# Up-or-Out Contracts: A Signaling Perspective

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A firm will typically gather information concerning its own workers that is not available to other potential employers, while other firms will attempt to reduce this information asymmetry by observing the actions of the initial employer. I argue that this process can be important in environments characterized by up-or-out contracts in that the retention decision can serve as a signal of productivity. The article investigates this argument in an environment where up-or-out contracts are employed because they provide workers with an incentive to accumulate general human capital and where learning takes place in a diffuse fashion.

## I. Introduction

Numerous labor market contracts can be characterized as "up-or-out" contracts. That is, if a worker is not promoted within some fixed interval of time, the worker must be fired. Examples of labor market settings char-

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acterized by such contracts include the academic environment and a variety of other professional employment settings such as law partnerships. This article considers environments characterized by up-or-out contracts and focuses on the potential role that signaling can play when up-or-out contracts are present.

In labor market settings it is typical that, during an individual's working lifetime, information about his productivity will gradually be revealed to firms in the economy. Most early studies that considered this issue assume either that the information is revealed in a public manner (see, e.g., Ross, Taubman, and Wachter 1981, Harris and Holmstrom 1982, and MacDonald 1982) or that the information is revealed only to the firm employing the worker (see, e.g., Prescott and Visscher 1980). More recently, however, attention has focused on an intermediate and more realistic case. That is, the initial employer gathers information concerning its own workers that is not directly available to other potential employers, but other firms observe the actions of the initial employer and in this way reduce the information asymmetry between the firms. For example, Waldman (1984*a*) and Ricart i Costa (1988) consider how other firms can partially infer a worker's productivity by considering his task assignment (see also the related work of Milgrom and Oster [1987]).[1]

This article argues that a similar process can be important in environments characterized by up-or-out contracts. The logic is that the retention decision serves as a signal of a worker's productivity and thus helps reduce the information asymmetry between the firms. I investigate the implications of this argument in an environment where up-or-out contracts are employed because they provide the worker with an incentive to accumulate general human capital and where learning about worker productivities takes place in a diffuse fashion. By the latter I mean that, for any specific worker, both the initial employer and other potential employers receive some direct information concerning the worker's productivity.[2]

The major finding of this article concerns the wage-setting process for those workers who are retained. Despite the fact that, as in Kahn and Huberman (1988), the up-or-out contract is employed in order to increase

[1] Other related papers include Greenwald (1986), Laing (1987), Borland and Prendergast (1988), Mori (1988), Novos (1988), Prendergast (1988), and Bernhardt (1989). See also Gibbons and Katz (1989) for interesting empirical support for the approach.

[2] In recent papers, Laing (1987) and Gibbons and Katz (1989) also consider signaling aspects of the retention decision. However, their papers focus on issues that are quite different than the issue under consideration here. Rather than considering the implications of this type of signaling in environments characterized by up-or-out contracts, Laing demonstrates how this type of signaling can lead to involuntary layoffs in a standard implicit-contract model, while Gibbons and Katz focus on what signaling suggests concerning the differences between layoffs and plant closings.

the expected wage of those workers who are retained, the actual retention wage specified in the contract is quite low. What drives this result is that, because of the diffuse fashion in which learning takes place, when retaining a worker the initial employer faces a winner's-curse-type problem that forces the firm to set a low retention wage. The final outcome is that for most workers who are retained the actual retention wage paid is determined by the bidding of other potential employers. In other words, I provide a potential explanation for the common occurrence in academia that achieving tenure contains no direct guarantee of a significant salary increase. Rather, much of the importance of clearing the hurdle is the signal that is sent and the bidding by other firms which ensues.

Before proceeding, I would like to discuss briefly the relationship between my analysis and that of Lazear (1986). To my knowledge, Lazear's paper contains the only previous analysis in which learning about a worker's productivity takes place in the type of diffuse fashion considered here. The result is that the two analyses share a number of common features. For example, in both analyses the initial employer infers some information about a worker's productivity by considering the wage offers (or lack thereof) made by other potential employers. The result is a type of "stigma" attached to retained workers who receive no outside offer, that is, such workers do worse than workers who look similar to the initial employer but who have an active outside market. There are, however, some important differences between the analyses. First, in Lazear's analysis there is no action taken by the initial employer between the time he receives information concerning a worker's productivity and the time other firms begin to bid for the worker's services. Hence, the type of signaling that is a central element here is not a feature of Lazear's analysis. Second, I consider a 2-period model while Lazear considers a single-period specification. The result is that the base or initial retention wage is determined in different fashions in the two papers. In Lazear's analysis the wage satisfies a zero-profit condition, while here it is a response to the strategic interaction between the firms in the second period.

## II. Kahn and Huberman (1988)

I begin by discussing the analysis of Kahn and Huberman (1988) that is also concerned with why firms might offer up-or-out contracts.[3] Kahn and Huberman define an up-or-out contract as a contract that satisfies two conditions. First, the contract is such that if a worker is not promoted within some fixed interval of time, the worker must be fired. Second, the

[3] O'Flaherty and Siow (1989) have also recently considered up-or-out contracts. Their model is based on a positive opportunity cost of filling a "job slot" with a low-ability old worker due to a potential return from screening an additional young worker. As will become clear shortly, their argument is quite different than the argument of either Kahn and Huberman or of the current paper (see also the related analysis of Carmichael [1988]).

contract specifies the wage the worker will receive if he is retained. Given this definition, they show that such a contract may be used to overcome a potential moral-hazard problem. The logic is as follows. Suppose the worker has the opportunity to invest in specific human capital, where the level of investment is not publicly observable—but the firm does get to observe privately the worker's postinvestment productivity. If the worker were to sign a contract that did not include the possibility of the worker being fired but, rather, specified that the worker could be retained at either a high wage or a low wage, then a problem would arise. With this contract the firm would always have an incentive to claim that the worker was of low productivity and hence deserved the lower retention wage. In turn, this moral-hazard problem on the part of the firm would then eliminate any incentive for the worker to invest in specific capital. In contrast, suppose the worker were to sign an up-or-out contract. The firm could now provide the worker with an incentive to invest in specific capital by setting the retention wage above the worker's opportunity cost. The reason the above moral-hazard problem is no longer an issue is that, given an up-or-out contract, the firm will not have an incentive to always claim that the worker is of low productivity because the firm does not retain the services of low-productivity workers.

My analysis accomplishes two things. First, as a preliminary result, it shows that Kahn and Huberman's explanation for the use of up-or-out contracts is equally valid in a world where human capital is general rather than specific. The logic here is that, in an environment where human capital is general, but information is private, then to some extent it is as if the human capital were specific. What this suggests is that the Kahn and Huberman argument may be important in understanding up-or-out contracts in the academic setting since the bulk of human capital in that case would appear to be general in nature. Second, I consider the general human capital case under the assumption, which seems quite realistic for the academic market, that learning takes place in a diffuse fashion, that is, for each worker, both the initial employer and other potential employers receive some direct information concerning the worker's productivity. As discussed in Section I, despite the fact that up-or-out contracts are employed in order to increase the expected wage of those workers who are retained, what is found here is that the retention wage specified in the contract is quite low. The result is that much of the return of being retained can turn out to be not the direct salary increase but rather the sending of a positive signal and the bidding by other firms that ensues.

## III. Up-or-Out Contracts and the Accumulation of General Human Capital

### A. The Model

In Section III, I derive the preliminary result that a slight variation of Kahn and Huberman's original story results in the emergence of up-or-out contracts in an environment where workers accumulate general rather than specific human capital. The description of the model follows. Within the economy there is only one good produced, and the price of this good is normalized to one. Workers live for 2 periods, and in each period labor supply is perfectly inelastic and fixed at 1 unit for each worker. During their first period of employment, workers will be referred to as young, while workers who are in their second period of employment will be referred to as old. A young worker produces an amount $X$, and while young the worker accumulates general human capital. It is further assumed that the amount accumulated depends on the worker's investment in human capital, where the worker's choice of an investment level is private information to the worker. The worker can make one of two choices. He can invest zero in the accumulation of human capital, in which case his productivity when old equals $X + G$ with probability $q$ and $X + F$ with probability $(1 - q)$, where $G > F$. Alternatively, he can invest an amount $I$, in which case his productivity when old equals $X + G$ with probability $p$ and $X + F$ with probability $(1 - p)$, where $p > q$. It is assumed that $(p - q)(G - F) > I$, that is, investing is socially efficient. Also, only the first-period employer gets to observe the realization of a worker's second-period productivity, and this observation takes place at the end of the first period.[4]

It is assumed that workers and firms are risk neutral and have a zero rate of discount. Hence, when coming into the labor market, a young worker will attempt to maximize his expected lifetime income minus any cost incurred in the accumulation of human capital. In the analysis two types of contracts are considered—an up-or-out contract and what will be referred to as a standard spot-market contract. I will begin by describing the latter. A standard spot-market contract simply specifies the wage the worker will receive while young, denoted $W^Y$. If a worker accepts a standard spot-market contract, then the worker's second-period wage and firm are determined by the following process. Following Greenwald (1986), Lazear (1986), and Milgrom and Oster (1987), it is assumed that this is an environment where the first-period employer can make counteroffers. That is, at the end of the first period, firms other than the initial employer have an opportunity to make wage offers. This is then followed by the first-period employer having an opportunity to make counteroffers. Fur-

[4] The assumptions that there are only two investment levels and that there are only two realizations for productivity are not at all crucial for the results to be derived but, rather, are imposed for expositional clarity. Throughout this article I abstract away from the possibility that retained old workers might perform a different task than young workers. Analyses concerning the task assignment issue include Sattinger (1975), Rosen (1982), Waldman (1984*a*, 1984*b*), and O'Flaherty and Siow (1989).

ther, it is assumed that, if at the beginning of the second period the worker is indifferent between moving or staying, then he stays.[5]

There are three important characteristics of an up-or-out contract. First, at the end of the first period, the firm makes a decision concerning whether to retain or fire the worker. Second, in addition to specifying $W^Y$, the contract specifies a retention wage that is offered to all workers who are retained. Third, after the retention decision, other firms have the opportunity to make wage offers, and then for the retained workers the initial employer has the opportunity to make counteroffers.

Finally, one additional restriction is imposed on the contracting process. Firms are restricted from offering contracts where wages are contingent on output. This is already implicit in the contracts offered to young workers. Here I am simply extending the restriction to the contracts offered to old workers by firms other than the first-period employer and to the counteroffers made by the first-period employer. The restriction can be justified by assuming that only aggregate output is publicly verifiable and that there are economies of scale, although not modeled, such that firms hire many workers.[6]

### B. Analysis

We begin by considering the equilibrium that results when firms can offer only standard spot-market contracts to young workers (all proofs are presented in the Appendix).

PROPOSITION 1. Suppose only standard spot-market contracts can be offered. Then the employment history of a representative worker is described by the following:

i) While young he works at a wage $W^Y = X + q(G - F)$ and invests zero in human capital.
ii) While old he remains with his initial employer and receives a wage $X + F$.

Intuitively, what is happening in proposition 1 is as follows. As discussed by Milgrom and Oster (1987), since a worker's productivity remains private

[5] This is similar to an assumption that workers face an infinitesimally small but positive cost of moving between firms.

[6] One paper that allows contingent contracting in a model of this sort is Ricart i Costa (1988). Note also, in regard to the absence of contingent contracting, it is implicitly being assumed that this is not an infinitely repeated game since the nonverifiability problem can frequently be avoided in such a setting (see MacLeod and Malcomson 1989). There is also a minor assumption imposed on the contracting process. That is, if a firm is indifferent between retaining or not retaining a worker because the retention wage equals the worker's productivity, it is assumed the firm tries to retain him. An equivalent way of putting this assumption is that workers accumulate an infinitesimally small but positive amount of firm-specific human capital.

information to the first-period employer, other firms will only be willing to bid what the lowest-productivity worker would produce after a move. If such a firm were to bid more, then, because the initial employer has the opportunity to make counteroffers, this other firm would find that it only employs the worker when he produces less than he is being paid. The result is that old workers earn $X + F$ independent of whether their productivity is low or high. Finally, $W^Y$ is determined by a zero-expected-profit constraint, and since there is no incentive for the accumulation of human capital, young workers decide not to invest.

The interesting aspect of the above described equilibrium is the last one mentioned. Specifically, even though it is socially efficient for investment to take place, that is, $(p - q)(G - F) > I$, workers decide not to invest. Notice that this inefficiency is very similar to the inefficiency originally pointed out by Kahn and Huberman (1988). That is, in both cases there is an inefficiency due to the fact that the postinvestment wage does not reflect the potential increase in productivity. The difference between the two stories is that Kahn and Huberman show that this factor can lead to underinvestment in an environment where human capital is specific, while I demonstrate that assuming human capital is specific is not at all crucial. Rather, underinvestment can arise just as easily in a world where human capital is general.

As with the inefficiency identified by Kahn and Huberman, the above inefficiency can be avoided if up-or-out contracts are available. This is demonstrated in proposition 2.

PROPOSITION 2. Suppose both standard spot-market contracts and up-or-out contracts can be offered. First, all young workers will sign up-or-out contracts for which $W^Y = X$ and the retention wage specified in the contract will fall in the interval $(X + F, X + G]$. Second, the employment history of a representative worker is described by the following:

i) While young he invests $I$ in human capital.
ii) With probability $p$, his productivity when old equals $X + G$, he is retained by his initial employer, and he earns $X + G$.
iii) With probability $(1 - p)$, his productivity when old equals $X + F$, he is not retained by his initial employer, and he earns $X + F$ at another employer.

In proposition 2, the firm avoids the inefficiency identified above by offering an up-or-out contract where the retention wage is set above the output of a low-productivity old worker but less than or equal to the output of a high-productivity old worker. The reason the contract avoids the potential inefficiency is as follows. With such a contract the initial employer will have an incentive to retain high-productivity workers and fire low-productivity workers. This means that the worker's productivity, whether high or low, is perfectly signaled to other potential employers. Hence, even if a worker is retained at a wage below $X + G$, the bidding of other firms will cause the actual retention wage paid to equal $X + G$. In other words, when up-or-out contracts are available, the actual wage paid to an old worker is always equal to his productivity. Further, because wages for old workers now reflect productivity differences, workers while young have an incentive to invest in human capital.

In addition to showing that the Kahn and Huberman result extends to the general human capital case, an interesting aspect of the above analysis is its suggestion concerning the role of signaling in environments characterized by up-or-out contracts. To overcome the underincentive for workers to invest in human capital, in the above it is not necessary for the firm to actually specify a high retention wage in the contract. Rather, because of signaling and the bidding of other firms, even a relatively low retention wage will do.

## IV. Up-or-Out Contracts, Signaling, and Diffuse Information

### A. A Simple Example

Although there is a role for signaling in the previous section, the role is rather weak in that there exists an equilibrium contract for which the bidding of other firms is not important for the wage paid to retained workers. In this section I show that signaling takes on a more central role when we move to an environment where learning about worker abilities takes place in a diffuse fashion.

I will begin with a simple example. It is no longer assumed that a worker's first-period employer directly observes the worker's second-period productivity and that other potential employers receive no direct information concerning productivity. Rather, the initial employer now receives noisy information concerning productivity, and the market also receives noisy information. Let $z_e$ denote the noisy information received by the initial employer and $z_m$ denote the noisy information received by the market. At this point, to keep the analysis simple, the following structure is imposed on these noisy pieces of information. The variable $z_e$ equals one with probability one when the worker's true productivity is high, while it equals one with probability $s$ and zero with probability $(1 - s)$ when the worker's true productivity is low, $0 < s < 1$.[7] The variable $z_m$ equals one with

[7] Given this specification, when $z_e = 0$, the initial employer knows that with probability one the worker's productivity is $X + F$. This specification is sufficient, but not necessary, for ensuring that the best up-or-out contract provides a higher incentive for the accumulation of human capital than does the best standard spot-market contract. A weaker condition that would also be sufficient is that $\tilde{X}(1, 1) - \tilde{X}(1, 0) > \tilde{X}(0, 1) - \tilde{X}(0, 0)$, where $\tilde{X}(z_e, z_m)$ denotes the expected value of a worker's productivity as a function of the realizations of $z_e$ and $z_m$ and given that the worker chooses to invest in human capital. See Sec. IVB and n. 11 below for a further discussion.

probability $t$ and zero with probability $(1 - t)$ when true productivity is high, while it equals one with probability $v$ and zero with probability $(1 - v)$ when true productivity is low, $t > v$. Further, it is assumed that the market does not observe the realization of $z_e$ and that the initial employer does not observe the realization of $z_m$.[8]

We will now consider the nature of equilibrium given this change in the environment and assuming that both standard spot-market contracts and up-or-out contracts are available. Also, in some sense to bias the model against exhibiting an important role for signaling, it is assumed that there is an infinitesimally small but positive cost for an initial employer to make a counteroffer that is different from the retention wage specified in the contract. If this assumption had been imposed in the previous section, then in proposition 2 the retention wage specified in the contract would have equaled the actual retention wage paid, that is, there would have been a unique equilibrium in which signaling did not play an important role. Note below, $\hat{X}(z_e, z_m)$ denotes the expected value of a worker's productivity as a function of the realizations of $z_e$ and $z_m$, given that the worker chooses to invest in human capital.[9]

PROPOSITION 3. Suppose both standard spot-market contracts and up-or-out contracts can be offered in the environment described above. There exists a critical value $\bar{I}$, $0 < \bar{I} < (p - q)(G - F)$, such that, if $I < \bar{I}$, then

[8] It is not necessary to assume that every firm in the market receives $z_m$. Rather, it is only necessary to assume that at least two firms receive $z_m$.

[9] There are also three additional assumptions employed for propositions 3 and 4. First, in the settings considered in propositions 3 and 4, there are sometimes multiple equilibria for the subgame starting with the worker's investment decision. It is assumed that, when this is the case, the subgame equilibrium that is realized is the one that makes the worker better off. Second, for both propositions 3 and 4, even with the above assumption there may be values for $I$ for which there are multiple equilibrium contracts. I focus on the contract where the probability of the worker remaining with his first-period employer while old is the highest. This is the equilibrium contract consistent with the assumption that workers face an infinitesimally small but positive cost of moving between firms (see n. 5 above). Third, to stop the market from bidding more than it would be willing to bid if there was a positive probability the worker would actually move, for propositions 3 and 4, trembling-hand-type assumptions are imposed. For proposition 3, the assumption is that the market acts as if the initial employer sometimes errs and does not make a counteroffer to the worker. For proposition 4, the assumption is that the market acts as if the initial employer sometimes does not make a counteroffer, but this occurs only when the initial employer has the smallest incentive for retaining the worker (and the market acts as if this occurs with a positive probability). Note, rather than imposing these trembling-hand assumptions, an alternative approach would be to assume that there is some probability the worker develops a small amount of disutility from working at his initial employer. This would result in equilibrium being characterized by some turnover and would thus make the trembling-hand assumptions unnecessary.

the following describes the equilibrium.[10] First, all young workers will sign up-or-out contracts for which $W^Y = X$ and the retention wage specified in the contract equals $\tilde{X}(1, 0)$. Second, the employment history of a representative worker is described by the following:

i) While young he invests $I$ in human capital.
ii) With probability $pt + (1 - p)sv$, he is retained by his initial employer when old and receives a wage $\tilde{X}(1, 1)$.
iii) With probability $p(1 - t) + (1 - p)s(1 - v)$, he is retained by his initial employer when old and receives a wage $\tilde{X}(1, 0)$.
iv) With probability $(1 - p)(1 - s)$, he is not retained by his initial employer when old and receives a wage $X + F$ at another firm.

Although propositions 2 and 3 are quite similar, there is one interesting difference. In proposition 2 the initial employer received perfect information about a worker's productivity, and one of the equilibria was characterized by the firm setting the retention wage in the contract equal to the high value for productivity. In contrast, now the initial employer receives noisy information concerning productivity, and the market also receives noisy information. What this means is that, if the initial employer observes $z_e = 1$, there are two potential values for what the worker's expected productivity will be after the market's information is taken into account. If the market also receives positive information, then expected productivity will be relatively high, while if it receives negative information, then expected productivity will be relatively low. The question that therefore arises is whether the firm will set the retention wage in the contract equal to the lower value or to the higher value. The interesting result in proposition 3 is that the wage is set equal to the lower value. That is, consistent with a common occurrence in the academic market, the retention wage specified in the contract is set low, and if the market receives positive information, then the wage is increased through the bidding of other firms.

What drives the above result is that, when information is revealed in the diffuse fashion considered in this section, then the initial employer faces a winner's-curse-type problem. Suppose the firm were to set the retention wage in the contract above the lowest possible value for what expected productivity will be after the market's information is taken into account. On the one hand, the firm would find that some of the workers who are retained will be those whom the firm has overvalued, that is, for these workers the retention wage specified in the contract exceeds the final realization for the worker's expected productivity. On the other hand, the other workers retained will have their wage bid up to this final realization.

[10] For $I$ sufficiently close to $(p - q)(G - F)$, neither the best standard spot-market contract nor the best up-or-out contract would provide an adequate incentive for the worker to invest in the accumulation of human capital.

The overall result would be that the average productivity of retained workers would be below the average retention wage paid, which in turn implies that the initial employer would be unwilling to retain any workers. By having the contract specify a low retention wage and having the actual retention wage frequently determined by a bidding process, firms avoid this winner's-curse-type problem.

## B. A Richer Specification

In the previous subsection I considered a simple example where the equilibrium up-or-out contract specifies a low retention wage, and signaling and the bidding of other firms play a central role in the actual retention wage paid. In this subsection I show that a similar result holds given a richer specification for how information is revealed to firms.

It is assumed that everything is the same as in the previous subsection except for the specification of the noisy pieces of information $z_e$ and $z_m$. Both $z_e$ and $z_m$ can now take on any value in the interval [0, 1]. Specifically, when the worker's true productivity is high, then $z_e$ is a random draw from the probability distribution $H_e(\cdot)$, while $z_m$ is a random draw from the distribution $H_m(\cdot)$, where $h_e(\cdot)$ and $h_m(\cdot)$ are the corresponding density functions. Similarly, when the worker's true productivity is low, then $z_e$ and $z_m$ are draws from $J_e(\cdot)$ and $J_m(\cdot)$, respectively, where $j_e(\cdot)$ and $j_m(\cdot)$ are the corresponding density functions. It is assumed that $d[h_e(z)/j_e(z)]/dz > 0$ and $d[h_m(z)/j_m(z)]dz > 0$ for all $0 \le z \le 1$, $d^2\tilde{X}(z_e, z_m)/dz_m dz_e > 0$ for all $z_e$, $z_m$ pairs, $0 \le z_m \le 1$ and $0 \le z_e \le \varepsilon$, $\varepsilon > 0$, and $h_m(0) > 0$. The first assumption states that, for both the initial employer and the market, a higher value for the noisy piece of information received translates into a higher value for the expected productivity of the worker. The second assumption guarantees that, for any fixed value for $z_m$, there is an interval around $z_e = 0$ such that an improvement in the information received by the market has the smallest effect on expected productivity when the initial employer receives the worst possible piece of information. This assumption is not important for determining the form that an up-or-out contract would take. Rather, it is imposed to guarantee that there exists a range of values for $I$ such that the equilibrium contract takes the up-or-out form. In particular, in combination with the last assumption, what this assumption does is ensure that the best up-or-out contract provides a higher incentive for the accumulation of human capital than does the best standard spot-market contract.[11]

PROPOSITION 4. Suppose both standard spot-market contracts and up-or-out contracts can be offered in the environment described above. There

[11] Similar to the specification employed in the example considered in Sec. IVA, one way to guarantee that the second condition is satisfied is to assume that $h_e(0) = 0$ and $j_e(0) > 0$.

exist critical values $\underline{I}$ and $\bar{I}$, $0 < \underline{I} < \bar{I} < (p - q)(G - F)$, such that, if $\underline{I} < I < \bar{I}$, then the following describes the equilibrium.[12] First, all young workers sign up-or-out contracts for which the retention wage specified in the contract equals $\tilde{X}(\hat{z}_e, 0)$, $0 < \hat{z}_e < 1$. Second, the employment history of a representative worker is described by the following:

i) While young he invests $I$ in human capital.
ii) If $z_e \geq \hat{z}_e$, then he is retained by his initial employer when old, and he receives a wage $\tilde{X}(\hat{z}_e, z_m)$.
iii) If $z_e < \hat{z}_e$, then he is not retained by his initial employer when old, and he receives a wage at another firm that is strictly less than $\tilde{X}(\hat{z}_e, z_m)$.

Proposition 4 tells us that under the richer specification now being considered, the equilibrium contract continues to exhibit a low retention wage, and signaling and the bidding of other firms continue to be important in the determination of the actual retention wage paid. To be specific, the retention wage specified in the contract is the worker's expected productivity given that the realization of $z_e$ equals the smallest value consistent with the worker being retained and given that $z_m$ takes on its lowest possible value overall. What subsequently happens is that, if the worker is retained, then a positive signal is sent to other potential employers, and the bidding of these firms causes the actual retention wage paid to equal $\tilde{X}(\hat{z}_e, z_m)$. In other words, unless the information received by the market equals its lowest possible value, the actual retention wage paid will be above the retention wage specified in the contract.

As for the simple example considered previously, what drives this result is that the initial employer faces a winner's-curse-type problem. If he were to set the retention wage paid above $\tilde{X}(\hat{z}_e, 0)$, he would find that he loses money by retaining a $\hat{z}_e$-type worker and would thus not have an incentive to retain him. The result is that the retention wage must be set at the expected productivity of what in some sense is the worst worker retained.

One question that arises is, What role does the assumption that human capital is general play in the above findings? The answer is that the assumption plays a central role. In the analysis of Section III, firms other than the initial employer received no direct information concerning a worker's productivity, and the equilibrium was basically independent of whether human capital was general or specific. In contrast, in the analysis

[12] On the one hand, for $I$ sufficiently small, a standard spot-market contract will provide an adequate incentive for the worker to invest in the accumulation of human capital. On the other hand, as for proposition 3, for $I$ sufficiently close to $(p - q)(G - F)$, neither the best standard spot-market contract nor the best up-or-out contract would provide an adequate incentive for the worker to invest in the accumulation of human capital.

of this section, firms other than the initial employer do receive direct information concerning productivity, and the nature of the equilibrium depends significantly on the assumption that human capital is general. In particular, if specific human capital were to be introduced into the analysis, then more of the return to being retained would be in terms of the direct salary increase, and less would be in terms of the signal sent and the subsequent bidding of other firms.

To see this, consider the example analyzed at the beginning of the section, but now assume that a small proportion of the human capital accumulated is specific rather than general. If we assume that firms employ the up-or-out contract that provides the largest incentive for the accumulation of human capital, we would see that the equilibrium changes in the following manner. The retention wage specified in the contract will increase, and the actual retention wage paid when both the initial employer and the market receive positive information will be smaller. That is, just as stated, more of the return to being retained will be in terms of the direct salary increase and less in terms of the bidding of other firms. What drives this result is that, given a fixed value for what the market observes, the market will be willing to bid less for a retained worker when some of the human capital is specific. This means that, when the market observes positive information about a retained worker, the wage is not bid as high. In turn, this somewhat reduces the winner's-curse problem faced by the initial employer in retaining workers and thus increases the retention wage that can be specified in the contract.

An interesting aspect of the above discussion concerns the extent to which it is consistent with how up-or-out contracts are actually employed. Consider, for example, two settings where up-or-out contracts are employed: the legal environment and the academic environment. Most descriptions of the legal environment indicate that historically this case was characterized by substantial specific capital, and the bidding of other firms did not play an important role in the wages of retained workers.[13] In contrast, the academic setting would seem to lack significant specific capital, and in that case, the bidding of other firms clearly does play an important role. In other words, at least for these two cases, the above discussion matches very well how up-or-out contracts actually seem to be employed.

## V. Conclusion

A firm will typically gather information concerning its own workers that is more accurate than information gathered by other potential em-

[13] For discussions of the legal setting, see Gilson and Mnookin (1985, 1989). These authors state that in recent years the legal environment has changed such that the level of specific capital is now much smaller. They then go on to suggest that this may be an important factor in why there are substantial and ongoing changes in the types of contracts that are prevalent in that environment.

ployers. In turn, other potential employers will attempt to reduce this information asymmetry by observing the actions of the initial employer. In this article I have argued that such a process can be important in environments characterized by up-or-out contracts. The logic is that the retention decision serves as a signal of a worker's productivity and thus helps reduce the information asymmetry between the firms. I investigated the implications of this argument in an environment where up-or-out contracts are employed because they provide the worker with an incentive to accumulate general human capital and learning about worker abilities takes place in a diffuse fashion.

My major finding concerns the wage-setting process for workers who are retained. Despite the fact that up-or-out contracts are employed because they increase the expected wage of those workers who are retained, the retention wage specified in the contract is set low, and the actual retention wage paid is typically determined by the bidding of other firms. Hence, this article provides a potential explanation for the common occurrence in academia that achieving tenure is no direct guarantee of a large salary increase. Rather, much of the return is in terms of the signal that is sent and the bidding by other firms that ensues.

As a final point, I would like to suggest that a potentially fruitful avenue for future research may be to consider other environments where learning takes place in the type of diffuse fashion considered here and in Lazear (1986). Both studies suggest that an environment with diffuse learning leads to a type of strategic interaction between the firms that is quite different from that which arises when learning does not take place in a diffuse fashion. Hence, important insights may be gained from the further investigation of models of this sort.

## Appendix

### Proofs of Propositions

Due to space considerations, proofs are somewhat abbreviated.

*Proof of Proposition 1.* Due to competition, the market's wage offer for old workers will be the highest wage offer consistent with zero expected profits. Given this, consider the following. If the market were to bid higher than $X + G$ for old workers, the initial employer would never be willing to match the offer. Hence, such an offer would attract all old workers and would lead to negative expected profits. If the market were to bid in the interval $(X + F, X + G]$, the initial employer would only match the market's offer for high-productivity workers, and thus such an offer would also lead to negative expected profits. Suppose the market offer were equal to $X + F$. Then the initial employer would have an incentive to match the market offer for both high- and low-productivity workers (see n. 6 above) and would thus retain the worker independent of his type. Hence, a market offer equal to $X + F$ is the highest offer consistent with zero expected profits and is thus the market offer. In turn, given that his second-period wage is independent of his productivity, our representative worker will clearly not have an incentive to invest in human capital. Finally, $W^Y$ must satisfy a zero-expected-profit constraint, that is,

$$W^Y + X + F = 2X + qG + (1 - q)F, \tag{A1}$$

or

$$W^Y = X + q(G - F). \tag{A2}$$

*Proof of Proposition 2.* If the equilibrium is that workers sign standard spot-market contracts, then the equilibrium is that described by proposition 1. Hence, for workers to sign up-or-out contracts there must be a zero-expected-profit up-or-out contract that results in higher expected utility for workers.

Let $\bar{U}$ denote the expected utility of a worker who signs the standard spot-market contract described in proposition 1. This utility is given by

$$\bar{U} = X + q(G - F) + X + F, \tag{A3}$$

or

$$\bar{U} = 2X + F + q(G - F). \tag{A4}$$

Consider an up-or-out contract for which the retention wage, denoted $W^R$, is above $X + G$. For such a contract the initial employer will not retain anyone, and thus the retention decision will not serve as a signal of productivity. In turn, this implies the second-period wage would not depend on a worker's productivity, and subsequently workers would not invest in human capital. The result is a level of expected utility equal to $\bar{U}$.

Consider an up-or-out contract for which $W^R \leq X + F$. Because of the assumption concerning specific capital in note 6 (see above), in this case the firm would attempt to retain everyone. Hence, the retention decision would not serve as a signal of productivity, which implies that such a contract would work just like the spot-market contract found in proposition 1. The result is again a level of expected utility equal to $\bar{U}$.

Now consider an up-or-out contract for which $X + F < W^R \leq X + G$. Given the assumption concerning specific capital in note 6, in this case the firm would retain high-productivity workers and not retain low-productivity workers. This means the retention decision would serve as a perfect signal of productivity. Thus, low-productivity workers would be offered $X + F$ by the market, while high-productivity workers would be offered $X + G$ by the market. Further, if $W^R < X + G$, and the worker is of high productivity, then the initial employer would make a counteroffer equal to $X + G$. Hence, given a fixed value for $W^Y$, all contracts in this class are identical in the sense that high-productivity workers are retained and earn $X + G$ at the initial employer, while low-productivity workers are not retained and earn a wage $X + F$ elsewhere.

Given such a contract, the expected return to investing in human capital equals $(p - q)(G - F)$, and hence such a contract leads to the worker investing. Given the zero-expected-profit constraint, the value for $W^Y$ for such a contract is $X$, which means the expected utility associated with such a contract equals $\bar{U} + (p - q)(G - F) - I$. This proves the proposition.

*Proof of Proposition 3.* We begin by considering how a spot-market contract would work in this environment. Consider the wage-setting process for old workers. Using logic similar to that in the proof of proposition 1, it can be shown that, whether $z_m$ equals zero or one, the market wage offer equals $X + F$ and the initial employer always makes a counteroffer equal to $X + F$ (any higher offer by the market would lose money because it would only attract the worker when $z_e = 0$, in which case the worker's expected productivity is $X + F$). Hence, the worker will not invest in human capital, and the expected utility associated with standard spot-market contracting is $\bar{U}$.

We now consider up-or-out contracts. In particular, consider up-or-out contracts for which $W^R = \tilde{X}(1, 0)$, and suppose for the moment the worker invests in the first period. If $z_e = 0$, the firm knows the worker's productivity is $X + F$ and will thus not retain the worker, while, if $z_e = 1$, the firm will attempt to retain the worker since, independent of what the market observes, the worker's expected productivity is greater than or equal to the retention wage. What this means is that the retention decision serves as a perfect signal of the initial employer's information, and for a worker who is not retained, the market will offer $X + F$.

We now consider the retained worker case in more detail. Suppose $z_m = 1$. Then the market will bid $\tilde{X}(1, 1)$ for the worker, the initial employer will make a counteroffer equal to $\tilde{X}(1, 1)$, and the worker will remain with the initial employer. Suppose $z_m = 0$. A market bid above $\tilde{X}(1, 0)$ is ruled out by the trembling-hand assumption of footnote 9 (see above). Hence, the market bid is $\tilde{X}(1, 0)$, and the worker remains with the first-period employer and earns $\tilde{X}(1, 0)$.

Now consider the worker's decision concerning whether to invest in human capital. If the firms think that the worker will invest, then from above the return is given by $[(p - q)t - (p - q)sv][\tilde{X}(1, 1) - (X + F)] + [(p - q)(1 - t) - (p - q)s(1 - v)][\tilde{X}(1, 0) - (X + F)] > 0$. Let $\bar{I}$ equal this value. Since $I < \bar{I}$, the worker will decide to invest. This demonstrates that investing is an equilibrium to the subgame starting with the worker's investment decision. Further, it can be demonstrated that this subgame equilibrium is better from the worker's standpoint than a subgame equilibrium where investment does not take place. Hence, given the assumption stated in footnote 9, if an up-or-out contract is employed and $W^R = \tilde{X}(1, 0)$, then the worker will invest. In turn, given that $W^Y$ is determined by a zero-expected-profit constraint, this yields that expected utility for this up-or-out contract equals $\bar{U} + (p - q)(G - F) - I$. Thus, this up-or-out contract dominates the spot-market contract previously described.

The final step of the proof is to demonstrate that this contract dominates any other up-or-out contract. Suppose $W^R > \tilde{X}(1, 1)$. No worker would ever be retained, and thus this contract is dominated by the previous one (see n. 9 above). Suppose $\tilde{X}(1, 0) < W^R \leq \tilde{X}(1, 1)$. The worker clearly would not be retained if $z_e = 0$, but suppose he is retained when $z_e = 1$. If $z_m = 1$, then the worker's final value for expected productivity equals $\tilde{X}(1, 1)$, and his final wage will be bid up to $\tilde{X}(1, 1)$, that is, the initial employer will break even on such a worker. Suppose $z_m = 0$. Then the worker's final value for expected productivity equals $\tilde{X}(1, 0)$, but the wage if the worker stays exceeds $\tilde{X}(1, 0)$, that is, the initial employer loses money on such a worker if the worker remains at the firm. This again implies that no worker would ever be retained, and thus this contract is dominated by the contract where $W^R = \tilde{X}(1, 0)$. Suppose $W^R \leq X + F$. Now the worker will be retained with probability one, and thus such a contract works just like a spot-market contract. Hence, this case can be ruled out using the same arguments as previously. Suppose $X + F < W^R < \tilde{X}(1, 0)$. In this case the firm would not retain the worker when $z_e = 0$ and would retain the worker when $z_e = 1$. Using the logic from the case $W^R = \tilde{X}(1, 0)$, for a retained worker, if $z_m = 0$, then the wage is bid up to $\tilde{X}(1, 0)$, while, if $z_m = 1$, then the wage is bid up to $\tilde{X}(1, 1)$. In other words, this case works exactly the same as the case $W^R = \tilde{X}(1, 0)$, except now the initial employer will make a counteroffer even if $z_m = 0$. However, given that there is now a positive cost of making a counteroffer, this case is also dominated by the case $W^R = \tilde{X}(1, 0)$.

*Proof of Proposition 4.* We begin by considering how a spot-market contract would work in this environment. Consider the wage-setting process for old workers. The trembling-hand assumption of footnote 9 (see above) yields that the market wage offer equals $\tilde{X}(0, z_m)$ and the initial employer makes a counteroffer equal to $\tilde{X}(0, z_m)$. Given this, the expected return to investing in human capital equals

$$(p - q) \int_0^1 \tilde{X}(0, z_m)[h_m(z_m) - j_m(z_m)]\,dz_m.$$

Let $\underline{I}$ equal this value. If $I > \underline{I}$, we now have that the worker will not invest in human capital, and thus the expected utility associated with standard spot-market contracting is $\bar{U}$.

We now consider up-or-out contracts. In particular, consider an up-or-out contract for which $W^R = W'$, $\tilde{X}(0, 0) < W' < \tilde{X}(1, 0)$, and suppose for the moment the worker invests in the first period. Let $\hat{z}_e$ be such that $\tilde{X}(\hat{z}_e, 0) = W'$. If $z_e > \hat{z}_e$, then the initial employer knows that the worker's expected productivity exceeds the retention wage, and the worker is retained. Let $\underline{z}_e$ be the lower bound on the set of workers who are retained. We know $\underline{z}_e \leq \hat{z}_e$. Suppose $\underline{z}_e < \hat{z}_e$, and consider what happens when a $\underline{z}_e$ individual is retained. The trembling-hand assumption of footnote 9 yields that the market wage offer for a retained worker will be $\tilde{X}(\underline{z}_e, z_m)$. What this means is that, when $\tilde{X}(\underline{z}_e, z_m) \geq \tilde{X}(\hat{z}_e, 0)$, then the worker's wage is bid up to his expected productivity, and when $\tilde{X}(\underline{z}_e, z_m) < \tilde{X}(\hat{z}_e, 0)$, then the initial employer retains the worker at a loss. This implies that the $\underline{z}_e$ worker would not be retained, and thus $\underline{z}_e = \hat{z}_e$.

Now consider the worker's decision concerning whether to invest in human capital. Let $\bar{I}$ denote this return when the firms believe that the worker invests and given that, in the relevant range, $W^R$ is chosen so as to maximize this return. From above, $\bar{I}$ is given by (A5):

$$\begin{aligned}\bar{I} = {} & (p-q)\int_{\hat{z}_e}^{1} h_e(z_e)dz_e\left[\int_0^1 \tilde{X}(\hat{z}_e, z_m)h_m(z_m)dz_m\right] \\ & + (p-q)\int_0^{\hat{z}_e} h_e(z_e)dz_e\left[\int_0^1 \tilde{\tilde{X}}(z_m)h_m(z_m)dz_m\right] \\ & - (p-q)\int_{\hat{z}_e}^{1} j_e(z_e)dz_e\left[\int_0^1 \tilde{X}(\hat{z}_e, z_m)j_m(z_m)dz_m\right] \\ & - (p-q)\int_0^{\hat{z}_e} j_e(z_e)dz_e\left[\int_0^1 \tilde{\tilde{X}}(z_m)j_m(z_m)dz_m\right],\end{aligned} \tag{A5}$$

where $\tilde{\tilde{X}}(z_m)$ is the expected productivity of a worker as a function of $z_m$, and given that $z_e$ falls in the interval $[0, \hat{z}_e)$. Given

$$\tilde{X}(\hat{z}_e, z_m) > \tilde{\tilde{X}}(z_m)$$

for all $z_m$ and $d[h_e(z_e)/j_e(z_e)]/dz_e > 0$ for all $z_e$, (A5) yields (A6):

$$\begin{aligned}\bar{I} > {} & (p-q)\int_{\hat{z}_e}^{1} h_e(z_e)dz_e\left\{\int_0^1 \tilde{X}(\hat{z}_e, z_m)[h_m(z_m) - j_m(z_m)]dz_m\right\} \\ & + (p-q)\int_0^{\hat{z}_e} h_e(z_e)dz_e\left\{\int_0^1 \tilde{\tilde{X}}(z_m)[h_m(z_m) - j_m(z_m)]dz_m\right\}.\end{aligned} \tag{A6}$$

Equation (A6) in turn yields (A7):

$$\bar{I} - \underline{I} > (p - q) \int_{\hat{z}_e}^{1} h_e(z_e)dz_e \left\{ \int_0^1 [\tilde{X}(\hat{z}_e, z_m) - \tilde{X}(0, z_m)] \times [h_m(z_m) - j_m(z_m)]dz_m \right\} + (p - q) \int_0^{\hat{z}_e} h_e(z_e)dz_e \left\{ \int_0^1 [\tilde{\tilde{X}}(z_m) - \tilde{X}(0, z_m)] \times [h_m(z_m) - j_m(z_m)]dz_m \right\}. \tag{A7}$$

Given $d^2\tilde{X}(z_e, z_m)/dz_m dz_e > 0$ for all $z_e$, $z_m$ pairs, $0 \leq z_m \leq 1$ and $0 \leq z_e < \varepsilon$, $\varepsilon > 0$, we have that for $W^R$ sufficiently close to $\tilde{X}(0, 0)$, both $[\tilde{X}(\hat{z}_e, z_m) - \tilde{X}(0, z_m)]$ and $[\tilde{\tilde{X}}(z_m) - \tilde{X}(0, z_m)]$ are increasing in $z_m$. Given that $d[h_m(z_m)/j_m(z_m)]/dz_m > 0$ for all $z_m$, there must exist a critical value $z_m^*$ such that $h_m(z_m) - j_m(z_m) > 0$ if $z_m > z_m^*$ and $h_m(z_m) - j_m(z_m) < 0$ if $z_m < z_m^*$. Combining this with the previous result and

$$\int_0^1 [h_m(z_m) - j_m(z_m)]dz_m = 0,$$

(A7) yields $\bar{I} > \underline{I}$.

If $\underline{I} < I < \bar{I}$, then the above yields that there is an up-or-out contract for which the worker invests if the firms think the worker invests. This demonstrates that, for this contract, investing is an equilibrium to the subgame starting with the worker's investment decision. Further, it can be demonstrated that this subgame equilibrium is better from the worker's standpoint than a subgame equilibrium where investment does not take place. Hence, given the assumption stated in note 9, if this up-or-out contract is employed, then the worker will invest. In turn, given that $W^Y$ is determined by a zero-expected-profit constraint, this yields that expected utility for this up-or-out contract equals $\bar{U} + (p - q)(G - F) - I$. Thus, this up-or-out contract dominates the spot-market contract previously described.

The final step is to derive which up-or-out contract is employed. If $W^R \geq \tilde{X}(1, 0)$, then no worker would ever be retained, and thus this contract is dominated by the previous one (see n. 9). Suppose $W^R \leq \tilde{X}(0, 0)$. Now the worker will be retained with probability one, and thus such a contract works just like a spot-market contract. Hence, this contract can be ruled out using the same arguments as previously. Finally, note 9 states that there is an infinitesimally small but positive cost for a worker to move between firms. Hence, for values of $W^R$ in the remaining interval, the one that is chosen is the smallest one that will cause the worker to invest.

## References

Bernhardt, D. "Skill Profiles, Observability, and Firm Hierarchies: A Theory of Promotion and Compensation." Mimeographed. Kingston, Ontario: Queen's University, June 1989.

Borland, J., and Prendergast, C. "Optimal Human Capital Accumulation and Task Assignment." Mimeographed. Parkville, Victoria: University of Melbourne, October 1988.

Carmichael, H. L. "Incentives in Academics: Why Is There Tenure?" *Journal of Political Economy* 96 (June 1988): 453–72.

Gibbons, R., and Katz, L. "Layoffs and Lemons." Mimeographed. Cambridge: Massachusetts Institute of Technology, 1989.

Gilson, R. J., and Mnookin, R. H. "Sharing among the Human Capitalists: An Economic Inquiry into the Corporate Law Firm and How Partners Split Profits." *Stanford Law Review* 37 (January 1985): 313–92.

———. "Coming of Age in a Corporate Law Firm: The Economics of Associate Career Patterns." *Stanford Law Review* 41 (1989): 567–95.

Greenwald, B. "Adverse Selection in the Labour Market." *Review of Economic Studies* 53 (July 1986): 325–47.

Harris, M., and Holmstrom, B. "A Theory of Wage Dynamics." *Review of Economic Studies* 49 (July 1982): 315–33.

Kahn, C., and Huberman, G. "Two-sided Uncertainty and 'Up-or-Out' Contracts." *Journal of Labor Economics* 6 (October 1988): 423–44.

Laing, D. "Involuntary Layoffs in a Contractual Model of the Labour Market with Person-specific Information." Mimeographed. Colchester: University of Essex, 1987.

Lazear, E. "Raids and Offer Matching." In *Research in Labor Economics*, vol. 8, edited by R. Ehrenberg. Greenwich, Conn.: JAI, 1986.

MacDonald, G. "A Market Equilibrium Theory of Job Assignment and Sequential Accumulation of Information." *American Economic Review* 72 (December 1982): 1038–55.

MacLeod, W. B., and Malcomson, J. M. "Implicit Contracts, Incentive Compatibility, and Involuntary Unemployment." *Econometrica* 57 (March 1989): 447–80.

Milgrom, P., and Oster, S. "Job Discrimination, Market Forces, and the Invisibility Hypothesis." *Quarterly Journal of Economics* 102 (August 1987): 453–76.

Mori, P. A. "Wages and Job Matching in Internal Labour Markets under Asymmetric Information." Mimeographed. Voghena, Italy: University of Pavia, June 1988.

Novos, I. "Worker Preferences and Firm Structure." Modelling Research Group (MRG) Working Paper no. 8821. Los Angeles: University of Southern California, November 1988.

O'Flaherty, B., and Siow, A. "On the Job Screening, Up or Out Rules, and Firm Growth." Discussion Paper no. 421. New York: Columbia University, February 1989.

Prendergast, C. "Career Development and the Signaling Effect of Wages and Promotion." Mimeographed. New Haven, Conn.: Yale University, 1988.

Prescott, E., and Visscher, M. "Organization Capital." *Journal of Political Economy* 88 (June 1980): 446–61.

Ricart i Costa, J. "Managerial Task Assignment and Promotions." *Econometrica* 56 (March 1988): 449–66.

Rosen, S. "Authority, Control, and the Distribution of Earnings." *Bell Journal of Economics* 13 (Autumn 1982): 311–23.

Ross, S.; Taubman, P.; and Wachter, M. "Learning by Observing and the Distribution of Wages." In *Studies in Labor Markets,* edited by S. Rosen. Chicago: University of Chicago Press, 1981.

Sattinger, M. "Comparative Advantage and the Distribution of Earnings and Abilities." *Econometrica* 43 (May 1975): 455–68.

Waldman, M. "Job Assignments, Signaling, and Efficiency." *Rand Journal of Economics* 15 (Summer 1984): 255–67. (*a*)

———. "Worker Allocation, Hierarchies, and the Wage Distribution." *Review of Economic Studies* 51 (January 1984): 95–109. (*b*)