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Choosing between Up-or-Out and Spot Contracts: Human Capital Investment versus Job-Matching Considerations

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Up-or-out contracts can improve human capital investment incentives but lead to suboptimal worker-employer separation. When job matching uncertainty is large relative to the return to human capital investment, spot contracts Pareto dominate up-or-out contracts. Otherwise, up-or-out contracts are more efficient. This view seems consistent with contractual choices in many different situations including those for university appointments with different emphases on research and teaching. The model also shows that human capital investment can be positively correlated with turnover under the up-or-out contract, a prediction different from that of the traditional human capital theory but consistent with casual observations of university professors' experiences. The result shows that the relationship between human capital investment and labor turnover should be understood in the context of a chosen contractual form. *Journal of Economic Literature* Classification Numbers: J24, J63.

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1. INTRODUCTION

Up-or-out and spot contracts are two important forms of labor contracts. While the former are frequently used in universities and corporate law firms, the latter are also observed in these as well as other organizations. In this paper we study the relative efficiency of these two types of contracts.

Our work benefits directly from Kahn and Huberman (1988) and Waldman (1990) who have studied the rationale for the use of up-or-out contracts. In our model, as in theirs, up-or-out contracts are used to improve workers' human capital investment incentives. We differ from them, however, in that we formally incorporate the problem of job-matching uncertainty (in the sense of Jovanovic, 1979) into the analysis and compare the relative efficiency of up-or-out and spot market contracts. [1] We show that up-or-out contracts, while improving incentives for human capital investment, lead to suboptimal separation. The choice of contract is determined by the tradeoff between the efficiency of human capital investment and that of job matching quality.

To see the tradeoff between a stronger incentive for human capital investment and matching quality under two different types of contracts, note that under spot contracting separation is always optimal because the contract makes no commitment to future compensation. When future compensation is determined through bargaining in the spot labor market, a worker changes employer only if he has a higher (expected) productivity at another firm. In contrast, under the up-or-out rule, the firm commits to a higher level of compensation to those who are up.[2] Because of matching uncertainty, it is possible that a worker who made the expected human capital investment still ends up with a productivity level that is below the level needed to be "up" but is above the level he can obtain in another firm. In such a case, the worker will be forced "out". The separation is suboptimal because the worker's (expected) productivity is lower at another firm. We show that, when matching uncertainty is high, the loss due to inefficient separation can outweigh the gain from more human capital investment induced by the up-or-out rule. It is then more efficient not to adopt an up-or-out contract. The opposite is true when uncertainty is rela-

[1] Kahn and Huberman do not explicitly consider an ex post spot market in which the worker's wage is negotiated because they assume that human capital is completely firm-specific and has no market value. Waldman assumes general human capital and specifies a spot market. However, he focuses on the signalling effects of retention decisions when up-or-out contracts are used. We investigate the factors that affect the choice between up-or-out and spot contracts.

[2] We assume that commitment to the up-or-out rule is credible. The credibility can come from reputation considerations. For example, when facing many assistant professors, a university has incentive not to renegotiate the contract with a single assistant professor. Thus, we have identified a rationale against the use of up- or-out contracts even when commitment is possible.

tively small and the gain from more human capital investment is relatively large. [3]

Our study sheds light on some interesting and puzzling labor market phenomena. For example, moral hazard and asymmetric information problems are the major underlying reasons that explain the use of up-or-out contracts in Kahn and Huberman (1988) and Waldman (1990). However, if these problems are common in employment relations as most people tend to believe, why are up-or-out contracts not more widely used? Also, why do American universities use up-or-out contracts more widely than their counterparts in many other countries? Why do U.S. universities also offer spot contracts to full time faculty members who have mostly teaching responsibilities? [4] Why are many corporate law firms in the U.S. moving away from the traditional up-or-out rule?

The model also enriches the human capital theory by showing that the relationship between human capital investment and labor turnover is sensitive to the choice of labor contracts. Specifically, it shows that under the up-or-out rule a higher level of human capital investment can be associated with more separation. This explains why an assistant professor at a top university has a lower probability of being tenured, albeit he is likely to invest more in human capital, than his counterparts in less prestigious universities.[5] This finding is very different from the fundamental proposition of the traditional human capital theory that the relationship between human capital investment and labor turnover is negative, if human capital is at least partially firm-specific.

Human capital investment and job matching are important theories of labor economics. The empirical predictions of the two theories are often identical or very similar.[6] The results of our model suggest that the two theories have quite different and testable implications for the choice of labor contracts.

[3] Another difference between this work and Kahn and Huberman (1988) and Waldman (1990) is that they assume information asymmetric with regard to the level of human capital investment. We show that this assumption is not crucial. Very similar results can be obtained when the information is symmetric between current and potential employers as long as enforceable contracts cannot be made contingent on workers' productivity. Other things being equal, however, information asymmetry does make the use of up-or-out contracts more advantageous vis-a-vis spot contracts.

[4] Note that tenure at universities is a separate issue. See Carmichael (1988) for an interesting explanation of tenure.

[5] The separation is typically involuntary. Some features of up-or-out contracts are similar to those of efficiency wage contracts in the efficiency wage literature (see Weiss 1990 for a review). One difference is that we deal with workers' investment rather than their effort. Our results suggest that efficiency wage may not be efficient when there is job matching uncertainty.

[6] Two theories have very similar implications for job tenure and wage profiles when contractual forms are not considered (see Mortensen 1988).

The plan for the paper is as follows. The model is laid out in Section 2. Sections 3 studies the contractual choice when there is no matching uncertainty and section 4 studies the case with uncertainty. The relationship between human capital investment and labor turnover is considered in Section 5. Section 6 relates our results to empirical evidence. Section 7 concludes the paper.

2. THE MODEL

2.1. Technology and Preferences

There are three dates: $t = 0, 1$, and 2. At $t = 0$, firms and new workers sign employment contracts. During the period from $t = 0$ to $t = 1$, new workers each make a human capital investment, h, which becomes productive in the next period (period between $t = 1$ and $t = 2$). The cost of the investment is $c(h)$, which is strictly increasing and convex with $c'(0) = 0$. If the worker stays with the same employer, his productivities in the two periods are, respectively,

$$x_1 = m + \xi, \quad \text{and} \quad x_2 = h + m + \xi,[7]$$

where ξ represents the quality of match between the firm and the worker and m is the worker's average productivity. The random variable ξ is symmetrically distributed around 0. Its realization is the same for both periods. Without loss of generality we assume that $m = 0$.

The worker can change employer after x_1 is realized. If this happens, his productivity with the new employer will be

$$y = \delta h + \psi.$$

Here the exogenously given δ measures the value of the worker's human capital to the new firm. The greater the value of δ , the more general is the worker's human capital. The random variable ψ measures the quality of the new match. It has a zero mean and is independent of ξ.

The worker is paid a wage at $t = 1$ and at $t = 2$. To abstract from risk sharing considerations, the worker is assumed to be risk-neutral and maximizes net income $E[w_1 + w_2] - c(h)$. The determination of the wage income w_1 and w_2 will be discussed below.

The firms will choose an employment contract to maximize expected profit subject to the constraint that the expected utility of a new worker is no less than u, where u is exogenously given and represents the best opportunity a new worker can obtain elsewhere.

[7] Allowing the investment h to be productive at $t = 1$ (in addition to at $t = 2$) would not change the nature of our results.

2.2. Information Structure

It is assumed that the components of a worker's productivity, h and ξ , cannot be verified by a benevolent court that enforces the contract. The idea is that even though accounting mechanisms can verify the firm's aggregate profit, it is very costly for outsiders to assess an individual worker's contribution.

We consider two different cases for the information structure between a worker's current and potential employers. In the case of asymmetric information, we assume only the worker's current employer can observe h.[8] Alternatively, in the case of symmetric information, both the worker's current and potential employers can observe h as in Harris and Holmstrom (1982). The importance of considering these two cases is that in many labor markets the situation often falls between these two extremes. For example, in the market for professors, publications may serve as a good but somewhat noisy signal of a worker's human capital investment. We will show that the tradeoff between human capital investment and matching quality determines the choice of contracting form in both cases. Thus the same is likely to hold in intermediate cases.[9]

2.3. Feasible Contracts

Since h, x_1 and x_2 are not verifiable, contracts cannot be made contingent on them. In particular, the first period wage w_1 has to be constant. Spot and up-or-out contracts, however, differ in the way the second period wage w_2 is determined. The spot contracting is an arrangement in which the worker receives a constant w_1 as the first period wage, and then bargains with the firm at $t = 1$ about second period wage w_2. We assume the Nash bargaining solution is used. The disagreement points are represented by the firm receiving zero profit and the worker receiving w_0, where w_0 is the wage the worker can obtain from the labor market. According to the Nash bargaining solution,

$$w_2 = \begin{cases} (x_2 + w_0)/2 & \text{if} \quad x_2 \geq w_0, \\ w_0 & \text{if} \quad x_2 < w_0. \end{cases} \tag{1}$$

[8]This assumption is in the spirit of Waldman (1984), Greenwald (1986), Lazear (1986), Milgrom and Oster (1987), Kahn and Huberman (1988), Waldman (1990), and Gibbons and Katz (1991).

[9]Kahn and Huberman (1988) assume that the employer has private information about the worker's productivity. Waldman (1990) assumes asymmetric information between the worker's current and potential employers regarding the worker's productivity. In Case B we assume that neither of these asymmetries exist. This implies that the key reason for the up-or-out rule is that wages cannot be tied to human capital investment or productivity. The asymmetric information problems in the cited works are special cases.

When other firms can observe h, $w_0 = \delta h$ is the worker's expected productivity when he leaves his current firm. When other firms cannot observe h, w_0 is equal to δh^c, where h^c is the outsiders' conjecture about the worker's choice of h (in equilibrium, the conjecture will be correct).

Note that the spot contracting will always yield efficient separation. That is, the worker will leave the firm if and only if his second period productivity is lower than the outside wage offer w_0.

Alternatively an up-or-out contract can be adopted. An up-or-out contract is an arrangement in which the firm pays the worker w_1 in the first period. In the second period, the firm will either retain the worker and pay him w, or fire the worker. The worker, if fired, will get w_0 from the market. The worker's second period wage is thus

$$w_2 = \begin{cases} w & \text{if} \quad x_2 \geq w \\ w_0 & \text{if} \quad x_2 < w. \end{cases} \tag{2}$$

Note that unless $w = w_0$, the separation is not efficient. The firm's problem is to maximize its expected profit subject to two constraints. One is the worker's incentive compatibility constraint: the worker chooses h to maximize his expected utility. The other is the worker's participation constraint, $w_1 + E[w_2] - c(h) \geq u$. Note that the participation constraint is always binding because w_1 can always be reduced to increase the profit. When $w_1 + E[w_2] - c(h) = u$ is substituted into the firm's expected profit, it becomes the total expected social surplus minus u. That is, the firm bears all the efficiency loss.

When an up-or-out contract is used, the choice variables are w and h (w_1 and w_2 disappear after substituting in the binding participation constraint). The firm's optimization problem is

$$\begin{aligned} &\max_{w,h} \int_{w-h}^{\infty} [h+\xi]dF(\xi) + F(w-h)w_0 - c(h) - u \\ &\text{s.t.} \quad h \in \text{Argmax}_{h'} [1 - F(w-h')]w + F(w-h')w_0 - c(h'). \end{aligned} \tag{3}$$

When a spot contract is used, the choice variable is h. The optimization problem becomes

$$\begin{aligned} &\max_{h} \int_{w_0-h}^{\infty} [h+\xi]dF(\xi) + F(w_0-h)w_0 - c(h) - u \\ &\text{s.t.} \quad h \in \text{Argmax}_{h'} \textstyle\int_{w_0-h'}^{\infty} [(h'+\xi+w_0)/2]dF(\xi) + F(w_0-h')w_0 - c(h'). \end{aligned} \tag{4}$$

In the case of symmetric information, $w_0 = \delta h$. That is, the worker's choice of h directly affects w_0. In the case of asymmetric information, $w_0 = \delta h^c$. That is, the worker takes w_0 as given in choosing h.

3. OPTIMAL CONTRACT WHEN POTENTIAL EMPLOYERS CAN OBSERVE *H*

When potential employers can observe h, the outside wage offer will depend on the actual $h, w_0 = \delta h$. Denote by h^* the first best investment level. That is, h^* satisfies $c'(h^*) = 1$.

Consider the simple case in which the matching uncertainty is absent. Then the first best h^* can be achieved by adopting an up-or-out contract which specifies $w = h^*$. If the worker chooses any h less than h^*, he will be out of the firm and receive $\delta h - c(h)$. Since $\delta h - c(h) \leq h - c(h) \leq h^* - c(h^*)$, the worker is worse off by choosing $h < h^*$. It is obvious that the worker will not choose $h > h^*$ either. When the spot contract is used, the worker's wage at date 2 becomes $(1+\delta)h/2$ according to (1). The worker's optimal h is characterized by equating marginal benefit with marginal cost,

$$(1+\delta)/2 = c'(h). \tag{5}$$

The investment level is less than the first best unless $\delta = 1$. The idea is that as long as human capital is partially specific ($\delta < 1$), the worker will be "held-up" to some extent by the firm. Anticipating this holdup problem, the worker will underinvest. The worker will not worry about possible holdup by the firm and will invest the first best h^* only if $\delta = 1$. Hence we have

PROPOSITION 1. *When matching uncertainty is absent and the worker's potential employers can observe h, the up-or-out contract Pareto-dominates the spot contract when $\delta < 1$. When $\delta = 1$, the two contracts are equally efficient.*

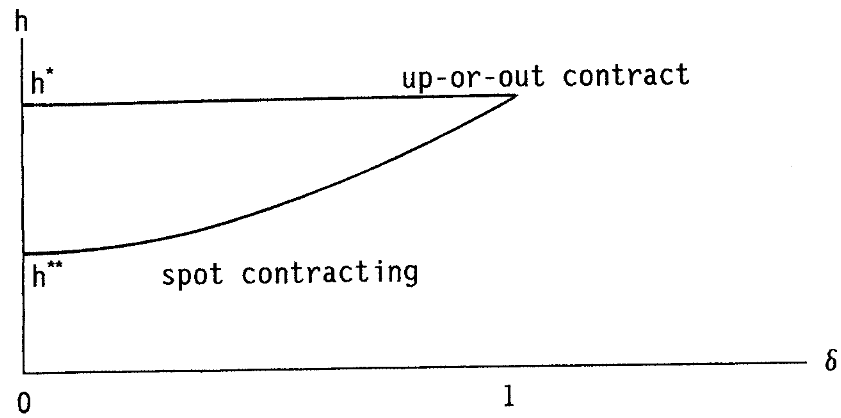
Proposition 1 is illustrated in Figure 1.

When matching uncertainty is present, choosing the optimal choice needs to consider the tradeoff between the efficiency in human capital investment and that in job matching. Given matching uncertainty, the higher the return on human capital, or, equivalently, the lower the cost of investment, the greater is the gain of more human capital investment induced by the up-or-out contract.[10] We thus have[11]

[10] The norm we use to measure the magnitude of the marginal cost function is the uniform norm, i.e., the maximum value of the marginal cost function in the relevant interval.

[11] Although Proposition 2 is intuitive, its proof is not trivial. When the cost is sufficiently large, the up-or-out contract may converge to the spot contract, making the comparison difficult. What is needed is to show that if the investment level under the up-or-out contract is higher than that under the spot contract (otherwise the spot contract is certainly superior), the loss due to inefficient separation must be higher than a posi-

FIG. 1.



PROPOSITION 2. *Suppose that $\delta < 1$ and that $f(\xi)$ is given and has a finite support. When the return on investment is sufficiently high, or cost of it sufficiently low, the up-or-out contract Pareto dominates the spot contract. Otherwise, spot contract is more efficient.*

Similarly, given the return on and the cost of investment, the magnitude of matching uncertainty will determine whether the up-or-out or spot contract is more efficient. The idea is given in Proposition 3 below.[12]

PROPOSITION 3. *Suppose that $\delta < 1$, ξ is bell-shaped,[13] and there exists a unique solution to the worker's maximization problem. The up-or-out contract Pareto- dominates the spot contract when matching uncertainty is sufficiently small (in the sense of ξ converging to 0 in probability).*

Although our results above require that the matching uncertainty or the marginal cost of investment be sufficiently high or low, the conditions need not be stringent. Proposition 4 gives an example with $c(h) = ch^2/2$ and ξ uniformly distributed in $[-b, b]$. In the example, the parameter c measures

tive constant. This positive loss will outweigh the gain due to more efficient investment, which approaches zero as the cost of investment increases.

[12]We know that when $\delta < 1$ and matching uncertainty is absent, the up-or-out contract is more efficient than the spot contract. It is intuitively plausible that the result should hold when the matching uncertainty is small. The formal proof shows that as converging to 0 in probability, the discontinuity does not change the result obtained under the assumption of no matching uncertainty.

[13]Although the assumption that ξ is bell-shaped is used in the proof, we suspect that it is probably not necessary.

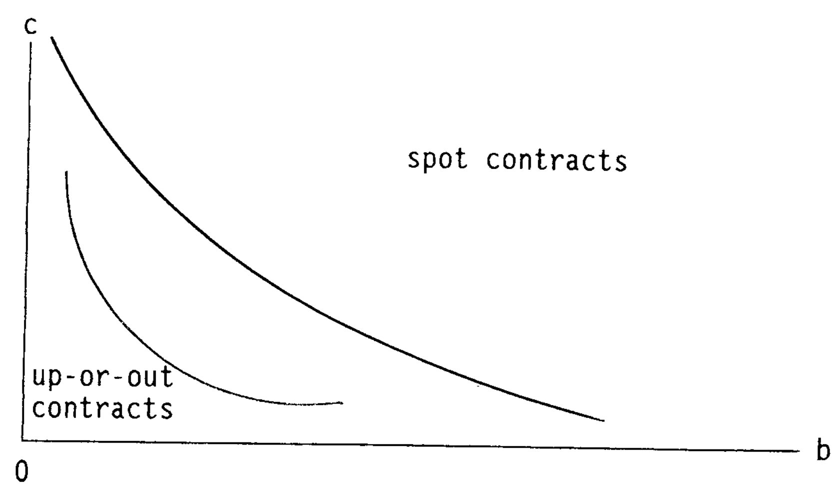
the importance of human capital investment. The lower it is, the higher the return (the more important) human capital is. The parameter b measures the uncertainty of a job match.

PROPOSITION 4. *Suppose that ξ is uniformly distributed in $[-b, b]$ and $c(h) = ch^2/2$. The up-or-out contract Pareto-dominates the spot contract when $bc < (1-\delta)^2/4$. The converse is true when $b^2c^2 > 0.5$.*

As one can see, in the inequalities that give the optimal contracting form, b and c play very similar roles, suggesting that we should understand the effect of b on contract choice in relative terms with c, and vice versa. One might have noticed that this idea is also in Propositions 2 and 3.

Proposition 4 is illustrated in Figure 2 below.

FIG. 2.



4. THE OPTIMAL CONTRACT WHEN POTENTIAL EMPLOYERS CANNOT OBSERVE *H*

Under asymmetric information, the market wage the worker will receive upon leaving the firm is $w_0 = \delta h^c$, where h^c is the market's conjecture of the worker's choice of h. Suppose that w is offered as the "up" wage. If the worker wants to stay and receive w, he can choose $h = w$. Because there is no uncertainty, the worker's productivity will be h, leaving the firm with no incentive to fire him. The worker's payoff is $w_1 + h - c(h)$. Alternatively, the worker can also choose $h = 0$ and receive $w_1 + \delta h^c$.

Define δ_1 by $h^* - c(h^*) = \delta_1 h^*$. The variable δ_1 is the δ that makes the worker indifferent between choosing $h = h^*$ (thus staying with the firm and receiving $w = h^*$ at $t = 2$) and choosing $h = 0$ (thus leaving the firm and receiving δh^* at $t = 2$). If δ is less than δ_1, the worker has incentive to choose h^*. If δ is greater than δ_1, the maximum h the worker will choose without cheating (i.e., choosing $h = 0$ and leaving the firm at $t = 2$) is the one that satisfies

$$h - c(h) = \delta h. \tag{6}$$

Denote by $h(\delta)$ the solution to (6) for a given δ.[14] Letting $w = h(\delta)$, the worker's response is to choose $h(\delta)$. It can be verified that as δ approaches 1, $h(\delta)$ falls to 0.

However, the pure strategy $h(\delta), \delta > \delta_1$, cannot be a stable equilibrium. The reason is that if the worker invests h and the market believes it, then the worker is better off by not investing. Potential employers in the market will rationally anticipate this and pay a market wage of $w = 0$ for those who change jobs. Given this market wage, the worker is better off by investing in h to raise productivity so that he will have a better chance to stay with the same employer and receive a higher wage in the second period.

We thus seek to find a mixed strategy equilibrium. A mixed strategy equilibrium is one in which potential employers conjecture that the worker invested h^* with probability π^u and $h = 0$ with probability $1 - \pi^u$, where π^u is the solution of

$$h^* - c(h^*) = \delta \pi^u h^*. \tag{7}$$

Equation (7) states that the worker is indifferent between choosing $h = h^*$ and $h = 0$ (thus leaving the firm and receiving $w_0 = \delta \pi^u h^*$). Under this condition, the worker is willing to randomize and potential employers' conjecture is correct.

It can be shown that the expected investment in this mixed strategy equilibrium, $\pi^u h^*$, is higher than the investment level in the pure strategy equilibrium defined by (6) when $\delta > \delta_1$.

PROPOSITION 5. *When the worker's potential employers cannot observe h, the "up" wage w in the optimal up-or-out contract is as follows: $w = h^*$. The worker chooses h^* if $\delta \leq \delta_1$. If $\delta > \delta_1$, the worker chooses h^* with probability π^u and 0 with probability $1 - \pi^u$.*

It is interesting to note that while in the pure strategy equilibrium there is actually no "out", in the mixed strategy equilibrium the worker will leave the firm with a positive probability even though matching uncertainty is absent.

[14] Note that, given our assumptions about $c(h)$, there is a unique solution.

Now consider the spot contract. From (1), we know that the worker will receive $w_1 + (h + w_0)/2 - c(h)$ if he chooses h. If he cheats (chooses $h = 0$ and leaves the firm), the worker can receive $w_1 + \delta h^c$. An equilibrium is one in which given the market's conjecture h^c, the worker's optimal choice of h equals h^c. Given the objective function, $w_1 + (h + w_0)/2 - c(h)$, the worker's optimal choice of h is characterized by the first order condition

$$0.5 - c'(h) = 0. \tag{8}$$

We will denote by h^{**} the solution of equation (8). For h^{**} to be an equilibrium, the worker must have no incentive to cheat. That is, $w_1 + (h + w_0)/2 - c(h) \geq w_1 + w_0$. When the market's conjecture is correct, $h^c = h^{**}$ and $w_0 = \delta h^{**}$. No cheating requires

$$(1 + \delta)h^{**}/2 - c(h^{**}) \geq \delta h^{**}. \tag{9}$$

Denote by δ_2 the highest δ that satisfies (9). That is, δ_2 is the δ that makes the worker indifferent between choosing $h = h^{**}$ and cheating when the spot contract is used.

If $\delta > \delta_2$, it can be shown that there is no pure strategy equilibrium. That is because for any w_0, the worker's optimal choice is either h^{**} or 0. If he chooses h^{**} and the market believes it, the worker then has incentive to choose 0, for (9) is violated when $\delta > \delta_2$. If he chooses 0 and the market believes it, he has incentive to choose h^{**}. Thus, when $\delta > \delta_2$, an equilibrium can only be in randomized strategies. Suppose that the market conjectures that the worker chooses h^{**} with probability π^s and chooses 0 with probability $1 - \pi^s$, where π^s is the solution of

$$(1 + \delta)h^{**}/2 - c(h^{**}) = \delta \pi^s h^{**}. \tag{10}$$

Equation (10) states that the worker is indifferent between choosing h^{**} (hence receiving $(1 + \delta)h^{**}/2 - c(h^{**})$) and choosing 0 (hence leaving the firm and receiving $\delta \pi^s h^{**}$). Thus, the worker is willing to randomize and the market's conjecture is correct.

PROPOSITION 6. *When potential employers cannot observe h, the optimal spot contract leads to investment $h = h^{**}$ for $\delta \leq \delta_2$. For $\delta > \delta_2$, only a mixed strategy equilibrium exists in which $h = h^{**}$ with probability π^s and $h = 0$ with probability $1 - \pi^s$.*

Since the efficiency is determined solely by the investment level when matching uncertainty is absent, we have

PROPOSITION 7. *The up-or-out contract Pareto-dominates the spot contract when there is no matching uncertainty and when potential employers cannot observe the worker's choice of h.*

Note that the results of Proposition 7 and Proposition 1, which are derived under asymmetric and symmetric information, respectively, are qualitatively the same. This result is not too surprising. In a spot contract the firm does not commit to a future wage and will share the gain of investment with the worker in the second period, as long as $\delta < 1$. This leads to the inefficiency of underinvestment. The key reason that the firm can hold up the worker is that, when human capital is not completely general, the worker cannot change employer without a loss. Although asymmetric information does quantitatively affect the magnitude of the loss when the worker changes an employer and hence his bargaining power and the division of the yield of the investment, it does not qualitatively affect the holdup problem that leads to underinvestment.

For the same reason, the results of Propositions 2 though 4, which deals with situations when matching uncertainty is present, also hold under asymmetric information. In fact, the proofs of these propositions in the Appendix have considered both cases.

5. LABOR TURNOVER UNDER UP-OR-OUT RULE

A central proposition of the traditional human capital theory is that labor turnover is negatively related with the amount of human capital when the human capital is firm-specific and is independent of the amount of human capital if the human capital is general. (See Becker 1975.) This proposition has been the subject of many empirical tests. One issue that has not been adequately studied, however, is how a contractual form may affect the relationship between human capital and labor turnover. Here we use an example to show that, under the up-or-out rule, the relationship between human capital investment and labor turnover can be positive.[15]

As in Proposition 6, assume that $c(h) = ch^2/2$ and ξ is uniformly distributed in $[-b, b]$. Assume also that potential employers cannot observe h (asymmetric information) and human capital is general ($\delta = 1$). Under these assumptions, the optimal investment and the optimal wage under an up-or-out contract are, respectively,

$$h = 1/[4bc^2 + 2c], \quad \text{and} \quad w = 1/(2c). \tag{11}$$

The labor turnover rate is

$$F(w - h) = 0.5 + 1/(2 + 4bc). \tag{12}$$

[15] Becker (1975, p.34) observes that long term contracting tends to increase human capital investment and reduce the turnover rate. Compared with spot contracts, up-or-out contracts increase both investment and turnover.

Since both human capital investment and turnover are endogenous variables, their relationship can only be described by exogenous variables such as b and c change. From (11) and (12) it is easy to see that as b or c increases, both h and $F(w-h)$ decrease, inducing a positive relationship between h and $F(w-h)$.[16] We have proven

PROPOSITION 8. *Under the up-or-out rule, the "up" wage w, the human capital investment h, and the turnover rate all increase (decrease) as matching uncertainty or the cost of investment decreases (increases), for any value of δ.*

It is easy to understand that the optimal "up" wage w and the optimal investment h will increase as b or c decreases. To see why turnover will increase, notice that changes in w and h have opposite effects on turnover: a higher h reduces turnover because it leads to a higher productivity, but a higher w increases turnover because it means a higher standard. Thus the prediction that turnover decreases in human capital as long as human capital is partially firm specific is no longer automatically true. The equilibrium turnover rate depends on which one of the two effects is stronger. It turns out that with a uniform distribution and a quadratic cost function, the effect of a higher w dominates that of a higher h so that turnover is actually positively associated with human capital investment.

The above example assumes that human capital is general ($\delta = 1$). It is easier to obtain a positive relationship between human capital and turnover under the assumption. However, when human capital is firm-specific, the relationship can still be positive. A simple way to see this is to look at equation (6). There, both the expected human capital investment level $\pi^u h^* = [h^* - c(h^*)]/\delta$ and the turnover rate $1 - \pi^u$ are decreasing in δ (strictly for $\delta > \delta_1$). Thus, a change in δ will cause human capital investment and turnover to change in the same direction.

6. SOME EMPIRICAL OBSERVATIONS

The results obtained from the model can explain many commonly observed important and somewhat puzzling labor market phenomena. A few examples are given

6.1. Turnover of junior university professors

[16] Of course, when b or c is sufficiently high, the spot contract will become optimal. We will no longer observe the relationship under the up-or-out contract. In fact, it can be verified that in this case the up-or-out contract dominates the spot contract if and only if $21 + 4b^2c^2 - 8b(4b^2c^2 + 4bc + 1) - 28bc > 0$.

The result of Proposition 8 seems consistent with the practices of the U.S. universities where up-or-out contracts are common. On average, new hires (assistant professors) at more prestigious universities are considered better researchers, meaning that, in the terminology of this paper, they have a lower investment cost (a smaller c). These universities set higher standards for tenure, i.e., a higher level of compensation for those who are "up". On average, assistant professors at these universities do better in research. Yet they are denied tenure more often than their counterparts in less prestigious schools.

6.2. Contract Variations in Universities

It is interesting to notice that although up-or-out contracts are common in universities, spot market contracts also exist. Our model can predict who should have up-or-out contracts and who should not in universities.

Universities have two primary responsibilities: research and teaching. Research creates new knowledge and teaching passes existing knowledge to students. Teaching involves mainly passing existing knowledge to others, which a new faculty member is supposed to have largely acquired, while research seems to require substantially more new human capital investment. Since new human capital investment is less important for teaching-oriented appointments, our theory predicts that spot contracts should be more commonly used for these than for research-oriented appointments. This is exactly what we observe. At the business school of the University of Minnesota there are currently at least nine full-time faculty positions whose main responsibility is teaching. For these faculty members contracts are renewed annually.

Comparisons can also be made across countries. Research does not seem to be emphasized as much in European or Asian as in U.S. universities. Our theory predicts that up-or-out contracts should be less common in European and Asian universities, which is what we observe.

6.3. Universities Compared with Business Organizations

For faculty appointments with more emphasis on research, human capital investment is obviously very important. At the same time, job matching quality seems relatively unimportant. Learning about co-workers, the boss and how to cooperate with them, which is a key element of matching (Prescott and Visscher 1980), does not seem very critical for a professor's research performance. Even when research collaborations develop among colleagues, they are often preserved when one colleague changes school. Our theory suggests that up-or-out contracts should be widely used for university professors.

Research can also be very important for some industrial firms. However, the commercial success of a research project often requires team efforts of those from basic research, design, production, marketing and many other parts of a company.[17] The team-oriented nature of research projects in business increases the importance of matching quality: how well one fits, communicates, and cooperates with the rest of the company plays a crucial role. Controlling for the importance of human capital investment, our theory predicts that up-or-out contracts should be less common in organizations where coordinated group efforts are essential for productivity because they increase the importance of matching quality. This offers an explanation as why in business firms up-or-out contracts are not as common as in universities.

6.4. Law Firms Moving away from the Up-or-Out Rule

In recent years a large number of corporate law firms have deviated from the traditional up-or-out rule. Numerous new categories, e.g., permanent associate, staff lawyer, special counsel, non-equity partner, and junior partner, have been created in addition to the two traditional categories of associates and partners to accommodate one need: retain those who have completed apprenticeship, proven productive, but do not meet partnership standards. Three major factors seem to explain the new trend: increased demand for associate lawyers, changes in the culture of law firms, and intensified competition.[18]

Increased demand for associates has led law firms to lower their recruiting standards from a given school and also to recruit from less prestigious schools. This leads to a fall in the average quality of the new recruits. (See Gilson and Mnookin, 1988, p.590.) This, in the terminology of this paper, translates to a higher cost of human capital investment. Another effect of expanded recruiting is that, as new hires are from more heterogeneous candidate groups, matching quality becomes more difficult to predict.[19] Neither effect, according to our model, is in favor of continued use of up-or-out contracts.

In the past twenty-five years, individual and family needs have been more emphasized by junior lawyers even if it means reduced compensation. Women lawyers who become mothers often ask to work on a reduced

[17] The examples are numerous. See, for example, New York Times' (September 23, 1992) article on Xerox's team effort to successfully introduce the Model 5100 that led to the revival of the company.

[18] The literature discussing law firms' deviation from the traditional up-or-out rule is surprisingly small. Heintz and Markham-Bugbee (1986) and Gilson and Mnookin (1989), are our primary sources for information. Other factors are also mentioned by these authors which seem to either overlap with or stem from the three factors we listed.

[19] Gilson and Mnookin (1989, p.590) point out that the problem of greater unpredictability is further aggravated by increased chances of mistakes because of the increased burden of evaluation and limited capacity of the partners in a highly subjective evaluation process.

schedule. Paternity leave has been more frequently requested. Also, leaves of absence or other forms of sabbaticals increasingly are being requested. (Heintz and Markham-Bugbee, 1986, p.22.) Such a cultural change means that investing an extra hour to become a more competent lawyer now has a higher opportunity cost than it used to, a factor not in favor of up-or-out contracts according to our theory.

Finally, intensified competition has reduced profit margins of many law firms.[20] This means that lawyers' human capital has become less productive (in terms of net earnings). In competition, the demand for specialists' services has increased. (Heintz and Markham-Bugbee, 1986, p.14 and 16, Gilson and Mnookin, 1989, p.592). A specialist, however, is not always well-positioned, and therefore likely to incur a high cost, to meet other criteria for admission to partnership such as new business development and practice area management capacities.[21] (Heintz and Markham-Bugbee, 1986, p.29.) Also, as more specialists are hired, employers (partners) may find it more difficult, due to their lack of expertise, to evaluate and predict the specialists' productivity. These changes make up-or-out contracts less efficient and therefore less desirable today than they used to be, according to our model.

7. SUMMARY AND CONCLUSION

The efficiency implications of two important forms of labor contracts, up-or-out and spot market contracts, are studied. Our model shows that the choice between these two forms of labor contracts is based on the tradeoff between human capital investment incentives and job matching quality. The model provides a good explanation to a number of important labor market phenomena. It also underscores the importance of understanding the relation between human capital investment and labor turnover in the context of labor contract forms. Specifically, when an up-or-out contract is adopted, human capital investment and turnover can have a positive relationship.

Many employment arrangements such as rank hierarchies and promotion systems seem to combine the elements of the two extreme contracts studied here. We suspect that these arrangements can achieve a better balance

[20] For example, Heintz and Markham-Bugbee (1986, p.15) reports that in the mid-1980s many firms' operating costs increased 40% while revenues increased about only 25%.

[21] Notice this problem suggests that human capital may be a multidimensional concept although this is not explicit in our model. Competition puts more emphasis on multidimensional requirements because when business is good being a good lawyer "was a sufficient contribution to a partnership" and "generating business and managing were not so important." (Heintz and Markham-Bugbee, p.2.)

between the efficiency of investment and the efficiency of job matching. Much more work remains to be done to understand these more complicated arrangements.

APPENDIX

Proof of Proposition 1:
See the text.
Proof of Proposition 2:
1. The case when the cost is sufficiently small. The optimal h under the spot contract is determined by the first-order condition

$$[1 - F(\delta h^s - h^s)]/2 - c'(h^s) = 0. \tag{$a1$}$$

When the marginal cost of investment becomes sufficiently low in (a1), the optimal h will be sufficiently high. When $\delta < 1, \delta h^s - h^s$ will be sufficiently small. Thus, the turnover rate $F(\delta h^s - h^s)$ will be 0.

When the marginal cost of investment is sufficiently small, the investment level h^* determined by $c'(h^*) = 1$ will be sufficiently large so that $f(h) = 0$ for $h \geq h^*$. Now the situation is the same as that without matching uncertainty, according to Propositions 4 and 6, the up-or-out contract is superior.

2. The case when the investment cost is sufficiently large. We first consider the case of asymmetric information. Let w and h^u be the optimal solution to (3). Then w and h^u must satisfy the first-order condition

$$f(w - h^u)(w - \delta h^u) - c'(h^u) = 0. \tag{$a2$}$$

If h^u is less than the h^s defined in (a1), then the spot contract must dominate the up-or-out contract, for the spot contract induces a higher (more efficient) level of investment in addition to inducing a more efficient separation. Thus, we need only to consider the case in which $h^u \geq h^s$. By using equations (a1) and (a2), we have

$$w-h^u = c'(h^u)/(f(w-h^u) \geq c'(h^s)/f(w-h^u) = [1-F(\delta h^s-h^s)]/[2f(w-h^u)].$$

When the marginal cost of investment increases, h^s will be sufficiently small. Thus, $1-F(\delta h^s-h^s)$ will approach $1-F(0) = 0.5$. Since $2f(w-h^u)$ is bounded above, $w-\delta h^u$ is bounded below by a positive constant k when the marginal cost of investment becomes large.

Note that the welfare loss due to inefficient separation under the up-or-out contract is

$$\int_{\delta h^u - h^u}^{w-h^u} \xi dF(\xi)$$

When h^u is sufficiently close to 0, and when $w - \delta h^u \geq k > 0$, the loss is bounded below by a positive constant.

Now compare the levels of investment under the two contracts. When the marginal cost is sufficiently large, the gain from investing even at the first-best level, $h^* - c(h^*)$, will approach 0. Thus, the gain from more efficient investment due to the use to the up-or-out contract also approaches 0.

We have shown that when the up-or-out contract is used, relative to the use of the spot contract, the loss due to inefficient separation is bounded below and the gain from more efficient investment approaches 0 as the marginal cost of investment increases. Therefore, the spot contract dominates the up-or-out contract.

We now consider the case in which potential employers can observe h, the first-order conditions (a1) and (a2) change to, respectively,

$$(1+\delta)[1 - F(\delta h^s - h^s)]/2 + \delta F(\delta h^s - h^s) - c'(h^s) = 0, \qquad (a3)$$

$$f(w - h^u)(w - \delta h^u) + \delta F(w - h^u) - c'(h^u) = 0. \qquad (a4)$$

The proof below follows the same strategy as in the case of asymmetric information: we show that when the up-or-out contract is used, relative to the use of the spot contract, the loss due to inefficient separation is bounded below by a positive number and the gain from more efficient investment approaches 0 as the marginal cost of investment increases. Since the first-order conditions are changed, the only thing we need to show is that $w - \delta h^u$ is bounded below.

Using (a4), (a3) and the fact $h^u \geq h^s$, we have

$$\begin{aligned} w - \delta h^u &= [c'(h^u) - \delta F(w - h^u)]/f(w - h^u) \\ &\geq [c'(h^s) - \delta F(w - h^u)]/f(w - h^u) \\ &= [(1+\delta)[1 - F(\delta h^s - h^s)] - 2\delta(F(w - h^u) \\ &\quad -F(\delta h^s - h^s))]/[2f(w - h^u)]. \end{aligned}$$

Since $F(w - h^u) - F(\delta h^s - h^s) = f(\sigma)(w - h^u - \delta h^s + h^s) \leq f(\sigma)(w - h^u)$ for $h^u \geq h^s$ and for some σ between $\delta h^s - h^s$ and $w - h^u$, we have

$$\begin{aligned} w - \delta h^u &\geq (1+\delta)[1 - F(\delta h^s - h^s)]/[2f(w - h^u)] \\ &\quad -\delta f(\sigma)(w - \delta h^u)/f(w - h^u), \end{aligned}$$

or

$$w - \delta h^u \geq (1+\delta)[1 - F(\delta h^s - h^s)]/[2f(w - h^u) + 2\delta f(\sigma)].$$

Since $f(\xi)$ is bounded above and $F(\delta h^s - h^s)$ approaches 0.5 as the marginal cost of investment increases, $w - \delta h^u$ is again bounded below by a positive constant. The rest of the proof is exactly the same. ▌

Proof of Proposition 3:

We first prove the proposition for case of asymmetric information. The proof follows three steps: 1) we can select an up-or-out contract (not necessarily optimal) that yields a payoff for the firm in the presence of matching uncertainty that is sufficiently close to the optimal payoff without the uncertainty; 2) we show that the firm's payoff under the optimal spot contract will not be changed much when the matching uncertainty is small; 3) since, in the absence of the uncertainty, the up-or-out contract dominates the spot contract, the same conclusion holds when the uncertainty is small.

Step 1: we want to select a w which induces the optimal investment level when the uncertainty is absent in such a way that the firm's payoff does not depart much from the optimal payoff without the uncertainty. Suppose that h_0 is the worker's investment level under the optimal up-or-out contract without the uncertainty. With uncertainty, the w that induces the optimal h_0 is determined by the first order condition of the worker's choice problem

$$f(w-h_0)(w-\delta h_0)=c'(h_0). \tag{$a5$}$$

Our claim is that w is less than h_0 when the uncertainty is sufficiently small. Since $f(w-h_0)$ is bell-shaped and $w-\delta h_0$ is increasing in w, equation (a5) can have at most two solutions. The second order condition implies that only the lower w that solves (a5) can induce the optimal h_0 (the lower solution always exists). Note that $f(w-h_0)$ achieves its maximum at $w=h_0$. When the uncertainty is small, $f(0)$ will be large because $f(\xi)$ is bell-shaped. The left-hand side of (a5) can also be made higher than $c'(h_0)$ when $w=h_0$. Thus, the lower w that solves (a5) must be less than h_0.

When the worker's investment is h_0 and when $w<h_0$, the firm's payoff is

$$\int_{w-h_0}^{\infty}[h_0+\xi]dF(\xi)+F(w-h_0)\delta h_0-c(h_0)-u,$$

which converges to $v_0=h_0-c(h_0)-u$, the firm's payoff in the absence of the matching uncertainty, as ξ converges to 0 in probability.

Step 2: we want to show that with the matching uncertainty the firm's payoff under the optimal spot contract converges to the firm's payoff without the uncertainty as ξ converges to 0 in probability. Since the worker's utility is continuous in the distribution of ξ and since the optimal solution, h, to the worker's optimization problem is single valued, h is continuous in the distribution of ξ by the Maximum Principle. Since the firm's payoff function in (4) is continuous in h and in the distribution of ξ , it is continuous in the distribution function of ξ .

Step 3: we have shown above that the firm's payoff under an up-or-out contract, call it U, is sufficiently close to v_0. We have also shown that the firm's payoff under the optimal spot contract is continuous in the distribution of ξ. Since, in the absence of the matching uncertainty, the firm's payoff under the up-or-out contract is higher than that under the spot contract, the firm's payoff under the contract U is higher than that under the optimal spot contract when the uncertainty is small. The firm's payoff under the optimal up-or-out contract, which is no lower than that under contract U, must also be higher than that under the optimal spot contract.

The proof for the case of symmetric information is similar. The only difference is that the worker's first order condition contains an extra term, $\delta F(w-h_0)$, on the left-hand side of (a5). Since $\delta F(w-h_0)$ is increasing in w, the same arguments used above still go through. The proof for the continuity of the firm's payoff function under the spot contract is exactly the same. ▮

Proof of Proposition 4:

By solving (a3) with uniform $F(\xi)$ and quadratic $c(h)$, we have $h^s=(1+\delta)/(2c)$ if $bc \le (1-\delta)^2/4$, and $h^s=(1+3\delta)b/[4bc-(1-\delta)^2]$ otherwise. By solving problem (3) and simplifying, we have $h^u=1/c$ if $bc\le(1-\delta)/3$ and $h^u=[b(1+\delta)(1+2\delta)+2b\delta(\delta+bc)]/[(1+\delta)^2(2bc+2\delta-1)+4(\delta+bc)(bc-\delta^2)]$ otherwise.

Since the spot contract induces more efficient turnover, it will dominate the up-or-out contract if $h^s \ge h^u$. After simplifying, $h^s\ge h^u$ is equivalent to

$$2(1-\delta)b^2c^2+(10\delta^3+5\delta^2+2\delta-1)bc-(1-\delta-\delta^2+\delta^3)\delta \ge 0. \qquad (a6)$$

It is easy to show that (a6) holds when $b^2c^2\ge 0.5$.

Since $bc<(1-\delta)^2/4$ implies $bc\le(1-\delta)/3$, we have $h^s=(1+\delta)/(2c)$ and $h^u=1/c$. In this case there will be no turnover no matter which contract is used. Thus, the up-or-out contract that induces the first best h is optimal. ▮

Proof of Proposition 5:

When w is offered as the "up" wage, the worker will either choose $h=w$ or $h=0$. That is because by choosing any h higher than w, he will not receive a wage higher than w. On the other hand, by choosing any h below w but higher than 0, he will leave the firm and always receive δw from potential employers (δw is the wage they will offer when they believe $h=w$ is chosen). Thus, possible equilibria consist of only two choices of $h: w$ or 0.

By plotting $c(h)$ and $(1-\delta)h$, it is easy to see that equation (5) has only two solutions when $\delta<1$. One is $h=0$ and the other is $h=h(\delta)$. $w=h=0$ is obviously not optimal. Thus, $w=h(\delta)$ is the optimal pure strategy equilibrium. A mixed strategy equilibrium has to satisfy (6). It is easy to see that the solution to (6) is unique. Thus, there is a unique mixed strategy equilibrium.

Since the return under the first best is the highest, we have for all $h \neq h^*$, $h - c(h) \leq h^* - c(h^*)$. By (5) and (6), this implies that $h(\delta) < \pi^u h^*$ because $h(\delta) < h^*$ for $\delta > \delta_1$. That is, the expected investment in the mixed strategy equilibrium is higher than that in the pure strategy equilibrium. Thus, it is optimal for $\delta > \delta_1$. ▮

Proof of Proposition 6:

From the worker's objective function $w_1 + (h + w_0)/2 - c(h)$, it is easy to see that the worker will either choose $h = h^{**}$ or $h = 0$. Even when the worker has no incentive to cheat (choose $h = 0$ and get δh^c from new employers), due to the expost hold-up problem, the highest h the worker is willing to choose is h^{**} determined by (7). Since δ_2 defined by (8) is the δ at which the worker is indifferent between choosing $h = h^{**}$ and choosing $h = 0$, for $\delta > \delta_2$ choosing h^{**} will violate the incentive constraint (8). Thus, $h = h^{**}$ cannot be an equilibrium. At the same time $h = 0$ clearly is not an equilibrium. The solution for (9) is unique. Thus, there is a unique mixed strategy equilibrium for $\delta > \delta_2$. ▮

Proof of Proposition 7:

By (6) and (9), we have $\delta \pi^u h^* = h^* - c(h^*) > h^{**} - c(h^{**}) \geq (1 + \delta) h^{**}/2 - c(h^{**}) = \delta \pi^s h^{**}$. Thus, the expected return is higher under the up-or-out contract. ▮

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