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Job Independence as an Incentive Device

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A firm can either subject its workers to strict rules and regulations or grant them independence. If independent, they can make entrenchment-investments which will not only raise their productivity but also make the firm depend on their cooperation. However, in contrast to a standard holdup problem, the firm can afterwards take over control, thus stripping such workers of a part of their bargaining assets. This leads to structural distortions and *may* aggravate the holdup problem. However, the threat of partial expropriation may also alleviate the holdup problem and even induce overinvestment.

Introduction

In most firms, wages, responsibilities and the independence of workers are positively correlated. Independent decision-making is regarded as a key feature of the so-called 'primary-sector' jobs, i.e. the well paid and secure employment relationships.[1] Most workers prefer independent jobs for many reasons. For example, having sole responsibilities makes a worker important and gives him influence in the firm. The paper concentrates on the aspect that independence strengthens a worker's bargaining position in individual wage negotiations. This is pivotal for explaining why workers in independent, responsible jobs are willing to invest in their jobs even if there is no reliable, formalized system of rewarding them.

We will consider a worker or middle manager whose expertise or on-the-job experience enables him to make improvements in the firm. Since such improvements cost effort, he has to decide on a relationship-specific investment. Such a situation is a natural candidate not only for granting him independence, but also for transferring ownership of the relevant assets to him; see Grossman and Hart (1986) and Hart and Moore (1990). However, in this paper we will assume that a transfer of ownership is not possible. One can easily conceive of reasons that forbid such a transfer, for example financial constraints of the worker, or co-specialization of the relevant assets with other assets of the firm. For similar reasons a firm may even want to retain full formal authority over the employee who is to work with the assets.[2] Accordingly, we shall regard 'job independence' as an *informal* permission or leeway to act without detailed instructions. Thus, we will analyse a very common situation. A worker with some degree of informal independence is expected to invest in the firm's assets although there is no explicit contract that guarantees him a reward and the firm can take over control at any moment. What incentive does he have to make such an investment?

In the model, worker investments simultaneously create private knowledge about the optimal use of the investments. Think for example of a production worker who has the permission (owing to independence) to restructure his workplace. If he makes improvements, he will be the only person who knows the details about the restructured workplace. Part of his productivity will therefore constitute a form of 'human capital', since it depends on his private knowledge. This raises his bargaining power in subsequent wage negotiations, even if the firm is able to re-impose control. For that reason, job independence-cum-individual wage bargaining can serve as an incentive device.

The model also points to a potential problem of job independence. A worker, instead of raising his productivity, may take unproductive, purely entrenching measures which will simply make it hard for the firm to produce without his cooperation. This misallocation problem has first been analysed by Shleifer and Vishny (1989) with regard to CEOs, who are in a fairly safe position *vis-à-vis* the firm's board; the problem could be even more severe in the case of middle managers or other independent employees who are in a less secure position. However, we will emphasize that this misallocation problem is only one aspect of the issues at hand. Recall that, in contrast to Shleifer and Vishny, we also consider the effort dimension and the aspect that a firm is tempted to renege on rewarding good performance. Allowing a worker to entrench himself is then a necessary precondition for getting any investments at all, since for the worker entrenchment is the very basis of getting a reward.

The upshot of this is that incentive effects and viability of job independence depend on the situation. To highlight some results of the paper, we will sketch a number of plausible cases that can emerge from the model. Suppose, for example, that a worker can easily take some very effective entrenchment measures which do not raise (maybe even reduce) his productivity. In this case independence will not be granted because the worker's incentives to misuse his freedom are just too strong. As a consequence, his expertise remains unutilized even though it could be very useful if properly channelled—but that is not possible. A programmer, for example, may not be allowed to introduce a novel computer language in which he is expert. Even if this language has potentially some very powerful applications, he would spend too much time rewriting existing programmes and would make them depend on his expertise.

As a converse example, suppose that a worker can make improvements only, but that the firm will afterwards have easy access to these improvements because, once developed and installed, they are easy for anyone else to understand. This means that the improvements do not translate into the worker's bargaining power. As a consequence, he has little incentive to develop them. It will therefore be difficult to induce a worker to develop an effective but structurally *simple* machine. In fact, the firm's ability to produce without him (after a 'takeover') expropriates him from a part of his bargaining assets. The takeover effect may therefore aggravate the usual holdup problem, which of course is also there, so that the worker's investment effort is low and most of his expertise remains unutilized. As a consequence, the firm will not grant independence in such a situation but rather will give detailed work instructions—instructions, although they take no account of the worker's expertise, at least force him to work hard.

However, it is also possible that the takeover threat *stimulates* effort, thus compensating for the holdup problem. The reason is that a worker's structural improvements will often *simultaneously* reduce the firm's ability to produce without him. If the productivity differential between him and the firm increases strongly with his investment effort, then incentives are strong and independence is likely to be granted. Indeed, it is possible that the threat of being expropriated stimulates a higher effort than safe asset ownership by the worker would do. Job independence is therefore most effective when there is a positive correlation between the productivity and complexity of structural developments.

As a general rule, a firm tends to grant independence if the worker can be expected to exert enough effort and make improvements: it will not do so if the worker's effort is expected to be either low or strongly misguided. But there is yet another obstacle to independence. Since independence is informal, the firm faces a commitment problem: a worker will accept a reduced entry wage only if the firm will not afterwards renege on its promise to grant independence. Since without appropriate reduction of the entry wage the firm would be unable to enjoy all the gains from granting independence, the problem of reneging can reappear on a higher level; i.e. there are situations where independence would be profitable for the firm (and efficient) but would not be viable.

We will also consider the effects of a worker's bargaining strength on the viability and profitability of independence. It turns out that in many cases workers' bargaining power should be at an intermediate level; i.e. they should have some but not all the bargaining power. Based on a parameterized example, it will be shown that independence is more profitable and more likely to be granted in jobs where workers have valuable on-the-job information. Moreover, the optimal strength of workers' bargaining power is increasing in the value of their on-the-job information. Hence independence, bargaining power and on-the-job information can be regarded as complementary. Finally, the model also predicts that the age–wage pattern will be more pronounced for independent workers than for others. These implications conform well to the stylized facts about independent jobs.

The paper's relationship to the literature on asset ownership, entrenchment, and the delegation of responsibility in organizations (for the latter see also Aghion and Tirole 1995, 1997; De Bijl 1994 and Prendergast 1995) have already been pointed out above. The paper is also related to the literature on incentive mechanisms under non-verifiability, mainly fixed promotion schemes (see Prendergast 1993 and Fairburn and Malcomson 1994) and up-or-out contracts (see Kahn and Huberman 1988 and Manove 1997). One difference from this literature is worth noting. These mechanisms require a binding attachment of wages to positions in the firm and thus the absence of individual wage bargaining. In contrast, job independence requires individual wage negotiations, but no commitment or contractual support at all.

Section I introduces the model and describes two alternative management styles—management by instructions and granting job independence—and their consequences for wage bargaining. Section II analyses the worker's actions. Section III analyses the firm's decision about whether or not to grant independence. Concluding remarks appear in Section IV.

I. The Model

There are two periods, a worker (or middle manager) and a firm (or top manager). The worker's wage for the first period, w_1, is fixed in the initial contract, whereas that for the second period, w_2, is determined in bilateral bargaining; the baseline of bargaining is a market wage of $\bar{w}$ per period. The worker's two-period payoff equals his wage earnings minus the disutility of effort; the firm's payoff is output minus wage payments; see (1) and (2) below.[3] Output is observable to both parties but not contractible; effort is private information. The basic problem is how the worker can be induced to exert effort and to make optimal use of his on-the-job information.

Timing and technology

During period 1, the worker's task is to structure his workplace. The term 'structuring' may refer to general decisions on working methods or on the use of machines, to planning and preparations, or just to the way work is started. Installing a workplace structure $s \in S$ costs an *investment effort* $e(s)$ that depends on the chosen structure.

During period 2, the worker's task is to follow the production method, and at the end of this period the output accrues. Output depends on both the workplace structure s installed in period 1 and the production method applied in period 2, since the latter has to fit the former. The maximal output that can be achieved with a given structure shall be denoted by $Y(s)$ and called the worker's 'productivity' with that structure. Since we focus on investment incentives for period 1, it is assumed that the production method in period 2 requires no further leffort.[4] To summarize, the workplace structure s (and thus the investment effort $e(s)$) determines productivity $Y(s)$, and the production method determines whether output is equal to or below $Y(s)$.

Once in the firm, the worker either gets detailed work instructions or does not; in the latter case we shall say that he is independent. (For reasons given below, independence is granted informally; it is not specified in the contract.) Wage bargaining takes place at the beginning of period 2 when productivity is revealed to both parties. During bargaining, the worker tries to reduce output as much as he can by following a relatively inefficient method of production—however, he cannot violate instructions. After an agreement on w_2 has been reached the worker cooperates and produces the maximal output $Y(s)$ that can be produced with the workplace structure that is in place. Payoffs are therefore:

(1) firm's payoff $= Y(s) - w_1 - w_2$

(2) worker's payoff $= w_1 + w_2 - e(s)$.

Figure 1 summarizes the timing of the model; the elements not yet introduced will be explained in this section.

Management by instructions

The various workplace structures and production methods are verifiable so that instructions are enforceable in both periods.[5] However, the firm's production knowledge is limited. For many workplace structures, the firm does not know the implied productivities or the suitable kinds of production methods. It has a certain 'standard structure' s_0; i.e. it knows how to install it and how to work with it. This is its fallback, so if the worker is to follow instructions in period 1, he will be told to install that structure, which costs

Period 1:	• Initial contract sets w_1.
	• Firm decides whether to give instructions or to grant independence.
	• *Workplace structuring:* The worker develops a structure $s \in S$ at effort $e(s)$.
Period 2:	• Worker's productivity $Y(s)$ and firm's takeover productivity $Y^F(s)$ are revealed to both parties.
	• Bargaining over wage w_2 starts.
	• *Production method:* In case of agreement, worker produces $Y(s)$; otherwise firm produces $Y^F(s)$ by instructions.

FIGURE 1. Timing of the model.

him an effort $e(s_0)$. In period 2, he will then be told to follow the 'standard' production method and output will then be $Y(s_0)$.

Wage bargaining with a non-independent worker is very simple. In order to retain the worker, the firm offers the wage $w_2 = \bar{w}$. The worker accepts this since he has no internal bargaining power—he is replaceable and cannot ignore instructions without being sued and losing his wages. Thus, for any given initial wage w_1, the firm's payoff from a non-independent worker is, according to (1),

(3) $$Y(s_0) - w_1 - \bar{w}.$$

Job independence and wage bargaining

Job independence means that the worker gets no instructions. In period 1 he can institute any structure he sees fit and thus decide on his effort level.[6] The firm may want to grant him independence because his on-the-job knowledge enables him to devise structures that are more productive than the standard one.

Independence is granted informally, not in a contract. Formal independence would mean that certain decisions would be irrevocably delegated to the worker. We assume that issuing such a contract is either impossible, or too costly or too dangerous for the firm. For example, if ambiguities in the contract enabled the worker to perform acts of sabotage, the firm would be extremely vulnerable to holdups.[7]

During bargaining, a worker who has been independent in period 1 tries to reduce output as much as he can by following a relatively inefficient production method. In order to mitigate the fall in output, the firm then 'takes over', either by replacing him (for example by rotating workers) or by requiring him to follow detailed work instructions. As a consequence, the worker can obstruct the production process only in those aspects that depend on his *willing* cooperation; his strike is a 'work to rule'.[8]

For a given structure s in place, let $Y^F(s)$ denote the firm's productivity after taking control. Since the firm is now at an informational disadvantage relative to the worker who has developed a novel workplace structure, its productivity is usually lower than his would be. In the following we assume

$\bar{w} \le Y^F(s) \le Y(s)$ for all $s \in S$. Hence a worker's strike reduces output from $Y(s)$ to $Y^F(s)$.[9]

Now turn to the bargaining outcome. The worker gets w_2 in case of agreement; otherwise his outside wage is $\bar{w}$. The firm's payoff in period 2 is $Y(s) - w_2$ in case of agreement; otherwise it replaces or controls the worker and gets $Y^F(s) - \bar{w}$.[10] Letting the exogenous variable $\pi \in [0, 1]$ measure the worker's ability to bargain, the Nash product is

$$(w_2 - \bar{w})^{\pi}[(Y(s) - w_2) - (Y^F(s) - \bar{w})]^{1-\pi}.$$

Applying the standard bargaining solution,

$$w_2 = \bar{w} + \pi(Y(s) - Y^F(s)). \tag{4}$$

This agreement is immediately reached so that the unrealistic events of sabotage by the worker and of a takeover by the firm are out of equilibrium.

Remark 1. If a worker has been independent in period 1, then in period 2 he stays in his job, retains his independent position (gets no instructions) and cooperates with the firm.

II. Incentive Effects of Independence

The model's concept of job independence can be summarized as follows. Job independence or sole responsibility resembles a property right, but it is an ephemeral one, since it is threatened by the firm's subsequent takeover. The worker's bargaining power will therefore rest on his private knowledge about the optimal production method. When structuring his workplace he implicitly creates such knowledge for himself and prevents this knowledge from being accessible to other members of the firm who are less familiar with his newly created production methods.

Remark 2. When an independent worker installs a new structure, s, he creates *human capital embodied in the firm's assets*. Its value is $Y(s) - Y^F(s) =: H(s)$.

Embodied human capital is firm-specific—it may well be one of the most widespread forms of firm-specific human capital—but it is different from a skill or a passing familiarity with the firm. It resembles the knowledge of a secret code. A striking example is that of a computer programmer who contaminates his programmes with passwords only he knows. In practice, a firm will forbid such obvious and destructive measures, but there are other means of entrenchment that cannot be forbidden so easily and may not be as destructive.

Worker's problem

The independent worker structures his workplace with the aim of creating embodied human capital. In order to see this, note that his total payoff is, according to (2) and (4),

$$w_1 + \bar{w} + \pi H(s) - e(s). \tag{5}$$

Since w_1 and $\bar{w}$ are fixed, he maximizes $\pi H(s) - e(s)$ by choice of a workplace structure $s \in S$. This maximization problem can be decomposed into two steps, as follows. In the first step, the worker considers all structures that are attainable with a given effort e and identifies among them the ones that maximize H. If $h(e)$ denotes this maximum for every e, he then in a second step maximizes $\pi h(e) - e$ by choice of e. This two-step procedure is now explained in more detail.

Step 1 consists of three substeps. For a given e, the worker first identifies all structures attainable with that effort; this is the subset $S_0(e) = \{s \mid s \in S, e(s) = e\}$ assumed to be non-empty for all $e \geq 0$. From this subset, he then identifies the structures that maximize H and obtains a subset $S_1(e) = \{s \mid H(s) \geq H(s')$ for all $s, s' \in S_0(e)\}$. From this subset (if it contains more than one element), he looks for the structures with the highest productivity Y. (Although he is indifferent between structures that yield the same H at the same effort, we assume that he does his employer a favour by choosing a most productive one.) He obtains a subset $S_2(e) = \{s \mid Y(s) \geq Y(s')$ for all $s, s' \in S_1(e)\}$. In the following, let $y(e), y^F(e)$ and $h(e)$ denote the resulting levels of Y, Y^F and H. That is, for every $s \in S_2(e)$, $y(e) = Y(s), y^F(e) = Y^F(s)$ and $h(e) = H(s)$. Of course, $h(e) = y(e) - y^F(e) \geq 0$ for all e. The Appendix shows by example how these functions of e can be derived from a fully fleshed job model. It also highlights some of the technological, informational and strategic issues behind these functions and generates the following example.

Example 1 (see Appendix). Suppose $\bar{w} = 0$. Technologically given are two parameters $x_h > x_l \geq 0$ and a function $p(e)$ with $0 \leq p(e) \leq 1, p(0) = 0, p' > 0, p'(0) = \infty, p'' < 0$, for which:

$$y(e) = p(e)x_h + (1 - p(e))x_l, \qquad y^F(e) = (1 - p(e))x_l, \qquad h(e) = p(e)x_h.$$

Worker's effort choice

Now we turn to step 2 of the worker's optimization problem, his choice of effort. For convenience, we make the technical assumptions that $y(e)$ and $y^F(e)$ are differentiable and satisfy $y'(0) - y^{F\prime}(0) = \infty$, $y'(0) = \infty$, $y'(\infty) < 1$ and $y'' < 0$.[11] Note that these properties are satisfied by Example 1 and hence can be an outflow of a more explicit job model. The worker's optimal effort choice is denoted by e^* and maximizes $\pi h(e) - e$; see (5). It satisfies:[12]

$$(6) \qquad h'(e^*) = 1/\pi$$

$$(7) \qquad \Leftrightarrow y'(e^*) - y^{F\prime}(e^*) = 1/\pi.$$

How does this compare to a first-best allocation? Suppose for simplicity that there is a unique first-best structure s^{fb}. It is given by

$$s^{fb} = \arg\max_{s \in S} Y(s) - e(s).$$

Even if the worker would choose the first-best effort level, $e^* = e(s^{fb})$, his productivity would probably be less than first-best, i.e. $y(e(s^{fb})) < Y(s^{fb})$, because his *structural* choices that underly the function $y(e)$ are usually distorted. They are the outcomes of step 1 of his optimization. The problem that an employed decision-maker tends to make structural distortions has already been emphasized by Shleifer and Vishny (1989) under the assumption that the agent's effort level is fixed. In our model, however, effort is not fixed and we are at least as much interested in his effort choice as in his structural choices.

Since not much can be said about the relation between e^* and $e(s^{fb})$, we need a more suitable benchmark for assessing the worker's effort choice. The maximizer of $y(e) - e$ shall be called second-best, e^{sb}, because it is efficient *conditional* on the structural distortions made by the worker. It is uniquely given by

$$(8) \qquad y'(e^{sb}) = 1.$$

The characterizations (8) and (7) differ by the terms $y^{F\prime}$ and π. In a standard holdup problem there is also a π but no such function as $y^F(e)$. By setting $y^{F\prime} = 0$, we therefore obtain still another interesting benchmark: the effort level under a 'standard holdup', e^{hu}, which maximizes $\pi y(e) - e$. This is uniquely given by

$$(9) \qquad y'(e^{hu}) = 1/\pi.$$

Assume $0 < \pi < 1$ so that $0 < e^{hu} < e^{sb}$. Obviously, from (7) and (9), we have the following proposition.

Proposition 1. If $y^{F\prime} = 0$, the worker's investment effort is below the second-best level as in a standard holdup problem, $e^* = e^{hu} < e^{sb}$.

Since the worker will get only the share π of the value of his human capital, (see (5)), and since only the part y of his human capital is responsive to effort (because $y^{F\prime} = 0$), there is the usual underinvestment problem.

Generally, however, $y^{F\prime}$ will not be zero. The employment relationship considered here is richer than a standard holdup problem in two respects. First, the firm can afterwards take over control and produce y^F; and second, the worker is not confined to investing in his own productivity y, but can also try to disinvest in the firm's takeover productivity y^F. How does the takeover threat affect incentives?

Proposition 2. If $y^F(e)$ is an increasing function, the underinvestment problem is aggravated, i.e. $e^* < e^{hu}$.

Proof. If $y^{F\prime} > 0$, then $h'(e) = y'(e) - y^{F\prime}(e) < y'(e)$ for all e. Hence, the first-order condition (7) implies $y'(e^*) > 1/\pi$, and $e^* < e^{hu}$ follows from (9). □

Figure 2 illustrates Proposition 2. For some concave function $y(e)$ and a fixed $\alpha \in (0, 1)$ it assumes that $y^F(e) = (1 - \alpha)y(e)$. The worker's investment effort e^* is well below the second-best effort e^{sb} for two reasons. First, his bargaining power is limited: $\pi < 1$. This is the standard holdup problem. But second, he will be stripped of the percentage $1 - \alpha$ of his bargaining assets by the firm's subsequent takeover. Thus, he gets only the percentage $\alpha\pi$ of $y(e)$, whereas under the standard holdup problem he would get the percentage π. This clearly aggravates the underinvestment problem so that $e^* < e^{hu}$. Now let us consider another case.

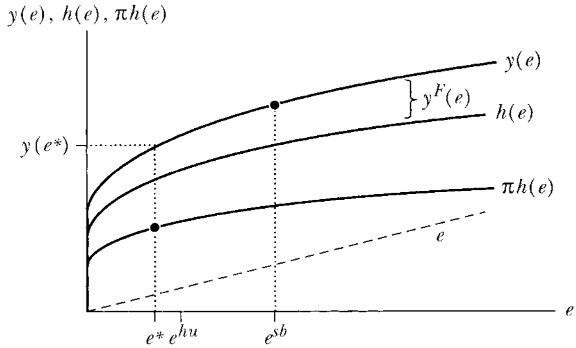

FIGURE 2. Effort choice when $y^F(e) = (1-\alpha)y(e)$ for $0 < \alpha < 1$. The dashed line is the worker's effort cost e. At e^* it parallels the tangent of $\pi h(e) = \alpha\pi y(e)$. At e^{sb} it parallels the tangent of $y(e)$. At e^{hu} it parellels the tangent of $\pi y(e)$, not shown.

Proposition 3. There exist functions $y^F(e)$, decreasing in some range, which imply that the underinvestment problem is alleviated: $e^* > e^{hu}$. If $\pi y(e^{sb}) > e^{sb}$, there exist functions $y^F(e)$ such that job independence leads to the second-best or even to overinvestment: $e^* \geq e^{sb}$.

Proof. By Propositions 1 and 2, the claim can hold only if $y^F(e)$ is decreasing in some range. We show by example the possibility of $e^* > e^{sb}$, which implies all the remainder. Suppose that $y^F(e) = y(e)$ for $e \leq e^{sb}$ and $y^F(e) = \bar{w}$ at $e = e^{sb} + \delta$, where δ satisfies $\pi y(e^{sb} + \delta) > e^{sb} + \delta$ and clearly exists if $\pi y(e^{sb}) > e^{sb}$. This implies $h(e) = 0$ for all $e \leq e^{sb}$ and $\pi h(e^{sb} + \delta) > e^{sb} + \delta$. As a consequence, $e^* > e^{sb}$. □

As an illustration of this case consider Example 1, which is based on the job model of the Appendix; i.e. it can be derived from explicit solution of the worker's optimization at step 1.[13] In this example the worker's effort choice is given by $x_h p'(e^*) = 1/\pi$ according to (6). The standard holdup would be given by $(x_h - x_l)p'(e^{hu}) = 1/\pi$ according to (9). Thus, $e^* > e^{hu}$ in Example 1. Moreover, since the second-best is given by $p'(e^{sb})(x_h - x_l) = 1$ according to (8), it follows that

$$\text{(10)} \qquad \pi > \frac{x_h - x_l}{x_h} \Leftrightarrow e^* > e^{sb}.$$

In Figure 3, illustrating this example, and Proposition 3, the worker's effort e^* is above e^{hu} and quite close to e^{sb}; for a higher π it would even exceed e^{sb}, by (10).

How is it that the threat of expropriating the investor alleviates a holdup problem? In order to discern the intuition behind Proposition 3, note that it requires a decreasing takeover productivity $y^F(e)$ of the firm. This provides strong incentives for the worker. His effort is dedicated not so much to increasing his own productivity $y(e)$—this motive is also there, but is diminished by the holdup problem—but to reducing the firm's takeover productivity $y^F(e)$, in order to get better entrenched during subsequent wage bargaining. A worker who invests in the firm's assets wants to make the firm depend on him in the

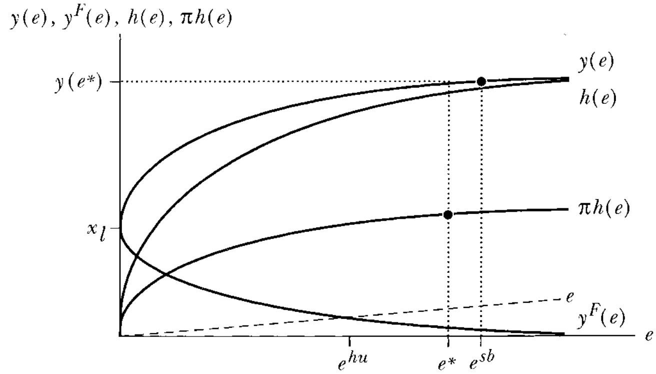

FIGURE 3. Effort choice in Example 1. The effort e^* maximizes $\pi h(e)-e$, while e^{sb} maximizes $y(e)-e$ and e^{hu} maximizes $\pi y(e)-e$ (not shown). The figure depicts Example 1 for the specifications $p(e)=2\sqrt{e}-e$, shown for $e\in[0, 0.7]$, $x_h=5$, $x_l=2$. The curve $\pi h(e)$ assumes $\pi=0.5$.

use of these assets; if the chances of achieving that goal are good, he will invest a lot.

Note that Proposition 3 is particularly relevant because the function $y^F(e)$ is quite likely a decreasing one. If the worker installs a fairly common workplace structure, i.e. develops it with little effort, the firm is likely to be fairly productive after a takeover (y^F high). But if the structure is really novel, which requires a great effort, the firm will be much less productive when taking over (y^F low). By gaining expertise and *applying* it in the firm, the worker actually reduces the production knowledge of other members of the firm.

III. VIABILITY AND PROFITABILITY OF INDEPENDENCE

Since independence is informal (granted simply by not giving instructions), the period 1 wage w_1 is already fixed when the firm decides to grant it. The firm's payoff from an independent worker is, according to (1) and (4),

$$(11) \qquad y(e^*)-w_1-\bar{w}-\pi h(e^*).$$

Its payoff from a non-independent worker is given by (3). The difference between (11) and (3) is

$$(12) \qquad \Delta := y(e^*)-\pi h(e^*)-Y(s_0).$$

Thus the firm grants independence if and only if $\Delta\geq 0$ ('viability condition').

In order to close the model, assume that both parties anticipate correctly at the outset whether or not independence will be granted (i.e. they know $Y(s_0)$, $e(s_0)$, $y(e)$, $y^F(e)$, π, and thus e^*). If $\Delta\geq 0$, the firm will offer the initial wage,

$$(13) \qquad w_1=\bar{w}-\pi h(e^*)+e^*,$$

in order to push the worker to his reservation level of $2\bar{w}$ (see (5)). The firm's total payoff is then $y(e^*)-e^*-2\bar{w}$ from (11). Similarly, if $\Delta<0$, the firm will offer the initial wage $w_1=\bar{w}+e(s_0)$ in order to compensate the non-independent worker for the 'standard' effort $e(s_0)$. (Recall that his second period wage will be $w_2 = \bar{w}$.) The firm's total payoff is then $Y(s_0) - e(s_0) - 2\bar{w}$, from (3), which we assume to be positive. Thus, the firm's total gain from granting independence is

$$\Delta_T := y(e^*) - e^* - (Y(s_0) - e(s_0)). \tag{14}$$

It follows from (14) and (12) that $\Delta_T > \Delta$, because $\pi h(e^*) > e^*$ by (6). If $\Delta_T > 0 > \Delta$, granting independence would be profitable *ex ante* (given that w_1 can be adapted accordingly), but not *ex post* (once w_1 is fixed). Hence the worker does *not* accept the wage (13) and the firm suffers from its inability to commit to granting independence. If $\Delta_T > \Delta > 0$, the firm will indeed grant independence and can adapt the initial wage accordingly, so that its *ex ante* gain from doing so is Δ_T. If $0 > \Delta_T > \Delta$, independence is neither profitable nor viable.

In passing we note the following.

Remark 3. An independent worker's wage is rising through time, i.e. $w_2 > w_1$, which is the familiar age–wage pattern. This pattern is more pronounced for independent workers than for non-independent ones.

Proof. If $\Delta \geq 0$, then $\pi h(e^*) > e^* > 0$, so that (4) and (13) imply $w_1 < \bar{w} < w_2$. If $\Delta < 0$, then $w_1 = \bar{w} + e(s_0) > \bar{w} = w_2$.[14] □

The impact of worker's bargaining power

For the purpose of comparative statics in π, assume in this section that the worker's maximization problem at step 2, $\max_e \pi h(e) - e$, is globally concave, i.e. that $h' > 0$ and $h'' < 0$, and that $h(0) = 0$.[15] An immediate implication is that $\mathrm{d}e^*/\mathrm{d}\pi > 0$, the worker's effort increases with his bargaining power.

The firm's total gain from independence, Δ_T as given by (14), is affected by π as follows:

$$\frac{\mathrm{d}\Delta_T}{\mathrm{d}\pi} = [y'(e^*) - 1]\frac{\mathrm{d}e^*}{\mathrm{d}\pi}. \tag{15}$$

Since $\mathrm{d}e^*/\mathrm{d}\pi > 0$, and recalling the definition (8) of e^{sb}, (15) tells us that Δ_T is increasing in π as long as $e^* < e^{sb}$ and decreasing if $e^* > e^{sb}$. Hence, if even $\pi = 1$ implies $e^* \leq e^{sb}$, Δ_T increases monotone in π. But otherwise, i.e. if $\pi = 1$ implies $e^* > e^{sb}$, Δ_T is hump-shaped in π and achieves a maximum at some $\pi^* < 1$. It could even become negative for $\pi \to 1$ (as it does generally for $\pi \to 0$: see (14)). Using (7), we can rewrite (15) as

$$\frac{\mathrm{d}\Delta_T}{\mathrm{d}\pi} = \left(\frac{1-\pi}{\pi} + y^{F\prime}(e^*)\right)\frac{\mathrm{d}e^*}{\mathrm{d}\pi}. \tag{16}$$

Thus, Δ_T can be hump-shaped only if $y^{F\prime}(e^*)$ is negative for some range. This of course is consistent with Propositions 1–3 since negativity of $y^{F\prime}(e)$ for some range is a precondition for $e^* > e^{sb}$ to be possible. But expression (16) also gives rise for a *sufficient* condition.

Proposition 4. If $y^{F\prime} < 0$, then $\Delta_T(\pi)$ is hump-shaped and has a maximum at some $\pi^* < 1$.

Proof. By (15) and $de^*/d\pi > 0$ and the uniqueness of e^{sb}, $\Delta_T(\pi)$ is at first increasing and has at most one point where its tangent is flat. If $y^{F\prime} < 0$ throughout, then (16) becomes negative for $\pi \rightarrow 1$. □

Thus, the case of a decreasing takeover productivity function $y^F(e)$ produces once more a result that contrasts with a standard result obtained in the literature. It is well known that a standard holdup problem could be solved by giving all the bargaining power to the investing party, i.e. $\pi = 1$.[16] In contrast, in our model with $y^{F\prime} < 0$ the takeover threat also works against the underinvestment problem, so that the latter vanishes at some $\pi^* < 1$. Since $\pi > \pi^*$ would only lead to inefficient overinvestment, a worker's bargaining power should not exceed π^*, from the firm's and from a welfare point of view.

Bargaining power also affects the viability of independence, owing to its effect on Δ. Using (6), one obtains from (12) and (15):

$$(17) \qquad \Delta'(\pi) = (y'(e^*) - 1)\frac{de^*}{d\pi} - h(e^*) = \Delta_T'(\pi) - h(e^*).$$

At $\pi = 0$ the two functions, $\Delta(\pi)$ and $\Delta_T(\pi)$, are increasing at the same rate, $\Delta'(0) = \Delta_T'(0) > 0$, since $h(0) = 0$. But since $h' > 0$ and $de^*/d\pi > 0$, we have $h(e^*) > 0$ and thus $\Delta'(\pi) < \Delta_T'(\pi)$ for all $\pi > 0$, and the wedge $\Delta_T'(\pi) - \Delta'(\pi)$ is increasing in π. This implies the following. If $\Delta_T(\pi)$ increases monotone for all $\pi \in [0, 1]$, then $\Delta(\pi)$ is either monotone or hump-shaped. If $\Delta_T(\pi)$ is itself hump-shaped with its maximum at $\pi^* < 1$, then $\Delta(\pi)$ will be hump-shaped too with its maximum already before π^*. Although the shape of the Δ function is not interesting *per se*, it determines the sign of Δ at different π. Figure 4, based on Example 1, shows Δ_T and Δ as functions of π implicitly: each of them is the difference between one of the solid curves and one of the dashed curves, as indicated in the figure. In this example the Δ_T curve is slightly hump-shaped with its maximum being at π^* and the Δ curve is pronouncedly hump-shaped with its maximum being well below π^*; Δ even gets negative at $\pi = b$.

In order to summarize the above discussion of the functions $\Delta_T(\pi)$ and $\Delta(\pi)$, consider a gradual increase of π from zero to one. For π close to zero, both Δ_T and Δ are negative but increasing. When Δ_T becomes positive, Δ is still negative. Only when Δ too becomes positive (if at all) will independence be granted. In the example of Figure 4, there is an interval (a', a) in which independence is not viable although it would be profitable, i.e. $\Delta_T(\pi) > 0 > \Delta(\pi)$. As in the figure, let a denote the critical π where independence gets viable, i.e. where $\Delta(a) = 0$ and $\Delta'(a) > 0$. While the firm's profit remains at $Y(s_0) - e(s_0)$ for $\pi < a$, it suddenly jumps upward at $\pi = a$ by the amount Δ_T(a) to reach $y(e^*(a)) - e^*(a)$ (see Figure 4). Afterwards profit increases gradually in π, at least for a while (since $\Delta_T'(a) > \Delta'(a) > 0$). Indeed, if $\Delta(\pi)$ is monotone, then $\Delta_T(\pi)$ is monotone too and profit is increasing up until $\pi = 1$. However, if $\Delta(\pi)$ is hump-shaped, the viability of independence can be endangered when π increases further. This is the case in Figure 4: There is a critical b where independence ceases to be viable, i.e. $\Delta(b) = 0$ and $\Delta'(b) < 0$. If such a point exists, the firm's profit suddenly jumps downward just after $\pi = b$ by the amount $\Delta_T(b)$ from $y(e^*(b)) - e^*(b)$, back to $Y(s_0) - e(s_0)$. There it remains for all $\pi > b$ since $\Delta(\pi)$ will not become positive again.

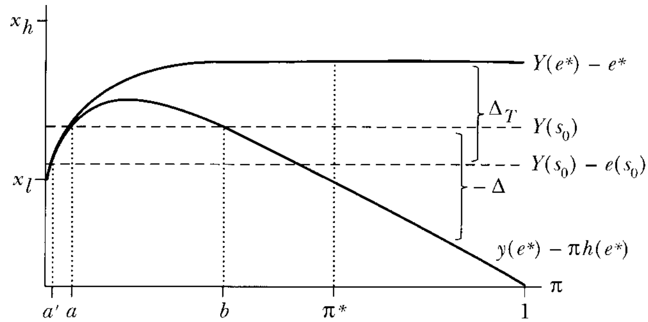

FIGURE 4. Effect of π on the viability and profitability of independence. By (12) and (14), $\Delta = y(e^*) - \pi h(e^*) - Y(s_0)$ and $\Delta_T = y(e^*) - e^* - [Y(s_0) - e(s_0)]$. The gain from independence, Δ_T, is positive for all $\pi > a'$ and achieves its maximum at π^*. Independence is viable, i.e. $\Delta \geq 0$, if and only if $\pi \in [a, b]$. The figure is based on Example 1 which implies that $\pi^* = (x_h - x_l)/x_h$ by (10). It assumes $p(e) = 2\sqrt{e} - e$ for $e < 1, x_h = 5, x_l = 2, Y(s_0) = 3, e(s_0) = 0.7$, and $\pi = 0.5$.

Taking up the discussion of the optimal allocation of bargaining power (which so far has been based only on the properties of Δ_T), we can now state the following result which contrasts the well-known standard result that $\pi = 1$ is optimal in a standard holdup problem.

Remark 4. Suppose there exists a π at which independence is viable. Then the efficient level of worker's bargaining power is strictly smaller than 1 if and only if one of the following conditions holds: $\Delta_T'(1) < 0$ or $\Delta(1) < 0$.

The property $\Delta_T'(1) < 0$ (for a sufficient condition see Proposition 4) means that the firm's profit is decreasing in π at $\pi = 1$ so that a smaller π is optimal. The property $\Delta(1) < 0$ means that independence is not even viable at $\pi = 1$. Only if none of these criteria applies, i.e. if $\Delta_T'(1) \geq 0$ and $\Delta(1) \geq 0$, is $\pi = 1$ optimal. In the example shown in Figure 4 both criteria apply. The example exhibits $b < \pi^*$, so that the efficient level of bargaining power is $\pi = b$, i.e. the largest π that is consistent with a credible promise of the firm to grant independence.[17]

Although π is exogenous in this model, it can be viewed as adapting to its optimal level. One can think of an evolutionary market process or of deliberate design of some contractual or organizational features that affect π.[18] In such a context, this model would predict not an extreme allocation of bargaining power, $\pi = 0$ or $\pi = 1$, but an intermediate one which depends on the technological environment.

The impact of worker's on-the-job information

In Example 1 the technological environment is described in greater detail allowing some more comparative statics. The parameter x_h can be interpreted as the value of the worker's on-the-job information.[19] It affects Δ and Δ_T both directly and indirectly via e^*. One shows that for the relevant part, $\pi \leq \pi^*$, both Δ and Δ_T are increasing in x_h. In Figure 4, the two solid curves shift upwards (in the relevant part) as x_h increases. This implies that a moves to the left and b to the right. Thus, both the viability (the interval $[a, b]$) and the profitability (Δ_T over that interval) of job independence are improving as the worker's on-the-job information gets more valuable.

Moreover, since in the example the optimal degree of bargaining power is $\pi = b$, and b increases in x_h, on-the-job information and bargaining power are complementary from the firm's point of view. Thus, if one takes the example as representative and assumes that π adapts to its optimal level, one would expect to observe a positive correlation between (i) the value of workers' on-the-job information in a branch, (ii) the likelihood that workers are independent in that branch and (iii) the bargaining strength of these workers. On the one extreme are branches where workers have no access to valuable on-the-job information; these workers would not be independent and their wages would not be determined in bilateral bargaining. On the other extreme are branches where workers have very valuable on-the-job information; these workers should be independent and have a considerable degree of bargaining power (but less than 1).

IV. Concluding Remarks

This model sheds light on why workers in independent, responsible jobs are willing to invest in their jobs even if there is no reliable and formalized system of being rewarded and their position in the firm is not secured by formal agreements. The model demonstrates that these workers' wages are usually determined by individual wage bargaining in which their personal contribution to the firm's or department's performance is a crucial point in the bargaining process. It also explains why wages rise with job seniority especially in these jobs. In highly regulated jobs, in contrast, wages are flatter and to a lesser degree subject to individual wage bargaining, and the workers have little incentives to invest in their jobs.

In contrast to traditional principal–agent models, where independence is an unavoidable consequence of unobservabilities and leads to shirking, holdups or other agency costs, this model shows that independence may be deliberately granted to a worker in order to stimulate effort. It is noteworthy that job independence works as an incentive device even without any contractual support. This is in contrast to other incentive mechanisms under non-verifiability, which need commitment about future wages conditional on the position in the firm and are thus incompatible with individual wage bargaining.

In the model we assume that during wage bargaining a worker tries to cause as much damage as he can. Is 'sabotage' realistic? Some authors, e.g. Akerlof (1982) and Akerlof and Yellen (1990), argue that it is. Note that the worker expects to be rewarded and that the firm has an incentive to underpin this expectation by verbal promises. Hence, during bargaining it is actually the firm that breaks the agreement, and so the worker may feel entitled to express his anger unmistakably. We also modelled a very limited form of sabotage by assuming that an individual worker cannot openly break rules or ignore instructions. In reality, since individual wage bargaining does take place (and not only when a worker has a particular outside option threat), workers have to have some kind of internal threat. Finally, modern bargaining theory predicts that agreement is immediately reached so that neither 'sabotage' by the worker nor a 'takeover' by the firm (the re-imposition of controls) are actually observed. The model is therefore consistent with the widely observed fact that wages rise smoothly in line with job seniority.

The incentive effects of independence depend crucially on the specific job situation. In particular, the firm's potential to take over control later on (which is relevant for bargaining, although it will not actually happen) affects a worker's incentives. On first sight, one would expect that the firm's takeover threat aggravates holdup problems so that workers' efforts will be low. This is one possibility. However, if the firm's productivity after a takeover is a decreasing function of the workers' investment effort, which appears to be a plausible case, then the takeover threat may actually *stimulate* effort, thus alleviating the holdup problem. This may even lead to overinvestment by a worker, for entrenchment reasons. Another caveat, which has already been pointed out by Shleifer and Vishny (1989), is that an independent worker will tend to make *structural* distortions (at every effort level) for entrenchment reasons. In order to avoid severe distortions, a firm may have to restrict independence or, in some cases, dispense with it altogether.

Since the worker is the investing party and the firm attracts all the surplus from the relationship by adapting the entry wage, the firm's gain from job independence is increasing in workers' bargaining power π for some range. However, it is possible that the firm's gain from independence achieves a maximum before $\pi = 1$ and then decreases again in π. This contrasts with a well-known result about the optimal allocation of bargaining power in a standard holdup problem, namely, that the investing party should be given the maximal bargaining power ($\pi = 1$). Our model's divergent result is due to one of two factors: First, the holdup problem may already be solved at some $\pi^* < 1$ as a result of the takeover threat, so that more bargaining power leads to inefficient overinvestment. Second, the firm has an incentive to renege on its promise to grant independence when the worker's bargaining power is high. Hence, if one assumes that π adapts to its optimum level, this model can predict an intermediate strength of bargaining power, $0 < \pi < 1$.

Whether or not independence is granted by a firm depends also on the worker's potential to raise his productivity. If he is able to improve his productivity considerably, independence is likely to be granted. On the basis of a particular specification, the model also shows that the value of a worker's on-the-job information, job independence, and bargaining power π are three complementary features of a job.

Currently it can be observed that many jobs are more tightly controlled than they used to be because on-the-job information in these jobs has become less important. At the same time, these jobs are tending to be replaced by automatic manufacturing, and there is an increasing number of employees who do the planning or operate the more complex technologies. In line with the results of this paper, these new jobs are often highly independent ones with valuable on-the-job information.

Future research should be devoted to the issue of job design. While we have treated the scope of a job (and of job independence) as given, they can be influenced in practice. Job enrichment, for example, can enable a worker to make larger productivity gains. On the other hand, it will also give him more opportunities to take unproductive, purely entrenching, measures. The net effect will be important for the firm's job design decision. Another issue is that of co-training of the workforce.[20] Since co-training makes it easier for the firm to replace each worker, it will probably improve the firm's takeover productivity. In view of the model, one can suspect that this will discourage effort in some situations and stimulate effort in other situations. The latter should be the case when a worker can neutralize the effect of co-training by making even better structural improvements, i.e. when his improvements are the less easily accessible, even to a co-trained worker, the more effort he puts in.

APPENDIX: A JOB MODEL

Consider a job that consists of a continuum of similar tasks, indexed by $k \in (0, 1)$. Each task needs to be prepared in period 1 and completed in period 2. Preparation may require effort whereas completion does not. A triple (P, C, k) means that preparation P and completion C are applied to task k. There is a *basic preparation* P_B which has to be matched by a certain completion C_B. This pair of actions is applicable to all tasks and produces $x_l > 0$ per task; the effort for applying P_B is normalized to zero. A more thorough preparation is the *standard preparation* P_0, which costs an effort of $e_0 > 0$ per task. If P_0 and the corresponding completion C_0 are applied to a task, the latter will contribute x_0 to total output, with $x_0 - e_0 > x_l$. Finally, there is for each task k one *specifically adapted preparation*, P_k, which requires a specific completion C_k. If P_k and C_k are applied to task k, it will contribute $x_h > x_0 - e_0$ (the required effort is described below).

All the combinations that yield a positive outcome are summarized as follows:

$$(P_B, C_B, k) \rightarrow \text{task } k \text{ contributes } x_l$$

$$(P_0, C_0, k) \rightarrow \text{task } k \text{ contributes } x_0$$

$$(P_k, C_k, k) \rightarrow \text{task } k \text{ contributes } x_h.$$

Any other combination (P, C, k) from $P \in \{0, P_B, P_0, \{P_k\}\}$ and $C \in \{0, C_B, C_0, \{C_k\}\}$ (zero stands for doing nothing) has the consequence that task k contributes zero. For example, (P_k, C_j, k) produces zero if $j \neq k$; (P_B, C_0, k) and (P_B, C_k, k) also produce zero. The firm's total output is

$$\text{Output} = \sum_{i = l,0,h} x_i \times (\text{percentage of tasks contributing } x_i).$$

The basic and the standard ways of production (P_B, P_0, C_B and C_0) are common knowledge and verifiable. Although the other ways of production can also be differentiated by their outside appearance (verifiable), no one knows at the outset how they match to the tasks.[21] Only the worker can find out the specifically adapted ways of production. He chooses an *adaptation effort* $e_A > 0$ which enables him to encounter the P_ks and C_ks for a *percentage* $p(e_A) \leq 1$ of tasks. The function $p(e_A)$ is increasing and strictly concave, with $p(0) = 0$, $p'(0) = \infty$.

If effort and output were contractible, the firm would choose a certain adaptation effort e_A. In addition, it is clear that the remaining $1 - p(e_A)$ tasks, which have turned out to be difficult to adapt to, should be prepared in the standard way. Hence total effort should be $e = e_A + e_0(1 - p(e_A))$, where the optimal e_A is given by $p'(e_A^{fb})(x_h - x_0) = 1$. The contract would require the implied levels of total effort and output, the latter being $p(e_A)x_h + (1 - p(e_A))x_0$.

However, effort and output are unverifiable. Suppose the firm produces by instructions. Since it does not know (and has no chance to guess) the specifically adapted ways of production, the best instructions are to let the worker apply the standard procedures P_0 and C_0 to all tasks; this is the standard structure s_0. It implies a total effort of $e = e_0$ and leads to an output of x_0; hence $Y(s_0) = x_0$ and $e(s_0) = e_0$.

The alternative is to grant independence. The worker will then choose some adaptation effort $e_A \geq 0$, since doing so builds embodied human capital. In $p(e_A)$ tasks he will then be able to produce x_h, whereas the firm cannot produce at all. Although the firm recognizes the tasks that have been adapted, it does not know which completion matches to an adapted preparation, and if it picks one at random the expected output from doing so is almost zero. This is why independence has a positive incentive effect for the worker. In contrast, he has no incentive to apply the standard preparation to the remaining $1-p(e_A)$ tasks, since this would cost him e_0 per task without giving him an informational edge relative to the firm (since the firm can recognize P_0 and knows C_0). Hence the independent worker's total effort is $e = e_A$ for the chosen adaptation effort e_A, and $1-p(e)$ tasks get no more than the basic preparation.[22]

The independent worker's productivity is therefore $y(e) = p(e)x_h + (1-p(e))x_l$. The firm's takeover productivity is $y^F(e) = (1-p(e))x_l$, since it recognizes P_B and knows C_B. Thus human capital is $h(e) = y(e) - y^F(e) = p(e)x_h$. This is Example 1 as given in the main text.

The example shows that job independence-cum-individual wage bargaining can serve as an incentive device, since $e^* > 0$. It also shows that independence usually leads to structural distortions. In particular, it would be better to allocate some portion of the total effort e^* to the standard ways of production, instead of focusing entirely on the specifically adapted ways. But the worker avoids the standard ways for entrenchment reasons.

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NOTES

1. See e.g. Milgrom and Roberts (1992, pp. 359).
2. Grossman and Hart (1986) noted that asset ownership (the possession of control rights) already implies a certain degree of authority over the actions of others. On the distinction between formal and informal authority, see Aghion and Tirole (1997).
3. Everyone is risk-neutral. There is no discounting.
4. The model can be extended to include work incentives for period 2. For example, if there is an (imperfect) indicator of production effort in period 2, a standard incentive contract can be used. In order to not disturb the model, however, such an indicator should be independent of output, of the *kind* of production method used in period 2, and should not be applicable to structuring effort in period 1. An example could be the amount of sweat produced by the worker, assuming that structuring effort is purely intellectual.
5. This assumption can be relaxed considerably.
6. In practice, independence may be restricted to a subset of actions. Note that independence has no direct effect on the worker's utility in this model.
7. Note that we assume a symmetric order of events in the case of non-independence, since instructions too are written *after* the contract. There are similar reasons why a firm may want to give instructions during the course of events, instead of committing to particular instructions in the initial contract. Since independence is only informal, the firm always retains ownership of its assets (and the worker's actions) in the sense of Grossman and Hart (1986) and Hart and Moore (1990) and retains formal authority in the sense of Aghion and Tirole (1995, 1997).
8. Note that, in contrast to collective bargaining, a 'strike' is not verifiable. Consequently, the default wage (here $\bar{w}$) cannot depend on the length of the strike; i.e. wage payment cannot be suspended during negotiations. This rules out renegotiation design mechanisms discussed in the literature, e.g. Hart and Moore (1988), Aghion *et al.* (1994), MacLeod and Malcomson (1995) or Nöldeke and Schmidt (1995).
9. Where the firm controls the worker from the beginning and lets him install the standard structure s_0, we have assumed that firm and worker have the same productivity $Y(s_0)$.
10. It is assumed that Y and Y^F are revealed to both parties at the beginning of period 2 and that, after an agreement has been reached, the two parties cannot communicate again.
11. We make all the standard assumptions on $y(e)$, but only a few on $y^F(e)$. Since the novelty of this model lies in the $y^F(e)$ function, we do not want to be too restrictive about it at this point. For comparative-statics purposes some more assumptions on $y^F(e)$ will be needed; see Section III.
12. Existence of a solution $e^* > 0$ is guaranteed by the above assumptions. Uniqueness of e^* is not required in what follows.
13. In contrast to the example given in the proof of Proposition 3, Example 1 uses a particular $y(e)$ function and $\bar{w} = 0$.

14. The inverse age–wage pattern is due to the assumption that no effort is needed in period 2. If an equal effort were required in period 2, the wage of a non-independent worker would be flat. (See n. 4 on the possibilities of extending the model by a period 2 incentive contract.)
15. This is equivalent to $y^{F\prime} < y', y^{F\prime\prime} > y''$ and $y^F(0) = y(0)$.
16. This solution to a holdup problem has been used in several renegotiation design mechanisms; see particularly Rubinstein and Wolinsky (1992) and some of the literature cited in n. 8.
17. The other conceivable cases are: (i) if $\pi^* < b$, then $\pi = \pi^*$ is optimal; (ii) if only one of the numbers (b, π^*) exists, then it is optimal to have π equal that number; (iii) if none of them exists, then $\pi = 1$ is optimal (as already noted). All this assumes that $\Delta(\pi)$ does become positive for some π, since otherwise π is irrelevant.
18. According to the bargaining literature, the relative bargaining powers are related to the parties' degrees of impatience and their abilities to communicate. The latter aspect is emphasized in Binmore's (1987) version of the alternating offers model, where π (resp. $1-\pi$) represent the two parties' probabilities of being able to make a proposal next round. Such probabilities—but also the impatience of agents—may be influencible by contractual or organizational measures.
19. In Example 1, $y(e)$ is a linear combination of x_l and x_h. The weight of x_h is $p(e) \in [0, 1]$ and increases in e so that the worker can move $y(e)$ closer to its upper bound x_h by exerting effort. Obviously, therefore, the larger is x_h, the more valuable is his effort.
20. This has been addressed in different contexts by Feinstein and Stein (1988) and Stole and Zwiebel (1996), who both recommend co-training for strategic reasons.
21. Each P_k and C_k carries a distinct flag which is verifiable, but it is not known how the flags correspond to the unobserved indices k which tell the correct matches to the tasks.
22. Note that the firm will not restrict independence by forbidding the basic preparation. If it did, the worker would not deviate to the standard preparation, but would choose a zero-output alternative, for example by doing nothing. On the other hand, if the basic preparation required some effort, the firm would restrict independence by requiring the worker to make at least the basic preparation (which assumes that P_B is included in P_0 and the P_ks).

REFERENCES

Aghion, P. and Tirole, J. (1995). Some implications of growth for organizational form and ownership structure. *European Economic Review*, **39,** 440–55.

—— and —— (1997). Formal and real authority in organizations. *Journal of Political Economy*, **105,** 1–29.

——, Dewatripont, M. and Rey, P. (1994). Renegotiation design with unverifiable information. *Econometrica*, **62,** 257–82.

Akerlof, G. A. (1982). Labor contracts as partial gift exchange. *Quarterly Journal of Economics*, **97,** 543–69.

—— and Yellen, J. L. (1990). The fair wage–effort hypothesis of unemployment. *Quarterly Journal of Economics*, **105,** 255–83.

Binmore, K. (1987). Perfect equilibria in bargaining models. In K. Binmore and P. Dasgupta (eds.), *The Economics of Bargaining*. Oxford: Blackwell.

De Bijl, P. W. J. (1994). Delegation of responsibility in organizations. Discussion Paper No. 9469, Center for Economic Research, Tilburg University.

Fairburn, J. A. and Malcomson, J. M. (1994). Rewarding performance by promotion to a *different* job. *European Economic Review*, **38,** 583–690.

Feinstein, J. S. and Stein, J. (1988). Employee opportunism and redundancy in firms. *Journal of Economic Behavior and Organization*, **10,** 401–14.

Grossman, S. J. and Hart, O. (1986). The costs and benefits of ownership: a theory of vertical and lateral integration. *Journal of Political Economy*, **94,** 691–719.

Hart, O. and Moore, J. (1988). Incomplete contracts and renegotiation. *Econometrica*, **56,** 755–85.

—— and —— (1990). Property rights and the nature of the firm. *Journal of Political Economy*, **98,** 1119–58.

Kahn, C. and Huberman, G. (1988). Two-sided uncertainty and 'up-or-out' contracts. *Journal of Labor Economics*, **6,** 423–44.

MacLeod, W. B. and Malcomson, J. M. (1995). Contract bargaining with symmetric information. *Canadian Journal of Econometrics*, **28,** 336–67.

Manove, M. (1997). Job responsibility, pay and promotion. *Economic Journal*, **107,** 85–103.

Milgrom, P. and Roberts, J. (1992). *Economics*, *Organization and Management*. Englewood Cliffs, NJ: Prentice-Hall.

NÖLDEKE, G. and SCHMIDT, K. M. (1995). Option contracts and renegotiation: a solution to the hold-up problem. *Rand Journal of Economics*, **26,** 163–79.

PRENDERGAST, C. (1993). The role of promotion in inducing specific human capital acquisition. *Quarterly Journal of Economics*, **108,** 523–34.

—— (1995). A theory of responsibility in organizations. *Journal of Labor Economics*, **13,** 387–400.

RUBINSTEIN, A. and WOLINSKY, A. (1992). Renegotiation-proof implementation and time preference. *American Economic Review*, **82,** 600–14.

SHLEIFER, A. and VISHNY, R. W. (1989). Management entrenchment: the case of manager–specific investments. *Journal of Financial Economics*, **25,** 123–39.

STOLE, L. A. and ZWIEBEL, J. (1996). Organizational design and technology choice under intrafirm bargaining. *American Economic Review*, **86,** 195–222.