ASYMMETRIC INFORMATION, LONG TERM LABOR CONTRACTS, AND INEFFICIENT JOB SEPARATIONS

by

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Economists have for some time been telling the world and each other that in a dynamic economy some labor turnover is to be expected and is in fact efficient. However, there is a pervasive feeling that not all of the observed turnover is efficient. The dilemma, of course, is to provide satisfactory reasons why inefficient turnover should occur with optimizing rational economic agents. In light of this problem, recent developments in implicit labor contract theory (e.g., Hall and Lazear (1982), Grossman and Hart (1981), Green (1980), Azariadis (1980)) have begun to focus on the idea that in a world of uncertainty, asymmetric information and moral hazard problems may prevent efficient, fully enforceable, contingent claims contracts from developing.

Two broad sets of results have emerged from this research. One set of results (e.g., Hall and Lazear (1982), Carmichael (1981), Hashimoto and Yu (1980)) stems from the argument that in a world of uncertainty, if bilateral asymmetric information (i.e., firms privately observe the value of a worker's product, and workers privately observe their alternatives) is present, then efficient turnover is unlikely unless a third party is involved in the labor contract. The second set of results (e.g., Grossman and Hart (1981), Green (1980), Azariadis (1980)) is based on the argument that if the asymmetric information is unilateral but the party with the superior information is risk averse, then risk shifting arrangements may prevent contracts with efficient turnover from emerging. These two sets of results are more easily understood if it is recognized that necessary conditions for an implicit labor contract to yield efficient turnover are that any party making a separation decision (whether it be employer or employee initiated) must have all available relevant information and have an incentive to use this information to make an efficient decision. Under the bilateral asymmetric information specification the first of these conditions is difficult to satisfy. Alternatively, risk aversion may prevent the second necessary condition from being fulfilled since if a party making a separation decision has the relevant information but has shifted away the risk associated with that decision, then the party may have no incentive to make the correct decision.

This paper presents an alternative set of reasons that in the context of asymmetric information the labor contracts that emerge may yield inefficient job separations. The argument is based on the inherent intertemporal allocation problems that materialize in a world of asymmetric information (whether it be bilateral or unilateral) in which separations may occur in each of several successive periods and recalls of laid off workers are explicitly considered. Such problems are not present in previous work because in all previous analyses, regardless of the number of periods assumed to be relevant in the model, the separations that are considered only occur in the final period of the model. In an intertemporal model in which separations may occur in any one of several successive periods, intertemporal allocation problems arise because compensation in a given period plays an allocative role not only in that particular period but also in all periods prior to that period. That the terms of compensation may play a multiple intertemporal role in allocating labor has been recognized previously in other contexts. For instance, this argument has been used to explain the observed occurrence of rising wage profiles with tenure in the presence of such factors as worker shirking or firm specific skill acquisition (e.g., Lazear (1980), Haltiwanger (1982)). In this asymmetric information setting, this intertemporal allocation problem takes on new dimensions. Specifically, we argue that if asymmetric information is present then it is very difficult to design an incentive compatible contract that simultaneously promotes in all periods efficient layoffs, efficient quits, and efficient waiting for recall by workers who have been laid off.

In what follows, we develop a simple multiperiod model that allows us to characterize the intertemporal allocation problems that emerge in an asymmetric information setting. We first examine the predetermined wage contracts that are the focus of much of the earlier work (e.g., Kuritani (1973), Hashimoto (1979), Hashimoto and Yu (1980), Carmichael (1981), Hall and Lazear (1982)). One of the primary initial results is that even in the multiperiod unilateral asymmetric information setting with all agents assumed to be risk neutral, inefficient turnover is a feature of the optimal predetermined wage contract. This in itself represents a departure from previous work since in previous analyses risk neutrality and unilateral asymmetric information implies an optimal predetermined contract that yields efficient turnover (see Hall and Lazear (1982)). We demonstrate that the distinguishing features that account for this difference in results are the intertemporal allocation problems discussed above. Having characterized the properties of the inefficient turnover that results from predetermined wage contracts in this setting, we then consider alternative contract structures that include such institutions as severance pay, pensions, quit penalties, and seniority provisions to determine whether alternative contract structures exist that might alleviate this inefficient turnover. In the process of considering alternative contract structures, considerable attention is devoted to the moral hazard problems that arise with such alternatives.

The Model

Consider a world in which firm specific skill accumulation and hiring costs imply the development of long term attachments in the labor force.

Suppose further that competition in the labor market insures that workers make implicit contracts with firms at the onset of their association so that each worker has an expected discounted income (taking into account the possibility of quits and layoffs) that is as good as is available elsewhere. In a world of uncertainty but in which all parties have identical information at each moment in time, an efficient contract would necessarily imply a wage and employment agreement contingent on the realized values of the worker's value to the firm and the worker's alternatives at each moment in time. However, if asymmetric information is a problem so that either the worker privately observes the realization of his alternative values or the firm privately observes the realization of the value of the worker's product then the full information contingent claims contact is not feasible. It is the properties of the multiperiod labor contracts that emerge under these circumstances that we analyze in this paper.

Formally, we consider a three period model. Three periods are the minimum necessary to model a "true" temporary layoff in which a worker is sequentially employed, laid off, and then recalled. Prior to the beginning of the first period the worker and the firm under consideration make some sort of implicit contract. In the first period the worker accumulates firm specific skills and therefore in the second and third periods the worker's productivity is enhanced. Specifically, let w_a be the open market value of the worker's general skills prior to the beginning of the association. The value of the worker's first period production is thus w_a at any firm with whom the worker is employed. However, in future periods if the worker remains attached to his original employer the worker's value in each period i is assumed to be $w_a + M + \eta_i$ where $M > 0$ and η_i is a firm specific random variable (representing a shock to the value of the worker's productivity at this firm). The random variable η_i is assumed to have the density function $f_i(\eta_i)$ where $E(\eta_i) = \int_{-\infty}^{\infty} \eta_i f_i(\eta_i)d\eta_i = 0$ and $Cov(\eta_i,\eta_j) = 0$ for $i \neq j$.

The first type of contract that we consider is the "predetermined wage" contract analyzed by Kuritani (1973), Hashimoto (1979), Hashimoto and Yu (1980), Carmichael (1981) and Hall and Lazear (1982). The predetermined wage contract takes the following form. At the outset of their attachment the worker and the firm agree upon terms of compensation that are not contingent on the realized state of the world in each period. Hence, the firm and the worker agree on the contractual wages (w_1,w_2,w_3). Following Hashimoto (1979) and Carmichael (1981), let the post training wages in periods 2 and 3 be such that:

(1) $w_2 = w_a + \gamma_2 M$

(2) $w_3 = w_a + \gamma_3 M$

However, departing from previous analyses we make no a priori restrictions on the values of γ_2 and γ_3.

With such a contract, now consider the responses of the worker and the firm to random shocks in the worker's alternatives and value, respectively. Before proceeding, it is important to emphasize that although the realization of the worker's alternative is privately observed by the worker and the realization of the worker's value to the firm is privately observed by the firm, it is assumed that both parties have the same ex ante information on the distribution of the relevant random variables.

In considering the quit and layoff decisions, it is helpful to consider the periods in reverse order. In period 3, if the worker is still attached to the firm, the value of the worker's product is revealed to the firm to be $w_a + M + \eta_3$. Given definition (2), the firm will thus layoff the worker if:

(3) $\eta_3 < (\gamma_3-1)M = \eta_3^*$.

This implies that the probability of a layoff in period 3 is given by:

(4) $L(\eta_3^*) = \int_{-\infty}^{\eta_3^*} f_3(\eta_3)d\eta_3.$

The worker, on the other hand, if he is still attached to the firm at the beginning of period 3 may choose to quit. The worker's alternative income in period 3 is taken to be $A_3 = w_a + \varepsilon_3$ where ε_3 is a worker specific random variable representing random shocks to the worker's alternatives. The random variable ε_3 is assumed to have the density function $g_3(\varepsilon_3)$ where $E(\varepsilon_3) = \int_{-\infty}^{\infty} \varepsilon_3 g_3(\varepsilon_3)d\varepsilon_3 = 0$. Following Carmichael (1981) and Hall and Lazear (1982), ε_3 may contain a subjective element related to the worker's job satisfaction. Given A_3, the worker quits if:

(5) $\varepsilon_3 > \gamma_3 M = \varepsilon_3^*.$

The probability of a quit in period 3 is thus given by:

(6) $Q(\varepsilon_3^*) = \int_{\varepsilon_3^*}^{\infty} g_3(\varepsilon_3)d\varepsilon_3$

Observe that in period 3 that the worker and the firm can make their respective separation decisions independently of the other's separation decision. This is a property found in most of the previous analyses using this sort of specification. However, as will soon become apparent, this independence does not emerge in period 2 in this analysis and we argue that in an n period analysis would not hold in periods 2,...,n-1. The key feature of period 2 is that even if the worker is laid off in period 2 he may not "quit" since as long as $L(\eta_3^*) < 1$ there is a positive probability of recall. There are thus two distinct types of quit decisions that the worker may face in period 2. If the firm has made an employment offer to the worker for that period the worker will quit if:

(7) $$A_2 > w_a + \gamma_2 M + \{(1-L_3)[(1-Q_3)(w_a+\gamma_3 M) + Q_3(w_a+E(\varepsilon_3|\varepsilon_3>\varepsilon_3^*)] + L_3 w_a\}\rho \quad , \quad \rho < 1$$

where A_2 is the expected discounted income available from the next best alternative and ρ is the discount rate. It should be emphasized that a quit in this context is assumed to be a permanent separation. It is assumed that $A_2 = w_a(1+\rho) + \varepsilon_2$ where ε_2 represents a random disturbance to the worker's alternatives in period 2. The random variable ε_2 is assumed to have the density function $g_2(\varepsilon_2)$ where $E(\varepsilon_2) = \int_{-\infty}^{\infty} \varepsilon_2 g_2(\varepsilon_2)d\varepsilon_2 = 0$ and $Cov(\varepsilon_2,\varepsilon_3) = 0.$[1] This specification of A_2 implicitly assumes that the worker does not expect to be able to acquire firm specific skills if in "mid-career" the worker changes firms. Thus, the worker's expected income is based entirely on the value of his general skills. This assumption is not critical for what follows since altering it merely entails adding another constant to A_2.

Given this specification for A_2, (7) can be rewritten to indicate that a worker quits only if:

$$(8) \quad \varepsilon_2 > \gamma_2 M + (1-L_3)[(1-Q_3)\gamma_3 M + Q_3 E(\varepsilon_3|\varepsilon_3 > \varepsilon_3^*)]\rho = \varepsilon_2^*$$

Given ε_2^*, the probability that the worker will quit given that he has an employment offer in period 2, $Q_2^e(\varepsilon_2^*)$, is defined accordingly.

Alternatively, if the worker is informed that he is laid off in period 2 then his "quit" decision is quite different. By "quit" decision here we mean the decision on whether or not to wait to be available for recall. In the context of this model accepting alternative permanent employment implies that the worker is not available for recall. This does not mean that the worker who chooses to wait to be recalled may not be employed while laid off but that such employment is by definition of only a temporary or stopgap nature. Specifically the laid off worker will quit, i.e., not be available for recall if:

$$(9) \quad A_2 > B + \{(1-L_3)[(1-Q_3)(w_a+\gamma_3 M) + Q_3[w^a+E(\varepsilon_3|\varepsilon_3>\varepsilon_3^*)] + L_3 w_a\}\rho$$

or equivalently if:

$$(10)\quad \varepsilon_2 > B - w^a + (1-L_3)\ [(1-Q_3)\gamma_3 M + Q_3 E(\varepsilon_3|\varepsilon_3 > \varepsilon_3^*)]\rho = \varepsilon_2^{**}$$

where B is the value associated with the worker's time in period 2 given that the worker remains available for recall. B can be thought of the income equivalent of the value of the additional leisure the laid off worker acquires and may also include any income that the worker earns through temporary or stopgap jobs. Since B is the opportunity cost of the worker's time in each period excluding alternative permanent employment opportunities and w_a is the opportunity cost of the worker's time each period including alternative permanent employment opportunities, it must be the case that $w_a > B$. The possibility that B may include government financed unemployment benefits is not considered because the inefficient turnover that might result from such government induced distortions has already been well documented (e.g., Feldstein (1976)). Given ε_2^{**}, the probability that the worker laid off in period 2, $Q_2^u(\varepsilon_2^{**})$, is defined accordingly.[2]

Given that the firm must transmit its employment offer prior to the worker making his quit decisions, the firm will layoff the worker in period 2 after observing η_2 if:

$$(11)\quad (1-Q_2^e)\ [(1-\gamma_2)M + \eta_2 + (1-L_3)(1-Q_3)[(1-\gamma_3)M + E(\eta_3|\eta_3>\eta_3^*)]\rho]$$
$$< \max\ [0,(1-Q_2^u)(1-L_3)(1-Q_3)[(1-\gamma_3)M + E(\eta_3|\eta_3>\eta_3^*)]\rho]$$

In other words, if the expected discounted gain to the firm associated with the worker being employed (given that the worker does not quit) is less than the expected gain associated with the worker being laid off (taking into account the possibility that the worker may not be available for recall), then the worker will be laid off. Observe that the properties of L_3, Q_3, Q_2 and $E(\eta_3|\eta_3>\eta_3^*)$ imply $(1-Q_2^u)(1-L_3)(1-Q_3)[(1-\gamma_3)M + E(\eta_3|\eta_3>\eta_3^*)]\rho > 0$ so that (11) may be rewritten as:

$$(12)\quad \eta_2 < (\gamma_2-1)M + [(Q_2^e-Q_2^u)/(1-Q_2^e)][(1-L_3)(1-Q_3)((1-\gamma_3)M + E(\eta_3|\eta_3>\eta^*_3)]\rho = \eta_2^*$$

Given η_2^*, the probability of a layoff in period 2, $L_2(\eta_2^*)$, is defined accordingly.

Observe that the layoff in period 2 may turn out to be either temporary or permanent. As long as $L_3 < 1$, there is a positive probability of recall but the worker may decide to forego that opportunity by quitting. This characterization of a layoff as being inherently indefinite seems to fit the description of many of the layoffs that are observed empirically. In this regard the laid off worker's quit decision embodied in $Q_2^u(\varepsilon_2^{**})$ reflects the inherent uncertainty faced by a typical indefinitely laid off worker.

Given L_3, Q_3, L_2, Q_2^e, and Q_2^u it is now possible to specify the maximization process prior to period 1 that establishes the terms of the contract (i.e., w_1, γ_2, and γ_3.) The expected discounted profits to the firm prior to period 1 associated with the firm entering into a long term contract with the worker are given by:

$$(13)\quad E(\pi) = w_a - w_1 + (1-L_2)\ (1-Q_2^e)[(1-\gamma_2)M\rho + E(\eta_2|\eta_2>\eta_2^*)\rho + (1-L_3)\ (1-Q_3)\ ((1-\gamma_3)M + E(\eta_3|\eta_3>\eta_3^*))\rho^2] + L_2(1-Q_2^u)\ [(1-L_3)(1-Q_3)[(1-\gamma_3)M + E(\eta_3|\eta_3>\eta_3^*)]]\rho^2$$

In an ex ante competitive labor market, the firm maximizes (14) subject to a constraint that requires that the expected income from its offer be as good as is available elsewhere. Letting K be the ex ante competitively determined market equilibrium contract value, this constraint takes the form:

$$(14)\quad w_1 + (1-L_2)\{(1-Q_2)[(w_a+\gamma_2 M)\rho + (1-L_3)[(1-Q_3)(w_a+\gamma_3 M)$$
$$+ Q_3(w_a+E(\varepsilon_3|\varepsilon_3>\varepsilon_3^*)) + L_3 w_a]\rho^2]$$
$$+ Q_2(w_a(1+\rho) + E(\varepsilon_2|\varepsilon_2>\varepsilon_2^*))\rho\}$$
$$+ L_2\{(1-Q_2^u)\ (\beta\rho+(1-L_2)\ [(1-Q_3)(w_a+\gamma_3 M)$$
$$+ Q_3(w_a + E(\varepsilon_3|\varepsilon_3>\varepsilon_3^*)]\rho^2 + L_3 w_a\rho^2)$$
$$+ Q_2^u(w_a(1+\rho) + E(\varepsilon_2|\varepsilon_2>\varepsilon_2^{**}))\rho\} > K$$

or equivalently,

$$(15)\quad w_1 + (1-L_2)\ \{(1-Q_2^e)(\gamma_2 M\rho + (1-L_3)\ [(1-Q_3)\gamma_3 M + Q_3 E(\varepsilon_3)\varepsilon_3>\varepsilon_3^*)]\rho^2)$$
$$+ Q_2 E(\varepsilon_2|\varepsilon_2>\varepsilon_2^*)\rho\}$$
$$+ L_2\{(1-Q_2^u)((B-w_a)\rho$$
$$+ (1-L_3)[(1-Q_3)\gamma_3 M + Q_3 E(\varepsilon_3|\varepsilon_3>\varepsilon_3^*)]\rho^2$$
$$+ Q_2^u E(\varepsilon_2|\varepsilon_2>\varepsilon_2^{**})\rho\} > K - w_a(\rho+\rho^2)$$

The firm thus maximizes (13) subject to (15). After some work, the optimality conditions reduce to:

$$(16)\quad \frac{-\partial Q_2^e}{\partial \gamma_2}(1-L_2)\ [\pi_2 + (1-L_3)(1-Q_3)\pi_3]$$

$$\frac{-\partial L_2}{\partial \gamma_2}(Y_2^e - Y_2^u) = 0$$

$$(17)\quad \frac{-\partial Q_2^e}{\partial \gamma_3}(1-L_2)\ [\pi_2 + (1-L_3)(1-Q_3)\pi_3]$$

$$\frac{-\partial L_2}{\partial \gamma_3}[Y_2^e - Y_2^u] - \frac{\partial Q_2^u}{\partial \gamma_3}L_2(1-Q_3)\pi_3$$

$$\frac{-\partial Q_3}{\partial \gamma_3}[L_2(1-Q_2^u)(1-L_3) + (1-L_2)(1-Q_2^e)(1-L_3)]\pi_3$$

$$\frac{-\partial L_3}{\partial \gamma_3}[L_2(1-Q_2^u) + (1-L_2)(1-Q_2^e)]Y_3^e = 0$$

where

$$\pi_i = [(1-\gamma_i)M + E(\eta_i|\eta_i>\eta_i^*)]\rho^{i-1} \quad , \quad i = 2, 3$$
$$Y_2^e = (1-Q_2^e)\ [\gamma_2 M\rho + (1-L_3)Y_3^e] + Q_2^e E(\varepsilon_2|\varepsilon_2>\varepsilon_2^*)\rho$$
$$Y_2^u = (1-Q_2^u)\ [(B-w_a)\rho + (1-L_3)Y_3^e] + Q_2^u E(\varepsilon_2|\varepsilon_2>\varepsilon_2^{**})\rho$$
$$Y_3^e = [(1-Q_3)\gamma_3 M + Q_3 E(\varepsilon_3|\varepsilon_3>\varepsilon_3^*)]\rho^2$$

Considerable insight can be gained from (16) and (17) alone. Condition (16) indicates that the benefits associated with a marginal increase in γ_2 (less quitting in period 2 and thereby increasing expected profits) ought to be balanced against the losses (more layoffs in period 2 and thus a higher compensating differential to the worker to induce the worker to bear the higher probability of layoffs). Condition (17) illustrates the multiple allocational role that the third period wage must play. The key is that γ_3 influences not only the third period quit and layoff decisions but the second period quit and layoff decisions as well. We argue that this intertemporal allocation problem provides another source of inefficient turnover in this framework in addition to the inefficient turnover caused by the bilateral asymmetric information.

The inefficient turnover caused by the bilateral asymmetric information is easy to illustrate. Consider that efficient turnover in period 3 entails the worker not being employed if $w_a + M + \eta_3 < w_a + \varepsilon_3$ or equivalently if

(18) $M + \eta_3 < \varepsilon_3$

Yet, the worker quits in period 3 if $\varepsilon_3 > \gamma_3 M$ and the firm lays off the worker if $\eta_3 < (\gamma_3-1)M$. Regardless of the value of γ_3, these decision rules cannot attain (18) because neither party takes into account the other party's private valuation.

The inefficient turnover generated by the intertemporal allocation problems is a little more difficult to discern. For simplicity (and also for the purpose of focusing on this feature of the model) suppose for the moment that $g_3(\varepsilon_3)$ is a degenerate density function centered on $\varepsilon_3 = 0$. In this event, the worker will not quit in period 3 as long as $\gamma_3 > 0$. Since $\varepsilon_3 \equiv 0$ in this special case, (18) indicates that efficient turnover implies separation only if $\eta_3 < -M$. Hence, $\gamma_3 = 0$ will in this case generate efficient turnover in period 3. This is consistent with the findings of previous studies analyzing predetermined wage contracts in a unilateral asymmetric information setting (which is essentually what we have imposed in period 3). However, in this multiperiod framework, while setting $\gamma_3 = 0$ generates efficient turnover in period 3, it generates inefficient turnover in other periods. To see this, observe that efficient turnover in period 2 entails the worker being laid off (in period 2) if:

$$(19)\quad \eta_2 < \max(-M - (\int_{-M}^{\infty} f_3(\eta_3)(M+\eta_3)d\eta_3)\rho + \varepsilon_2, B - w_a - M)$$

and waiting for recall if:

$$(20)\quad \varepsilon_2 < B - w_a + (\int_{-M}^{\infty} f_3(\eta_3)(M+\eta_3)d\eta_3)\rho.$$

Yet, when $\gamma_3 = 0$, by the decision rule L_2, Q_2^u the worker waits for recall if (given $\varepsilon_3 \equiv 0$):

$$(21)\quad \varepsilon_2 > B - w_a + (1-L_3)\gamma_3 M\rho = B - w_a$$

First, observe that equation (21) and (20) together imply that if $\gamma_3 = 0$ the probability of a quit by the worker in his "middle-aged" years is suboptimally high. This is because when $\gamma_3 = 0$ the worker laid off in period 2 does not take into account the loss of the third period firm specific capital that occurs when he quits. On the other hand, if γ_3 is chosen so that (21) and (20) are synonymous (which would require $\gamma_3 > 0$) then while this would eliminate suboptimal quitting by a worker laid off in period 2, it causes an excessively high probability of layoffs in period 3. Hence, there is a trade-off between promoting efficient quits by a worker laid off in period 2 and promoting efficient layoffs in period 3. This is a classic case in which attempts to reduce a distortion on one margin implies that the distortion on another margin is necessarily increased.

It is this type of intertemporal tradeoff that is one of the distinguishing features of this analysis. Since no first best solution is possible given the structure imposed upon the model (i.e., predetermined wage contracts with no direct payments to laid off workers), it is of interest to fully characterize the properties of the optimal second best contract. In what follows, we focus our attention on the inefficiencies caused by intertemporal allocation problems by assuming that $\varepsilon_2 \equiv \varepsilon_3 \equiv 0$ so that only unilateral asymmetric information is present. We demonstrate that with the optimal predetermined wage contract there is a bias towards excess layoffs of older workers who are in their final period(s) of potential employment (which may be interpreted as forced retirement) and a bias towards overemployment of middle-aged workers. We then investigate the role that such institutions as severance pay, pensions and seniority provisions might play towards alleviating the inefficiencies associated with the simple predetermined wage contract.

Unilateral Asymmetric Information

Under the unilateral asymmetric information specification, the worker's quit decisions become discrete. That is, the worker quits in period 3 if $\gamma_3 < 0$ but stays otherwise; the worker offered employment in period 2 quits if γ_2 and γ_3 in combination are such that $\gamma_2 M + (1-L_3)(1-Q_3)\gamma_3 M\rho < 0$ but stays otherwise; and the worker laid off in period 2 "quits" if γ_3 is such that $B - w_a + (1-L_3)(1-Q_3)\gamma_3 M\rho < 0$ but waits to be recalled otherwise. Given these discrete decision rules that now underly Q_3, Q_2^e, and Q_2^u respectively, the optimal contract is derived by maximizing the appropriately modified (13) subject to (15). Analysis and derivation of the optimality conditions (which with these discrete decision rules involves dividing the problem into mutually exclusive regimes, calculating the optimal contract under each regime, and then comparing expected profits across regimes -- see the appendix) allows us to prove the following proposition.

Proposition 1: In the unilateral asymmetric information setting, the optimal predetermined wage contract satisfies the following properties:

(i) $\gamma_3 > 0$ (implying that $Q_3 = 0$).

(ii) $\gamma_2 M + (1-L_3)(1-Q_3)\gamma_3 M\rho = \gamma_2 M + (1-L_3)\gamma_3 M\rho > 0$ (implying that $Q_2^e = 0$).

(iii) there exists a B^* such that if $B < B^*$ (denote this as regime I_w), then $\gamma_2(I_w) = \gamma_3(I_w) = 0$ (which implies $Q_2^u = 1$). Alternatively, if $B > B^*$ (denote this as regime II_w), then $\gamma_2(II_w) = (B-w_a)/M$ and $\gamma_3(II_w) = (w_a-B)/(\int_{(\gamma_3(II_w)-1)M}^{\infty} M f_3(\eta_3)d\eta_3)\rho$ (which implies $Q_2^u = 0$) where B^* is such that: $w_a - (\int_{-M}^{\infty} (M+\eta_3)f_3(\eta_3)d\eta_3)\rho < B^* < w_a$

(iv) If $B < w_a - (\int_{-M}^{\infty} (M+\eta_3)f_3(\eta_3)d\eta_3)\rho$ or $B = w_a$, then the optimal contract yields efficient turnover. However, if $w_a - (\int_{-M}^{\infty} (M+\eta_3)f_3(\eta_3)d\eta_3)\rho < B < w_a$, then the optimal contract yields inefficient turnover. Moreover, in the inefficient turnover range, if $B < B^*$ then the inefficient turnover is characterized by overemployment of a worker in his "middle-aged" years (period 2) and an excess probability of quitting by a worker laid off in his "middle-aged" years. Alternatively, if $w_a > B > B^*$, then the inefficient turnover is characterized by too high a probability of a layoff in a worker's older years (period 3).

Proof: Provided in the Appendix.

Proposition 1 fully characterizes the optimal predetermined wage contract in this setting. First, given the discrete quit decision rules, it should not be surprising that it is optimal for the terms of compensation to be such that a worker with a employment offer does not quit. For otherwise, the firm would obviously be foregoing profits. However, Proposition 1 indicates that the decision on whether to induce a worker laid off in period 2 not to quit is not so straightforward. Recall that efficiency requires that a worker be laid off in period 2 if:

$$(22)\quad \eta_2 < \max\left(-M - \left(\int_{-M}^{\infty} (M+\eta_3)f_3(\eta_3)d\eta_3\right)\rho,\ -M+B-w_a\right);$$

waits to be recalled when laid off in period 2 if:

$$(23)\quad B > w_a - \left(\int_{-M}^{\infty} (M+\eta_3)f_3(\eta_3)d\eta_3\right)\rho;$$

and that the worker should be laid off in period 2 if:

$$(24)\quad \eta_3 < -M$$

However, with the predetermined wage contract, (22)-(24) may be very difficult to achieve. For the only way to induce a worker laid off in period 2 not to quit is to pay a sufficiently high third period wage. Yet this generally implies inefficient turnover in period 3.

The decision on whether to induce a worker laid off in period 2 to wait for recall depends on how much the firm must increase γ_3 in order to do so. It should, therfore, not be surprising that for extreme values of B (relative to the other parameters) that the decision is straightforward. However, when B falls in an intermediate range (i.e., $w_a - \left(\int_{-M}^{\eta_3^{max}} (M+\eta_3)f_3(\eta_3)p < B < w_a\right)$ the decision becomes more difficult because as Proposition 1 indicates either regime results in some inefficient turnover. We can say, however, that for sufficiently high B, (i.e., $B > B^*$), the required compensation for inducing a worker laid off in period 2 to wait for recall becomes sufficiently small that the gains (i.e., the additional third period profits associated with the laid off worker being available for recall and the additional second period profits associated with no longer overemploying the worker in the second period for fear that the worker would be unavailable for recall) outweigh the costs (i.e., the loss in third period profits associated with the excess layoffs in the third period) of doing so.

Given these findings, the natural question to ask is whether there exists an alternative to the predetermined wage contract that has no additional information requirements but can alleviate the inefficient turnover. In light of this question, we now examine the potential role that might be played by institutions such as severance pay, pensions and seniority provisions. Since we are concerned with the problem of inefficient turnover, we will henceforth assume that $w_a - (\int_{-M}^{\infty} (M+\eta_3)f_3(\eta_3)d\eta_3)\rho < B < w_a$. Moreover, since $Q_2^u = Q_3 = 0$ are optimal in all situations in the unilateral asymmetric information setting, we will henceforth assume that this is the case (with the accompanying restrictions on the decision variables.)

First, consider severance pay. Severance pay generally takes the form of a payment made to a worker upon an employer initiated separation that is not contingent on the worker agreeing to provide or to be available to provide future services to the firm. Letting S_i be the severance payment in period i, the layoff and quit decisions are modified in the following manner. The worker is laid off in period 3 if:

(25) $\eta_3 < (\gamma_3-1)M - S_3$;

the worker is laid off in period 2 if:

(26) $\eta_2 < (\gamma_2-1)M - S_2 - Q_2^u\,[(1-L_3)\,[(1-\gamma_3)M\rho + E(\eta_3^*)]\rho - L_3S_3\rho]$;

and the worker laid off in period 2 waits for recall if:

(27) $B - w_a + (1-L_3)\gamma_3M\rho + L_3S_3\rho > 0$

Given these decision rules, the firm maximizes expected profits subject to an appropriately modified expected income constraint. Derivation and analysis of the optimality conditions (see the appendix) reveals that the optimal contract calls for $S_3\rho = \gamma_3 M\rho > w_a - B$ and $B + S_2 = w_a + \gamma_2 M$. Observe that this implies that the decision rules embodied in (25)-(27) satisfy the necessary and sufficient conditions for efficient turnover given by (22)-(24). The key to the apparent success of this severance pay contract is that the severance pay is chosen so that the worker's income is independent of his employment status in both periods 2 and 3. By making the guaranteed income in period 3 sufficiently high the worker laid off in period 2 is induced to not quit suboptimally. Moreover, since the firm essentially pays the worker the same amount regardless of the worker's employment status, the firm has the incentive to make the efficient layoff decision.

The severance payment contract, while appearing to yield efficient turnover, suffers from several major limitations. One significant problem with this and other similar mechanisms that might induce a laid off worker to quit efficiently is that the firm has difficulty monitoring the worker's activities while laid off. To understand the difficulties this creates consider a situation in which the worker has been laid off in period 2. Under the severance payments contract the worker has a guaranteed income in period 3 that should induce him not to quit suboptimally. However, since the worker laid off in period 2 may receive a severance payment in period 3 (above and beyond the initial severance payment paid in period 2) without having to provide any services to the firm except to claim that he is available for recall, the worker may be able to take advantage of the system. In particular, a worker laid off in period 2 could accept alternative employment (which with the context of this model implies that he is unavailable for recall) but deceptively inform that he is available for recall. The advantage of this deception is, of course, that there is a positive probability that the worker will not be recalled in period 3 and in that event the worker receives this additional severance payment. The worker may find that he is recalled in period 3 but in that event the worker may simply inform the firm that he is in fact not available for recall. Given the structure of the contract the worker bears no cost from this deception.

Formally, this moral hazard problem implies that the characterization of the laid off worker's quit decision given by equation (27) is incorrect. The worker, perceiving that he can obtain L_3S_3 regardless of whether he is actually available for recall quits if:

$$B + (1-L_3)\ (w_a+\gamma_3 M)\rho + L_3S_3\rho < w_a(1+\rho) + L_3S_3\rho$$

or equivalently if:

(28) $B - w_a + (1-L_3)\gamma_3 M\rho < \varepsilon_2$

Equation (28) indicates that the laid off worker's quit decision is not influenced by S_3 (which is essentially perceived as a gift) and hence the severance payments mechanism cannot be used to induce efficient turnover.

It may, however, be possible to overcome this moral hazard problem by introducing a penalty mechanism wherein a worker who deceptively claims to be available for recall is forced to make a payment to the firm in the event that he is recalled and refuses the recall offer. Letting P be the penalty payment, P must be such that $(1-L_3)P > L_3S_3$ for otherwise there is still an incentive for the worker to deceive the firm. It should be emphasized that the penalty must only be imposed on a laid off worker who deceptively claims to be available for recall and refuses a recall offer. For if it is imposed on a laid off worker who claimed to be unavailable for recall from the outset or if it is imposed as a general quit penalty for any worker who refuses the firm's employment offer, then it will yield inefficient turnover. Thus, it is a very selective instrument aimed at laid off workers who otherwise would have an incentive to deceive the firm. For this reason, it is easy to see that such a mechanism would not be successful in eliminating deception in the bilateral asymmetric information context. In the unilateral asymmetric information setting, the deceiving worker is readily identifiable. This is because the firm knows that a worker attached to the firm at the beginning of the third period has no incentive to quit if $\gamma_3 > 0$. Hence, a laid off worker who claimed to be available for recall but who rejects a recall offer when $\gamma_3 > 0$ must have been lying about his availability for recall. In contrast, in the bilateral asymmetric information setting, a laid off worker who accepted alternative permanent employment in period 2 but deceptively claimed to be available for recall could maintain his deception in rejecting a recall offer by claiming that he had received a better offer in the third period. Since the worker privately observes the realization of his alternatives in the bilateral specification, the firm would have difficulty verifying the worker's claim. This suggests that if bilateral asymmetric information is present then this reinforces the potential inefficiencies caused by the intertemporal allocation problems addressed here.

Another potential problem with the severance pay-deception penalty contract is present if one party can manipulate the separation decision of the other party. There is a clear incentive to do so in order to avoid having to pay a separation penalty and to be potentially eligible for a separation penalty from the other party. To understand this, consider a worker who has decided to quit. By inducing an employer initiated discharge (through, say, shirking on the job) rather than quitting the worker may be able to avoid any quit penalty and become eligible for severance pay. The firm, on the other hand, may have similar incentives to induce a worker to quit (through affecting the worker's job satisfaction) rather than having to discharge the worker. The possibility that such manipulation might occur casts doubt on the ability of separation penalty mechanisms to promote efficient turnover.[3]

Given the relative complexity and the problems of the severance pay-deception penalty contract, it is worth considering alternative structures. One obvious alternative is to introduce a pension system. For instance, consider a pension which does not become vested until the third period. Any worker who remained attached to the firm until the beginning of the third period would thus be entitled to this pension regardless of the employment status of the worker in the third period. Similar to the severance payments contract, such a pension system would allow a worker's expected third period income associated with remaining attached to the firm until the third period to be sufficiently high to induce the worker laid off in the second period to wait for recall while at the same time not distorting the firm's third period layoff decision.[4] Again, similar to the severance payments contract, the pension contract would entail the worker's second and third period expected income to be independent of the worker's employment status. Nevertheless, the pension system would be subject to the same problem of laid off workers having an incentive to deceive the firm with regard to his availability for recall (which again might be overcome by introducing a deception penalty scheme.)[5] Thus, the pension system while an interesting alternative yields essentially the same results and requires the same degree of complexity as the severance pay contract.

Another interesting alternative is a seniority system. By a "seniority system" we mean a system in which older workers are essentially granted immunity from layoffs.[6] In the present context, this is taken to mean that workers in their third period of attachment with the firm would not be subject to layoff. Given the problems encountered above in designing an incentive compatible contract with efficient turnover, seniority provisions have some natural appeal. For with a seniority system, the worker's third period wage could be increased to induce a worker laid off in the second period to wait for recall, without increasing the layoff probability in the third period (which is constrained to be zero). Moreover, there would be no incentive for a laid off worker to deceive the firm with regard to his availability for recall. These advantages notwithstanding, it should be recognized that a contract with seniority provisions will necessarily yield some inefficient turnover for it precludes the efficient layoffs of older workers. However, it is of interest to determine whether a contract with a seniority provision can do better than the simple predetermined wage contract.

The optimal contract with a third period seniority provision is determined by maximizing expected profits subject to an appropriately modified expected income constraint. Analysis and derivation of the optimality conditions (see the appendix) reveals that the optimal contract is characterized by two regimes. If $B < w_a - M\rho$ (denote this as regime I_s), the optimal contract calls for $-\gamma_2(I_s) = \gamma_3(I_s)\rho$ and $0 < \gamma_3(I_s) < (w_a - B)/M\rho$. This implies that under regime I_s the worker is laid off in period 2 if $\eta_2 < -M(1+\rho)$ and always quits when laid off. Comparing this with the efficient turnover conditions embodied in (22)-(24), if $B < w_a - (\int_{-M}^{\infty} (M+\eta_3)f_3(\eta_3)d\eta_3)\rho$ then while a worker who is laid off in period 2 quits efficiently, the probability of layoffs in period 2 is too high and the probability of layoffs in period 3 is too low. On the other hand, if $w_a - (\int_{-M}^{\infty} (M+\eta_3)f_3(\eta_3)d\eta_3)\rho < B < w_a - M\rho$, then the worker who is laid off in period 2 suboptimally quits, there is underemployment in period 2 and overemployment in period 3.

In the alternative regime (regime II_s) where $B > w_a - M\rho$, the optimal contract is such that $\gamma_2(II_s)M = B - w_a$, $w_1(II_s) + \gamma_3(II_s)M\rho^2 = K - w_a\rho^2 - B\rho$ and $\gamma_3(II_s) > (B-w_a)/M\rho$. This implies that a worker will be laid off in period 2 if $\eta_2 < B - w_a - M$ and will wait for recall with probability one. Comparing the decision rules under this regime with the efficient turnover rules given by (22)-(24) indicates that there are efficient layoffs and quits in period 2 but overemployment in period 3 (given that $B > w_a - M\rho$).

Comparing and contrasting the seniority contract with the simple predetermined wage contract reveals that under both contracts, for sufficiently high B, it becomes optimal for the firm to induce a worker laid off in period 2 to wait for recall. However, the inefficient turnover in period 3 that results from such inducement is quite different under the two alternative contracts. The predetermined wage contract yields excess layoffs of older workers while the seniority contract yields overemployment of older workers. It is therefore of interest to compare the expected profits associated with the alternative contracts in order to determine which type of yields more efficient turnover. The following proposition provides this comparison.

Proposition 2: For extreme values of B, the predetermined wage contract dominates the seniority contract. Specifically, if $B < w_a - M\rho$ then $E[\Pi|I_w] > E[\Pi|I_s] > E[\Pi|II_s]$ and if $B = w_a$, $E[\Pi|II_w] > E[\Pi|II_s] > E[\Pi|I_s]$. However, for intermediate values of B (i.e., $w_a - M\rho < B < w_a$) either type of contract may dominate depending on the parameters of the distributions of η_2 and η_3.

Proof: Provided in the appendix.

That for extreme values of B the predetermined wage contract dominates the seniority contract should not be surprising since, by Proposition 1, for extreme values of B the predetermined wage contract yields efficient turnover. Given that the seniority contract necessarily yields some inefficient turnover, as B becomes sufficiently close to the values necessary to attain efficient turnover under the predetermined wage contract, the inefficient turnover generated by the predetermined wage contract will necessarily become less than that generated by the seniority contract. However, for intermediate values of B the question is not so unambiguous. To understand this it is helpful to consider a brief example. Suppose the parameters of the model are such that $\gamma_3(II_w)M\rho \int_{(\gamma_3(II_w)-1)M}^{\infty} f_3(\eta_3)d\eta_3 = \frac{1}{2}M\rho = w_a - B$ (recall from Proposition 1 that $\gamma_3(II_w)$ is the optimal γ_3 for the predetermined wage contract under regime II_w). The smallest (and the optimal) value of γ_3 that will satisfy this equation is $\gamma_3(II_w) = 1$. Hence, comparing expected profits under the alternative contracts in this special case yields:

$$(29)\quad E[\Pi|II_w] - E[\Pi|II_s] = \left(\int_0^{\infty} \eta_3 f_3(\eta_3)d\eta_3 - \frac{1}{2}M\right)\rho^2$$

and

$$(30)\quad E[\Pi|I_w] - E[\Pi|II_s] = \left(\int_{-M-Z}^{\infty} [M + \eta_2 + Z]f_2(\eta_2)d\eta_2\right)\rho$$

$$- \left(\int_{-M(1+\frac{1}{2}\rho)}^{\infty} [M(1 + \frac{1}{2}\rho) + \eta_2]\rho\, f_2(\eta_2)d\eta_2 + M\rho^2\right)$$

where $Z = \left(\int_{-M}^{\infty} (M+\eta_3)f_3(\eta_3)d\eta_3\right)\rho$.

Equations (29) and (30) reveal that if the tails of the distribution of η_3 (assumed to be symmetric for this example) above M and below -M have sufficiently small mass then the seniority contract may dominate the predetermined wage contract. This makes intuitive sense because by reducing the size of the tails of the distribution of η_3 above M and below -M this reduces the inefficient turnover in period 3 associated with the seniority contract. At the same time, this suggests that for any given combination of B, w_a and M, if the tails of the η_3 distribution are sufficiently large then the inefficient turnover of the seniority contract can be made sufficiently severe so that the predetermined wage contract dominates.

In summary, this examination of the contracts that emerge in the multiperiod unilateral asymmetric information setting reveals that inefficient turnover may be a feature of the contracts. A key reason for this is that the compensation agreed upon for a given period influences not only the separation decisions in that period but in all previous relevant periods as well. The issue that highlights this intertemporal allocation problem is whether an incentive compatible and information feasible contract exists that will simultaneously induce laid off workers to wait for recall efficiently while not distorting other separation decisions. The predetermined wage contract cannot, in general, accomplish this and yields either excess employment of middle-aged workers or excess layoffs of older workers. A relatively complex deferred severance payment or pension system may provide a means to produce efficient turnover but, in general, requires the addition of a deception penalty mechanism that penalizes laid off workers who deceptively claim to be available for recall and then reject the recall offer. However, this severance payment-deception penalty contract only achieves efficient turnover if each party in the agreement cannot manipulate the separation decision of the other party. Moreover, it appears that it would be problematic in a bilateral asymmetric information setting. A seniority system, on the other hand, avoids some of these moral hazard problems but, because it necessarily generates some inefficient turnover, is for some combinations of the relevant parameters dominated by the simple predetermined wage contract.

Concluding Remarks

Recent developments in implicit contract theory have sought to provide an explanation for why we might observe a job separation even when the value of the marginal product of a worker exceeds his reservation wage. Previous studies have focused on the potential inefficient separations induced by either bilateral asymmetric information problems or the interaction between asymmetric information and risk aversion. However, in previous studies, analysis has been limited to models in which separations occur only in the final period of the model. In this paper, a simple multiperiod model is developed in which separations may occur in each of several successive periods. The multiperiod specification enables us to distinguish between temporary and permanent separations and to focus attention on the potential for inefficient separations induced by asymmetric information problems in an intertemporal setting.

The issue that highlights the problems induced by asymmetric information in an intertemporal setting is whether an incentive compatible and information feasible contract exists that will simultaneously induce laid off workers to wait for recall efficiently while not distorting other separation decisions. We demonstrate that inducing laid off workers to not "quit" suboptimally may be accomplished through specifying a wage structure that rises with firm specific experience. However, this, in general, requires an experience-wage profile that is steeper than that consistent with promoting efficient layoffs of older workers. On the other hand, if the experience-wage profile is not sufficiently steep then "middle-aged" workers who are laid off may quit suboptimally and accordingly, firms, fearing that laid off workers may not be available for recall, overemploy "middle-aged" workers. Introduction of alternative payment instruments (e.g., severance pay, pensions) or contract provisions (e.g., seniority provisions) appears to help alleviate the inefficient separations induced by such intertemporal allocation problems. However, careful consideration reveals that these alternative contract structures are subject to potentially severe moral hazard problems of deception and manipulation. We argue that these moral hazard problems may prevent efficient turnover contracts from emerging. Nevertheless, the observed existence of non-wage deferred compensation schemes (e.g., severance pay, non-vested pensions, seniority provisions) may be at least partially justified as a means of inducing temporarily laid off young and middle-aged workers to wait for recall without necessarily increasing the probability of layoffs of older workers.

Footnotes

[1]It is further assumed that $Cov(\eta_i, \varepsilon_j) = 0$ for all i,j.

[2]This specification of Q_2^e and Q_2^u presumes that the firm must transmit its employment offer to the worker prior to the worker making his quit decision. This appears to be a reasonable characterization but alternative possibilities exist. For instance, suppose the worker in each period had to make a binding decision on whether or not he would be available to the firm for employment in that period prior to knowing whether he would actually be employed in that period. This would change the whole nature of the decision rules. For in this case, there would only be one type of quit decision in period 2. Considering such an alternative sequence of decision making is of interest not so much because it represents a more accurate depiction of the dynamics of the labor market (which it probably does not) but rather because it highlights the potentially critical role played by the assumed sequence of separation decisions. In the present analysis, we focus our attention on the type of contracts that emerge under the structure embodied in the decision rules Q_2^e and Q_2^u but recognize that an in-depth analysis of the significance of the assumed sequence of decision making is of interest.

[3]Carmichael (1981) emphasizes this possibility of manipulation in his analysis of a two period, bilateral asymmetric information model.

[4]The optimal pension contract (ignoring moral hazard problems) is given by $\gamma_2 = (B-w_a)/M$, $\gamma_3 = 0$ and a pension, PEN, such that $PEN > (B-w_a)/\rho$.

[5]It is worth noting that the pension system has one advantage over the severance payment contract in that it, by itself, provides no incentive for either party to manipulate the other party's separation decision. This is because the pension is granted to the worker independently of the worker's

employment status. Note, however, that the addition of a deception penalty might induce manipulative behavior.

[6]Carmichael (1981) also considers "seniority provisions" but his concept of a seniority provision is quite different than that modeled here. In his two period model, he arbitrarily imposes a steady-state number of workers that the firm will employ and a steady state number of workers who will in their second period of employment be promoted to a higher paying job. This promotion ladder concept is his version of a seniority provision. Consideration of such promotion ladders would be of interest in the present framework although a more general specification in which the number of jobs and high paying jobs are not imposed would be preferable.

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APPENDIX

Proof of Proposition 1: It is helpful to consider (i) and (ii) in reverse order. (ii) Suppose that γ_2 and γ_3 are chosen so that $\gamma_2 M + (1-L_3)(1-Q_3)\gamma_3 M\rho < 0$. This implies $Q_2^e = 1$. Denote this as regime I. Letting w_1 be adjusted so that a worker's expected income is equal to K, expected profits under this regime are given by:

(A1) $$E[\Pi|I] = w_a(1+\rho+\rho^2) - K$$
$$+ L_2(I)(1-Q_2^u(I))[(B-w_a)\rho + (1-L_3(I))(1-Q_3(I))[M+E(\eta_3|\eta_3 > \eta_3^*(I))]\rho^2$$

Now consider an alternative regime (regime A) where $\gamma_3(A) = \gamma_3(I)$ but $\gamma_2(A)$ and $\gamma_3(A)$ together are such that $\gamma_2(A)M + (1-L_3(A))(1-Q_3(A))\gamma_3(A)M\rho = 0$. Under this alternative regime, $Q_2^e(A) = 0 < Q_2^e(I)$, $Q_2^u(A) = Q_2^u(I)$, $L_2(A) < L_2(I)$, $L_3(A) = L_3(I)$, and $Q_3(A) = Q_3(I)$. Expected profits under regime A are given by:

(A2) $$E[\Pi|A] = w_a(1+\rho+\rho^2) - K + (1-L_2(A))\ [M + E(\eta_2|\eta_2 > \eta_2^*(A))]\rho$$
$$+ (1-L_2(A)Q_2^u(A))(1-L_3(A))(1-Q_3(A))\ [M + E(\eta_3|\eta_3 > \eta_3^*(A))]\rho^2$$

Comparing (A1) and (A2) reveals that $E[\Pi|A] > E[\Pi|I]$. Hence, $\gamma_2 M + (1-L_3)(1-Q_3)\gamma_3 M\rho > 0$ and $Q_2^e = 0$ are optimal.

(i) Given that $\gamma_2 M + (1-L_3)(1-Q_3)\gamma_3 M\rho > 0$, suppose nevertheless that $\gamma_3 < 0$. This implies $Q_3^e = 1 = Q_2^u$. Maximizing (13) subject to (15) under the constraints $\gamma_3 < 0$ and $\gamma_2 M + (1-L_3)(1-Q_3)\gamma_3 M\rho > 0$ yields expected profits given by (denote this as regime II):

(A3) $$E[\Pi|II] = w_a(1+\rho+\rho^2) - K + (1-L_2(II))\ [M + E(\eta_2|\eta_2 > \eta_2^*(II)]\rho$$

Now consider an alternative regime (regime A) where $\gamma_2(A) = \gamma_2(II)$ and $\gamma_3(A) = 0 > \gamma_3(I)$ (and $w_1(A)$ is adjusted so that a worker's ex ante expected income remains equal to K). Under this regime $Q_3^e(A) = 0$ and $Q_2^u(A) = 1$. Expected profits under regime A are given by:

(A4) $E[\Pi|A] = w_a(1+\rho+\rho^2) - K +$

$(1-L_2(A))\ \{[M + E(\eta_2|\eta_2 > \eta_2^*(A))]\rho + (1-L_3(A))[M + E(\eta_3|\eta_3 > \eta_3^*(A))]\rho^2]$

Comparison of (A3) and (A4) (taking into account that $L_2(A) < L_2(II)$, $L_3(A) < 1$, and $\eta_2^*(A) < \eta_2^*(II)$) reveals that $E[\Pi|A] > E[\Pi|II]$. Hence, $\gamma_3 > 0$ and $Q_3 = 0$ are optimal.

(iii) Since $\gamma_3 > 0$ and $\gamma_2 M + (1-L_3)\gamma_3 M\rho > 0$ are optimal, there are essentially two possible remaining regimes. Either γ_3 is chosen to be sufficiently large that $Q_2^u = 0$ or γ_3 is chosen so that $Q_2^u = 1$. For the latter regime (denote this as regime I_w), maximizing (13) subject to (15) along with the constraints that insure $Q_2^e = Q_3 = 0$ and $Q_2^u = 1$, yields an optimal contract such that $\gamma_2(I_w) = \gamma_3(I_w) = 0$. Expected profits under regime I_w are thus given by:

$$(A5) \qquad E[\Pi|I_w] = w_a(1+\rho+\rho^2) - K + \int_{-M-Z(I_w)}^{\infty} (M + Z(I_w) + \eta_2)\rho\ f_2(\eta_2)d\eta_2$$

where $Z(I_w) = \int_{-M}^{\infty} (M + \eta_3)\rho\ f_3(\eta_3)d\eta_3$. On the other hand, for the alternative regime (denote as regime II_w) γ_3 is chosen so that $Q_2^u = 0$. Maximizing (13) subject to (15) (and the constraints that insure that $Q_2^e = Q_2^u = Q_3 = 0$) yields an optimal contract where $\gamma_2(II_w) = (B-w_a)/M$ and $\gamma_3(II_w) = (w_a-B) / (\int_{(\gamma_3(II_w)-1)M}^{\infty} M\ f_3(\eta_3)d\eta_3)\rho$. Expected profits under regime II_w are given by:

$$(A6) \qquad E[\Pi|II_w] = w_a(1 + \rho + \rho^2) - K + \int_{-M+B-w_a}^{\infty} [M + w_a - B + \eta_2]\rho\ f_2(\eta_2)d\eta_2 + (B - w_a)\rho \int_{(\gamma_3(II_w)-1)M}^{\infty} (M + \eta_3)\rho^2\ f_3(\eta_3)d\eta_3.$$

Comparison of (A5) and (A6) reveals that if $B = w_a$, then $E[\Pi|II_w] > E[\Pi|II_w]$ but that if $B < w_a - \int_{-M}^{\infty} (M+\eta_3)\rho\ f_3(\eta_3)d\eta_3$ then $E[\Pi|II_w] <$

$E[\Pi|I_w]$. Since $E[\Pi|II_w] - E[\Pi|I_w]$ is a continuous function over the relevant intermediate range, then by the intermediate value theorem there exists a critical B^* such that for $B < B^*$, $E[\Pi|II_w] < E[\Pi|I_w]$ and for $B > B^*$, $E[\Pi|II_w] > E[\Pi|I_w]$ where B^* is such that:

$$\int_{-M}^{\infty} (M + \eta_3)\rho\ f_3(\eta_3)d\eta_3 < B^* < w_a.$$

(iv) Efficiency requires (22)-(24) to hold. If $B < w_a - \int_{-M}^{\infty} (M + \eta_3)\ f_3(\eta_3)d\eta_3$, then by (23) the worker laid off in period 2 should quit and in regime I_w, since $\gamma_3(I_w) = 0$, this is the case. Moreover, $\gamma_3(I_w) = 0$ implies that (24) holds. As for condition (22), $B < w_a - \int_{-M}^{\infty} (M + \eta_3)\rho\ f_3(\eta_3)d\eta_3$ implies that condition (22) becomes:

$$\eta_2 < -M - \int_{-M}^{\infty} (M + \eta_3)\rho\ f_3(\eta_3)d\eta_3 \tag{A7}$$

Since $\eta_2^*(I_w)$ is equal to the RHS of (A7), regime I_w induces efficient layoffs in period 2 under these circumstances. Hence, if $B < w_a - \int_{-M}^{\infty} (M + \eta_3)\rho\ f_3(\eta_3)d\eta_3$, then regime I_w induces efficient turnover.

On the other hand, if $B = w_a$, then $\gamma_2(II_w) = \gamma_3(II_w) = 0$ and $Q_2^u(II_w) = 0$. In this event, (22)-(24) are obviously satisfied under regime II_w.

However, if $w_a - \int_{-M}^{\infty} (M + \eta_3)\rho\ f_3(\eta_3)d\eta_3 < B < w_a$, and $B < B^*$ so that regime I_w is optimal, then by (22)-(24), there is overemployment of the worker in period 2, an excess probability of quitting by a worker laid off in period 2, and efficient turnover in period 3. Alternatively, if $B < w_a$ but $B > B^*$ so that regime II_w is optimal, then by (22)-(24), there is efficient turnover in period 2 but an excessively high probability of layoffs in period 3.

Severance Pay Contract: Given that there is no deceptive or manipulative behavior by either the firm or the worker, under the severance pay contract (and given that $w_a - \int_{-M}^{\infty} (M + \eta_3)\rho\ f_3(\eta_3)d\eta_3 < B < w_a$) the firm maximizes expected profits given by:

$$\text{(A8)} \qquad E(\Pi) = w_a - w_1 + (1-L_2)\{[(1-\gamma_2)M + E(\eta_2 > \eta_2^*)]\rho + (1-L_3)\ [(1-\gamma_3)M + E(\eta_3|\eta_3 > \eta_3^*)]\rho^2 - L_3S_3\rho^2\} + L_2\{-S_2\rho + (1-Q_2^u)(1-L_3)\ [(1-\gamma_3)M + E(\eta_3|\eta_3 > \eta_3^*)]\rho^2 - L_3S_3\rho^2)\}$$

and the expected income constraint becomes:

$$\text{(A9)} \qquad w^1 + (1-L_2)\ [\gamma_2M\rho + (1-L_3)\gamma_3M\rho^2 + (1-L_3)\gamma_3M\rho^2 + L_3S_3\rho^2] + L_2[S_2\rho + (1-Q_1^u)((B-w_a)\rho + (1-L_3)\gamma_3M\rho^2 + L_3S_3\rho^2] > K - w_a(\rho + \rho^2)$$

The optimal contract calls for $S_3\rho = \gamma_3M\rho > (w_a - B)$ and $B + S_2 = w_a + \gamma_2M$. By (22)-(24), this yields an efficient turnover contract in the absence of deceptive or manipulative behavior.

Seniority Contract

The optimal contract with a third period seniority provision is determined by maximizing expected profits which in this case are:

$$E(\Pi) = w_a - w_1 + (1-L_2)\ [((1-\gamma_2)M + E(\eta_2|\eta_2 > \eta_2^*))\rho + (1-\gamma_3)M\rho^2] + L_2[(1-Q_2^u)(1-\gamma_3)M\rho^2]$$

subject to the expected income constraint which takes the form:

$$w_1 + (1-L_2)(\gamma_2M\rho + \gamma_3M\rho^2) + L_2((B-w_a)\rho + (1-Q_2^u)\gamma_3M\rho^2) = K - w_a(\rho + \rho^2)$$

(and the accompanying constraints that insure $Q_2^e = Q_3 = 0$). The optimal contract calls for two regimes. For regime I_s (which is optimal when $B < w_a - M\rho$), the optimal contract calls for $-\gamma_2(I_s) = \gamma_3(I_s)\rho$ and $0 < \gamma_3(I_s) < (w_a - B)/M\rho$. Expected profits under this regime are given by:

$$\text{(A10)} \qquad E[\Pi|I_s] = w_a(1 + \rho + \rho^2) - K + \int_{-M(1+\rho)}^{\infty} (M(1+\rho) + \eta_2)\rho\ f_2(\eta_2)d\eta_2$$

Under regime II_s (which is optimal when $B > w_a - M\rho$), the optimal contract calls for $\gamma_2(II_s)M = B - w_a$, $w_1(II_s) + \gamma_3(II_s)\rho^2 = K - w_a\rho^2 - B\rho$

and $\gamma_3(II_s) > (w_a - B)/M\rho$. Expected profits under regime II_s are given by:

(A11) $$E[\Pi | II_s] = w_a(1 + \rho + \rho^2) - K + \int_{-M+B-w_a}^{\infty} (M + w_a - B + \eta_2)\rho \, f_2(\eta_2)d\eta_2 + (B-w_a)\rho + M\rho^2$$

Proof of Proposition 2: Comparing (A10) and (A11), reveal that if $B < w_a - M\rho$, then $E[\Pi|I_s] > E[\Pi|II_s]$. Comparing (A10) with (A5) and recognizing that $\int_{-M}^{\infty} (M + \eta_3)\rho \, f_3(\eta_3) > M\rho$ reveals that $E[\Pi|I_w] > E[\Pi|I_s]$. Alternatively, comparing (A10) to (A11) reveal that if $B = w_a$, then $E[\Pi|II_s] > E[\Pi|I_s]$. Moreover, comparing (A11) to (A6) and again noting that $\int_{-M}^{\infty} (M + \eta_3)\rho \, f_3(\eta_3)d\eta_3 > M\rho$, indicates that $E[\Pi|II_w] > E[\Pi|II_s]$. That the seniority contract may nevertheless dominate the simple predetermined wage in the intermediate range $w_a - M\rho < B < w_a$ is demonstrated by the example embodied in equations (29) and (30).