $v(\varepsilon) = f(\varepsilon)$, $\bar{\omega}(\varepsilon)$ and $\underline{\omega}(\varepsilon)$ are respectively the firm's and worker's reservation wages. In all states in which it is $\bar{\omega}(\varepsilon) > \underline{\omega}(\varepsilon)$ there is a range $[\underline{\omega}(\varepsilon), \bar{\omega}(\varepsilon)]$ of feasible agreements and ex post bargaining determines where the equilibrium agreement lies within this range. To simplify notation, we subsume the dependence of payoffs on the state ε in what follows.

MacLeod and Malcomson (1993) have shown that if production realistically occurs over time, rather than at a single date, an existing wage contract affects the bargaining outcome through its effect on payoffs during bargaining. We model bargaining along their lines. In each period, the worker and firm propose, respectively with probability α and $1 - \alpha$, the terms at which production or separation take place. Trade takes place over time and in each round in which an agreement has not been reached the parties have to decide whether to produce or not. Either party can pay the termination penalty and unilaterally and irreversibly abandon the match to trade outside.

In equilibrium the parties always bargain efficiently over the higher between the joint payoff from continuation and the total return from separation. This is captured by the following result.

Result 1 *In equilibrium the parties share the joint payoff* $v = \max\{f, z + u\}$.

The proof of Result 1 in the Appendix establishes that, given unconstrained transfers, the separation decision is always efficient - it maximizes the total payoff - independently from the existence of contracted or legislated termination penalties. This is just one more instance of the Coase theorem.

As argued by Binmore, Rubinstein and Wolinsky (1986), equilibrium payoffs in an alternating offer game are determined by the appropriate Nash bargaining solution with threat points given by the parties' respective payoffs during negotiation. The parties share the surplus from reaching an agreement over what they would get by holding out. The respective payoffs from unilateral termination constrain the Nash bargaining solution, as each party can credibly threat to end the match if offered a lower payoff.

If during renegotiation both parties prefer trading under the terms of the existing wage contract the latter determines the respective payoffs in case of disagreement. Since renegotiation is consensual, the party who loses from renegotiation can block it. Therefore, if production continues in the absence of renegotiation no renegotiation takes place. Thus renegotiation occurs only if either party can credibly threat not to trade. The threat not to trade under the terms of the existing contract is credible if and only if in case of disagreement: (a) one agent is better off not trading without severing the match, or (b) one agent prefers irreversibly ending the match to trading at the current wage.

Consider first the case in which termination penalties are so large that no party has an incentive to unilaterally sever the match. In each round in which it is $w_c > 0$, the worker prefers trading to going on strike in the current round[14]. Since lockouts are illegal, trade takes place in all rounds in which it is $w_c > 0$. Therefore, if $w_c > 0$ the parties trade at w_c in all rounds during negotiations and threat points are respectively $f - w_c$ for the firm and w_c for the worker. From the asymmetric Nash bargaining solution the worker's bilateral monopoly payoff is

$$\omega = w_c + \alpha (v - f) . \tag{6}$$

The worker's payoff equals her threat point w_c plus a share α of the surplus from agreement $v - f$. The firm's receives $v - \omega$. If continuation is efficient, the surplus from agreement is zero, the contract wage w_c is not renegotiated and $\omega = w_c$. If, instead, separation is efficient there is a surplus $v - f > 0$ to be made from agreeing to separate and the parties agree to share the difference according to their respective probability of proposing.

In general, though, the parties are not locked in a bilateral monopoly situation. They may trade outside, but doing so irreversibly ends the current match. Hence, their payoffs from unilateral separation do not act as threat points as they do not affect payoffs during negotiation. They only determine the boundary of the set of feasible payoffs. If $\omega > \bar{\omega}$

[14]We restrict attention to the case $w_c > 0$. Choosing $w_c \leq 0$ cannot be optimal as it w_c would be renegotiated, and hold up would bite, with probability one. MacLeod and Malcomson (1995) discuss the equilibrium of the renegotiation game when $w_c \leq 0$.

the firm strictly prefers to lay the worker off and the worker is better off accepting to produce at a lower wage $\bar{\omega}$, as long as continuation is efficient. If instead separation is efficient, the firm does fire the worker. Either way the firm's receives its reservation payoff $z - F_c$. Similarly, if the worker's reservation payoff is binding the firm raises the wage to $\underline{\omega}$ if continuation is efficient and the worker quits and obtains $\underline{\omega}$ otherwise. Either way, the firm receives $v - \underline{\omega}$.

We can thus state, without proving, the following result.

Result 2 (MacLeod and Malcomson) *If $w_c > 0$ and lockouts are illegal the firm's payoff is given by*

$$\pi = \begin{cases} f - w_c + \alpha\,(v - f) & \text{if } \underline{\omega} \leq \omega \leq \bar{\omega} \\ z - F_c & \text{if } \omega > \bar{\omega} \\ v - u - Q_c & \text{if } \omega < \underline{\omega}. \end{cases} \tag{7}$$

5 Firm's investment in worker's general training

5.1 Investment without conditional separation penalties

Result 1 has established that separation always takes place efficiently independently from the level of separation payments. This implies that the set of states of nature $S(h) = \{s : s \in \Sigma,\ f \geq u + z\}$ such that the match survives depends on contractual arrangements only through the level of training h. Let us denote by $I_S(s)$ the indicator function which takes value 1 if $s \in S(h)$ and zero otherwise. The constrained efficient level of investment in training h^* maximizes the ex ante joint payoff and, by the envelope theorem, satisfies the optimality condition

$$c'(h) = \int_{s\in\Sigma} \{I_S(s) f_h + [1 - I_S(s)] u_h\} d\mu. \tag{8}$$

The marginal return to training on the right hand side of (8) equals the marginal increase in the match product f_h if the match survives and the marginal increase in the worker's payoff outside u_h in case of separation.

In a competitive market with lump-sum mobility costs like the one considered in section 2 the level of training h^* satisfying equation (8) is socially optimal. In general, though, h^* is only constrained efficient if the market for the labour services of a newly trained worker is imperfectly competitive[15].

Contract incompleteness within the current employment relationship further reduces investment below the constrained efficient level in (8). When training is non-contractible, the firm chooses its level to maximize its expected profits rather than the joint payoff. Without conditional separations payments it is $F_c = Q_c$, possibly equal to zero. If $w_c > 0$, by Result 2 the firm's marginal private return to investment is

$$\int_{s:\underline{\omega}\leq\omega\leq\bar{\omega}} I_S(s) f_h d\mu + \int_{s:\omega<\underline{\omega}} I_S(s)(f_h - u_h) d\mu. \tag{9}$$

[15] Acemoglu (1997) shows that if labour markets are non-competitive because of search frictions, then part of the return to general training in case of separation is held up by *future* employers, even if contracting is complete within the current employment relationship. This implies that the worker's private marginal return to training in a new job $u_h(\varepsilon)$ is below its marginal social value and the constrained efficient level of training is less than first best.

If the match survives, the firm captures the full marginal return to training as long as the contract wage is not renegotiated. Since training increases firms' revenues, this is the well known result that a fixed-price contract provides high incentives to self-invest[16]. The wage contract is not renegotiated, though, only in those states in which $\omega = w_c$ lies between the worker's and firm's reservation wages. If, instead, the match survives but it is $w_c < \underline{\omega}$, the contract wage is renegotiated up to the worker's reservation payoff $\underline{\omega}$. The firm's marginal return is below the social one as $\underline{\omega}$ is increasing in the stock of general training. In all other states the firm receives its reservation payoff $z - F_c$ which is independent from the level of investment. Hence, the worker, but not the firm, is full residual claimant to the marginal return to training. Comparing the marginal return in equation (9) with the left hand side of equation (8) shows that the sources of inefficiency lie in the renegotiation of the wage contract w_c in case continuation is efficient and the fact that the firm's marginal return to training is zero in case of separation.

Unconditional termination penalties are ill-suited to deal with these two sources of inefficiency. As they raise both the worker's reservation payoff and the firm's reservation concession by the same amount, their impact on the probability that w_c is renegotiated is ambiguous. Furthermore, $F_c = Q_c$ implies $\bar{\omega} - \underline{\omega} = v - z - u$. When separation is efficient it is $\bar{\omega} - \underline{\omega} = 0$: either party prefers unilateral termination to any alternative partition of the joint separation payoff. Since training is vested in the worker, the worker but not the firm captures the full marginal return to training outside the match.

[16]More generally, Acemoglu and Pischke (1999) show that a compressed wage structure provides incentives for firms to invest in general training.

In a competitive labour market with neither switching costs nor specific assets, quasi-rents are zero in all states of the world. If the match is viable, it is $f = u + z$ which implies $\bar{\omega} - \underline{\omega} = 0$ in all states. Furthermore, it is $f_h = u_h$. Therefore, the firm's marginal return to general training in equation (9) is zero and the firm does not invest. This is Becker's (1964) well-known result.

We now show how conditional termination penalties can lessen or eliminate the underinvestment problem.

5.2 Investment with conditional separation penalties

Consider now the case in which conditional termination penalties F_c and Q_c are agreed upon before investment is carried out. As long as it is $F_c > Q_c$, the difference $\bar{\omega} - \underline{\omega} = v - z - u + F_c - Q_c$ between the firm's reservation concession and the worker's reservation payoff is always positive and increasing in $F_c - Q_c$. In other words, conditional termination penalties create scope for bilateral bargaining and allow the firm to capture a share of the return to training even in case of separation.

If $w_c > 0$ the firm's marginal return to investment is now

$$\int_{s:\underline{\omega}\leq\omega\leq\bar{\omega}} I_S(s)\, f_h d\mu + \int_{s:\omega<\underline{\omega}} I_S(s)\left[f_h - u_h\right] d\mu + \int_{s:\underline{\omega}\leq\omega\leq\bar{\omega}} \left[1 - I_S(s)\right]\left[\alpha\left(f_h - u_h\right) + u_h\right] d\mu. \tag{10}$$

The last addendum in expression (10) reflects the possibility of bargaining in case of separation. In so far as $\underline{\omega} < \omega < \bar{\omega}$ when separation is efficient, no party has an incentive to unilaterally terminate the match. Yet, since separation yields a strictly positive joint surplus, it is optimal for the parties to agree to renegotiate the contracted separation payment and the firm receives a payoff equal to $f - w_c + (1 - \alpha)[u + z - f]$, which is increasing in the level of training. Intuitively, by increasing the level of training the firm increases the worker's return in a new job u and reduces the ex post severance payment that it pays the worker to induce her to accept separation for a given contract wage w_c.

In general, a positive severance payment F_c from the firm to the worker increases the firm's reservation concession $\bar{\omega}$ and reduces the probability that it is binding. Since the firm's marginal return to training is zero when $\bar{\omega}$ is binding, F_c enlarges the set of states in which the firm's return to training is positive.

A positive quit payment from the firm to the worker, a negative Q_c, reduces the worker's reservation payoff $\underline{\omega}$ and the probability that it is binding. This further improves incentives as the firm is full residual claimant to the marginal return if the match survives and w_c is not renegotiated, and receives less than the full return when the worker's reservation payoff is binding. Hence, conditional separation penalties increase a firm's return to training up to the point where they are so large (in absolute value) that all separations are consensual or

$$u + Q_c \leq w_c + \alpha [v - f] \leq \max \{f - z, u\} + F_c \tag{11}$$

for any $s \in \Sigma$. In other words, if condition (11) is satisfied the contracted separation payments are so large that they are renegotiated down with probability one whenever separation is efficient. When (11) is satisfied, any further increase in the absolute values of F_c and Q_c has no effect as reservation payoffs are never binding.

When conditional termination penalties are large enough for condition (11) to hold, the firm's investment level $\hat{h}$ satisfies

$$c'(h) = \int_{s\in\Sigma} \{I_S(s) f_h + [1 - I_S(s)] [\alpha (f_h - u_h) + u_h]\} d\mu. \tag{12}$$

We thus have the following result.

Result 3 *Within the class of contracts considered and for given $w_c > 0$, firms' marginal expected returns to training are non-decreasing in F_c and non-increasing in Q_c. They are maximized if all separations are consensual, or equivalently if termination payments are so large that $\underline{\omega} \leq \omega \leq \bar{\omega}$, for any $s \in \Sigma$.*

Though Result 3 states that firms' incentives to train are maximized when all separations are consensual, it does not automatically imply that quit penalties are necessary to achieve this. In fact, they are not under reasonably weak conditions. This is important because quit penalties are not common in employment contracts and are indeed illegal in nearly all countries for most blue and white collar jobs.

For all separations to be consensual the pair of inequalities in (11) must hold. This requires either $F_c > 0$ or $Q_c < 0$. Otherwise the interval defined by (11) would be empty when separation is efficient. Yet, as long as the constraint $w_c > 0$ is slack, there are three variables $\{w_c, F_c, Q_c\}$ to satisfy just two inequalities. Denote by $\bar{u}$ the supremum of u and $\underline{d}$ the infimum of $f - z$ over all $s \subseteq \Sigma$ when training is at its level $\hat{h}$ satisfying equation (12). As long as separation takes place with positive probability, it is $\bar{u} > \underline{d}$: the highest possible outside payoff to the worker lies strictly above the lowest value of the difference between revenues and the outside return to capital. Hence, a contract consistent with (12) does not require quit penalties if there exist $F_c > 0$ and $w_c > 0$ satisfying $\bar{u} \leq w_c + \alpha [v - f] \leq \underline{d} + F_c$. Since $v - f$ is always non-negative, a wage $w_c > \bar{u}$ and a large enough F_c can achieve this as long as $\bar{u}$ is finite.

On the other hand, there are good reasons to expect positive severance payments to be a necessary part of an optimal contract. For this not to be the case there must exist $Q_c < 0$ and $w_c > 0$ such that $\bar{u} + Q_c \leq w_c + \alpha [v - f] \leq \underline{d}$. This requires $0 < w_c < \underline{d}$. Since, there is no reason to expect $\underline{d}$ to be positive, it is likely that (11) cannot be satisfied with $F_c = 0$. This can be summarized by

Result 4 *Consider a contract featuring $w_c > 0$. If u is bounded above on Σ quit penalties are not required to achieve consensual separation. Severance payments are instead necessary to ensure that all separations are consensual unless it is $f - z > 0$ for any $s \in \Sigma$.*

As it is proved in the Appendix, as long as entry wages are flexible a contract that ensures that all separations are consensual maximizes not only efficiency but also ex ante profits. Therefore, our result can explain the voluntary commitment to zero-layoff policies at firms such as IBM, Eli Lilly, NUMMI, Texas Instruments. It is also consistent with the evidence in Osterman and Kochan (1990) showing that such arrangements are at times renegotiated, and incentive resignation plans agreed, in the face of persistent falls in demand.

The model also predicts that job security policies boost training, as long as wages are flexible or, if not, provided they do not make employment unprofitable. Consistently with these predictions, Bishop (1991) finds that the likelihood and amount of formal training are higher at firms where firing a worker is more difficult.

The model does not provide any rationale for mandated, as opposed to privately contracted, separation restrictions. Yet, if the assumption is made that observed legislated measures reflect the extent to which private arrangements call for them, the model may account for institutions like the German[17] "social plan" and the Japanese lifetime employment system, that impose that redundancies can only be consensual. Large German firms cannot carry out mass redundancies unless they reach an agreement with their works council on a "social plan" specifying the terms on which redundancies take place, including severance payments. Lifetime employment in Japan is the practice at large firms of hiring workers directly out of school, substantially train them in house and retain them until retirement[18]. When persistent demand shortfalls cannot be absorbed only by laying off temporary workers, though, Japanese firms do negotiate voluntary "retirement" incentives with permanent workers (see Kondo [1999]).

Provided entry wages are flexible these institutions cannot reduce efficiency as firms and workers would bargain away any excessive cost. This seems to contradict the often

[17] Abraham and Houseman (1993) argue that the introduction of job security legislation in Germany just codified existing practices.

[18] High training levels and lifetime employment do not apply to all workers, though. A buffer of temporary workers are hired and dismissed in response to demand fluctuations.

cited argument in Lazear (1990) that mandated job security measures are welfare reducing if they prescribe third-party payments. As noted in Malcomson (1997) and Fella (1999), though, as long as information is symmetric, Lazear's argument applies only to unconditional separation payments, but not to restrictions which, as it is the case in practice, are *conditional* on firms initiating separation[19].

Though quit penalties are not a necessary part of an optimal contract under mild conditions, they are not uncommon in employment contracts in professional sports. Players are required to pay a fee to the club of origin in case of transfer to a new club. Our framework is capable of shedding light on when quit penalties may be desirable. Consider the extreme case in which $\bar{u} = \infty$. In such a case there exists no contract wage high enough to satisfy (11) with $Q_c = 0$. For all quits to be consensual it has to be $Q_c = -\infty$. More generally, suppose $\bar{u}$ is very large relative to a worker's ex ante share of the expected surplus. A contract featuring $w_c > \bar{u}$ and no quit penalties would require large upfront payments by workers. If borrowing constraints prevent the payment of large entry fees then infinite, or large enough, quit payments are part of an optimal contract as they ensure that separation is always consensual even with a contract wage below $\bar{u}$. Independently from the size of $\bar{u}$, clubs have no incentive to invest in players' training if the market for players is competitive and players can walk out at will. Players would have to

[19] To see this suppose that, in case the firm sends a layoff letter, it has to pay a firing cost F_c of which only a fraction $F_c' < F_c$ accrues to the worker, while the rest is a deadweight loss. Of course, the firm has an incentive to send a layoff letter only when $z - F_c > f - w_c$. Yet, even in such a case it is optimal for the parties to avoid the deadweight loss by labelling the separation a quit, rather than a layoff, and negotiating a pure transfer $F_c - \delta$ from the firm to the worker with δ arbitrarily small. With $F_c - \delta$ a pure transfer, the deadweight $F_c - F_c'$ is never incurred and, therefore, has no effect on either ex ante payoffs or the separation decision.

pay for their training costs and they would underinvest if they faced binding borrowing constraints at the beginning of their career.

Given the huge differences in pay between top soccer players and their more average colleagues it is highly likely that the highest ex post market payoffs exceed the ex ante expected joint payoff, let alone workers' ex ante share. Also, competition for the services of top professional players is intense and search frictions negligible. Borrowing constraints are also likely to be binding given the magnitudes involved and the difficulty to borrow against a form of human capital whose ex ante market value is so uncertain and difficult to observe by outsiders.

The transfer system ruling European soccer contracts until the Bosman court judgement in 1995 provides support for the model's predictions. It required players to pay a transfer fee in order to move to another club while allowing players to leave football at no cost. Since players' football skills are specific to the industry (football) but not to a team, such a system imposed a penalty only on those terminations which did imply a spillover of the return to training. Furthermore, since for terminations associated with movements between clubs the parties negotiating the fee, the clubs of origin and destination, have "deep pockets" this is exactly an instance where the often heard objection that quit penalties may result in involuntary servitude for borrowing-constrained workers does not apply.

With the exception of Belgium and Spain where finite transfer fees were explicitly incorporated in contracts, transfer fees were by default infinity in all other European countries. Therefore, observed transfer fees were the outcome of renegotiation of the (infinite) contractual quit penalty. Furthermore, Carbonell-Nicolau and Comin (2001) document that transfer fees in the Spanish football league were large enough to result in ex post renegotiation for 90 per cent of all transfers in 1999-2000 and 2000-2001 featuring a positive contractual transfer fee.

The Bosman judgement ruled that transfer fees for players out of contract violated the article 39 of the EEC Treaty of Rome concerning the free mobility of workers across member states. It started a process which eventually led FIFA to abolish, after a protracted dispute with the EU commission, transfer fees for all transfers involving players more than 2 years into their contract[20]. In line with the model's insight, FIFA vociferous argued throughout the dispute that the abolition would seriously undermine clubs' incentives to train young players.

5.3 Efficiency

Result 3 states that large enough conditional termination penalties maximize firm's incentives to invest, within the class of simple contracts considered. Yet, in general, we cannot say whether they result in constrained-efficient investment. At the constrained efficient training level h^* there is a wedge $WG = \int_{s\in\Sigma} \alpha \left[1 - I_S\left(s\right)\right] \left[f_h - u_h\right] d\mu$ between the firm's marginal return to training under consensual separation - the right hand side of equation (12) - and the social return on the right hand side of equations (8). If such a wedge is

[20]More than three years for players younger than twenty-eight at the age of signing. Fees for transfers before such period can still be freely contracted, as evidenced by the 35 million euros transfer fee paid by Real Madrid for David Beckham. See art. 22 of the "FIFA regulations for the status and transfer of players."

negative, conditional termination payments, though efficiency-enhancing, cannot achieve full efficiency.

On the other hand, without further restrictions on payoffs, it could be $WG \geq 0$ and investment could even be inefficiently high. Yet, the latter outcome does not seem very reasonable. If the parties could increase their joint payoff by investing less than according to (12) one would expect them to write a contract to this effect. In fact, this is what happens under the following conditions.

Result 5 *If $WG \geq 0$ and the firm's marginal return to training is continuous in w_c for $w_c > 0$, then there exists a contract $\{w_c, F_c, Q_c\}$ under which the firm invests efficiently.*

The proof of Result 5 in the Appendix establishes that if the firm's marginal return is continuous in w_c[21] the firm can raise w_c, thus increasing the probability that its reservation payoff is binding. Since the firm's marginal return to training is zero when it receives its reservation payoff, raising w_c reduces the firm's marginal payoff and aligns it with the social one. Inspection of the expression in (11) reveals that F_c and w_c are perfect substitutes in increasing the probability that the firm's outside option is binding.

A remarkable implication of Result 5 is that if training is general in Becker's (1964) sense large enough conditional termination penalties induce efficient firms' investment. Becker's definition of (perfectly) general training requires training to raise a worker's marginal product equally at *all* firms. Since if the labour market is imperfectly competitive workers receive less than their marginal product, Becker's definition of general training

[21] This is the case, for example, if the distribution over Σ is such that the implied distribution of payoffs has no mass point for any h, as assumed in MacLeod and Malcomson (1993).

implies $u_h = \gamma f_h$ for $0 < \gamma \leq 1$, with γ not necessarily constant. This implies $[f_h - u_h] \geq 0$ for any s[22]. Importantly, our efficiency result does not require either contractibility of investment, or that workers have access to perfect capital markets, or a competitive labour market.

To get a deeper intuition of the scope of Result 5, assume that a worker's stock of training is the same in all jobs and that firms have the same production function but not necessarily the same shock realization. This implies that training is technologically general. Becker's definition of general training imposes the stronger requirement that a worker's marginal product is separable in h and s. Consider instead what happens when such separability requirement is not satisfied.

Assume the state of the world affects a firm's production function through the realization of a multiplicative shock. All the firms are ex ante identical and differ only in their shock realization. Hence, a worker's productivity with the current employer is $f = A(s)\, g(h)$ and her outside payoff is $u(h) = \gamma [B(s)\, g(h)]$ with $0 < \gamma \leq 1$ and $B(s)$ the expectation of the shock realization at a new employer. The sign of the wedge between the social and private marginal returns to training WG is the same as the sign of the expected difference between the worker's productivity with the current employer and her return outside $g(h) \int_{s \in \Sigma} [1 - I_S(s)] [A(s) - \gamma B(s)]\, d\mu$ conditional on separation. Since separation takes place whenever $f - u \leq z$, the sign of the wedge is no larger than the sign of $\bar{z}$, the expected return to capital in case of separation. So $\bar{z} > 0$ is a necessary but not sufficient condition for the firm to invest efficiently. If, conditional on separation,

[22] Of course, $\gamma = 1$ and $u_h = f_h$ if the labour market is competitive as Becker assumed.

the expected return on the firm's assets is non-positive in equilibrium, efficient investment in training cannot be achieved within the class of contracts considered.

Hence, it is not sufficient that training is technologically general for efficiency to obtain. On the other hand, that training is general in Becker's sense is a sufficient but not a necessary condition for efficiency.

6 Conclusion

This paper has analyzed non-contractible firms' investment in general human capital. General training increases workers' productivity with other employers but is vested in the worker on separation. This is a source of underinvestment as the return to the firm differs from the social one whenever the worker's or firm's reservation payoffs are binding. Large enough conditional termination penalties, improve employers' incentives to train by locking the parties in an ex post bilateral monopoly situation.

Appendix

A.1 Proofs of Results 1 and 5

Proof of Result 1. It needs to be proved that at each node at which a proposal which is accepted in equilibrium is made the proposer offers to share the higher between the joint payoff from separation and from continuation. Assume by contradiction that there is an equilibrium in which one party proposes to share $\min\{f, u+z\}$ at some node at which an acceptable proposal x is made. Offering the responder the same payoff of x, but out of a cake of size $\max\{f, u+z\}$ is a profitable one-stage deviation. ■

Proof of Result 5. At the socially efficient level of investment h^*, the right hand side of (12) equals the right hand side of (8) plus the term $WG = \int_{s\in\Sigma} \alpha\,[1 - I_S(s)]\,[f_h - u_h]d\mu$. If $WG = 0$, equation (12) coincides with (8) and efficiency follows. If $WG > 0$, at the constrained efficient level of training h^* the firm's marginal return under a contract featuring $w_c > 0$ and consensual separation is above the social return. Take any contract (w_c', F_c', Q_c') with finite F_c' and Q_c' under which all separations are consensual. Equation (7) implies that the probability that the firm receives its reservation payoff, $\hat{\mu} = \mu\{s : s \in \Sigma, w_c > \bar{\omega}\}$, is increasing in w_c and decreasing in F_c for w_c high enough relative to F_c. The firm's marginal return is continuous in w_c by assumption. Furthermore, by definition of $\bar{\omega}$, w_c and F_c are perfect substitutes in their effect on the probability $\hat{\mu}$ that the firm's payoff is binding. Since, the firm's marginal return to training is zero when its reservation payoffs is binding the firm's return to training can be reduced to its constrained efficient level by increasing w_c or reducing F_c. ■

A.2 Termination restrictions and ex ante profits

This section shows how firms' ex ante profit are non-decreasing in conditional termination penalties as long as entry wages are perfectly flexible.

To see this denote by w_e the entry wage and by $W(w_c, Q_c, F_c)$ the expected present value of all *net,* post-training, payments from the firm to the worker. The firm's ex ante optimization problem is

$$\begin{aligned} &\max_{w_e, w_c, Q_c, F_c} -w_e + \int_{s\in\Sigma} I(s) f(\varepsilon) \, d\mu - W(w_c, Q_c, F_c) \qquad (13) \\ &\text{s.t. } w_e + W(w_c, Q_c, F_c) + \int_{s\in\Sigma} [1 - I(s)] \, u(\varepsilon) \, d\mu \geq V, \\ &\qquad \text{Equation (10).} \end{aligned}$$

The Pareto optimal choice of contract maximizes firm's profits subject to the worker receiving a given utility level V and taking into account that the training level will be chosen, after the contract is signed, to satisfy equation (10) in the main text. Profit maximization requires the worker to receive exactly the ex ante utility level V and w_e can achieve this whatever w_c, Q_c, F_c. Hence, the firm's problem reduces to

$$\max_{w_c, Q_c, F_c} \int_{s\in\Sigma} I(s) f(\varepsilon) \, d\mu + \int_{s\in\Sigma} [1 - I(s)] \, u(\varepsilon) \, d\mu - V \qquad (14)$$

$$\text{s.t. Equation (10).} \qquad (15)$$

The contract maximizes the ex ante joint surplus $S = \int_{s \in \Sigma} \{I(s) f(\varepsilon) + [1 - I(s)] u(\varepsilon)\} d\mu$ net of the worker's ex ante payoff V, within the class of contracts considered. All known bargaining solutions imply $V = a + \beta S$ with $a \geq 0$, $0 \leq \beta \leq 1$. Hence, ex ante profits are maximized at $\hat{h}$ satisfying (12) and maximizing the ex ante joint surplus.

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