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INVOLUNTARY UNEMPLOYMENT AND THE THREAT TO SHIRKING WORKERS

by

Hiroshi Osano*

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*Department of Economics, Shiga University, Japan, and currently visiting at the Department of Economics, Northwestern University, Evanston, Illinois 60208.

Abstract

This paper examines the worker moral hazard problem under the two multi-period contract models in which firms can use layoff policies as well as deferred payment schemes as an incentive device. The key difference between these two models is the threat to shirking workers. One is a model in which firms threaten shirking workers with contract termination. The other is a model in which firms can make their wage and layoff policies contingent on whether workers shirk in the previous periods or not. The results obtained in both of these models show that the workers' incentive to shirk can yield the involuntary layoff and underemployment of junior or senior workers if workers are strictly risk averse. The results also exhibit that involuntary retention may arise only if firms cannot make their wage policies contingent on whether workers shirk in the previous periods or not.

questions about the implication of the Lazear model to the efficiency wage model. The key point is that deferred payment schemes do not prevent shirking in the beginning of long-term contracts although they may provide sufficient incentive to prevent shirking in the later life of the long-term contracts.

However, the standard efficiency wage model including Akerlof and Katz suffers from another restrictive assumption: Firms eliminate the workers' incentive to shirk by adjusting only wages instead of both wages and employment. This implies that the standard efficiency wage model neglects the effect of the firm's employment policies on the workers' incentive to shirk. This assumption is unduely restrictive because rational contracting firms should consider how their employment policies as well as their wage policies affect the workers' incentive to shirk. Allowing both wage and employment policies a role in the resolution of the workers' shirking problem may lead to richer and more desirable resolution of the problem.

Mookherjee (1986) has recently extended the standard efficiency wage model into the one in which firms can use their employment policies in addition to their wage policies as an incentive device.[2] He constructs a two-period contract model where shirking workers have some probabilities of being employed and receive the same wages and severance payments as no-shirking workers. The main point argued in his paper is that the worker moral hazard hypothesis does not necessarily yield involuntary layoff if firms can use both their wage and their employment policies as incentive devices. He shows that incentives may be better provided through involuntary retention in a wide variety of circumstances: the effort incentives can be provided by the threat of involuntary retention rather than involuntary layoff in later periods.[3]

The Mookherjee's analysis, however, leaves open several questions about

seniority skills model has the advantage of being able to deal with the internal employment structure of the firm explicitly. Ioannides and Pissarides (1983) examine the internal employment structure for junior and senior workers in the presence of uncertainty about outside offers to workers. They show that there exists the involuntary layoff and overemployment of senior workers if workers are risk averse and if firms can monitor the *ex post* outside offers to workers. Oswald (1984) also obtains the result of the involuntary layoff and overemployment of senior workers using the internal labor market framework.

The second purpose of this paper is to reconsider the internal employment structure with the workers' shirking problem independently of firm-specific seniority skills. To do so, we must make a hierarchical firm model based on the workers' shirking problem but not on firm-specific seniority skills. This hierarchical firm model can also generate deferred payment schemes so as to attain our first purpose.

This paper is organized as follows. Section 2-1 describes a multi-period, worker moral hazard model in which the firm uses employment policies and deferred payment schemes as incentive devices and threatens shirking workers with contract termination. Section 2-2 characterizes the stationary optimal contract arrangements of the model. The key result is that the workers' incentive to shirk can yield the involuntary layoff and underemployment of junior or senior workers if workers are strictly risk averse. Section 3 extends the model in section 2 to a more comprehensive model which includes the Mookherjee model as a special case. We show that the workers' shirking problem still provides some satisfactory explanations for involuntary layoff and underemployment even if the firm can freely choose the

> 0. The firm has imperfect ability to monitor shirking. If a worker shirks, there is some probability q per period that he will be caught. The key point of our analysis is how the firm deals with a worker who is caught shirking. In this section, we assume that, if a worker is caught shirking, he will be forced to leave the firm and be paid no severance payments or pensions.[6] We also assume that workers will be unable to return to the firm once the firm detects their shirking and fires them.[7]

The firm offers a lifetime labor contract $\{w_{t1}, s_{t1}, w_{t+1,2}, s_{t+1,2}, w_{t+2,3}, s_{t+2,3}, L_t, l_{t1}, l_{t+1,2}\}$ to workers born in period t (see Fig. 1.). In the first period of the contract, the firm recruits L_t workers born in period t as junior workers, employs $l_{t1}L_t$ junior workers with a wage w_{t1}, and lays off $(1-l_{t1})L_t$ junior workers with a severance pay s_{t1}.[8] If an employed junior worker shirks and gets caught shirking, he is fired and is paid no severance pays or pensions throughout the subsequent periods; otherwise, junior workers are promoted to senior workers in the next period unless they leave the firm. In the second period of the contract, the firm employs $l_{t+1,2}L_t$ senior workers with a wage $w_{t+1,2}$, and lays off $(1 - l_{t+1,2})L_t$ senior workers with a severance pay $s_{t+1,2}$. We assume that the firm is unable to hire any senior workers who did not belong to part of its junior labor force in the previous period. This assumption can be justified if the firm has no records of whether workers outside of its labor force shirked in the previous period. If an employed senior worker shirks and gets caught shirking, he cannot obtain any pensions in the next period; otherwise, employed senior workers receive a pension $w_{t+2,3}$ in the next period. If senior workers are laid off, they receive a pension $s_{t+2,3}$ in the next period.

We assume that the firm has reputations for honesty and does not cheat on

A senior worker employed by the firm in this contract faces two choices in period t+1: shirking or working. If he chooses to shirk and does not get caught shirking, he enjoys the discounted utility stream $U(w_{t+1,2}) + (1+r)^{-1}U(w_{t+2,3}+b)$, where r denotes the discount rate and b represents the outside income accruing from his retirement.[9] In contrast, if he gets caught shirking, his discounted utility stream is $U(w_{t+1,2}) + (1+r)^{-1}U(b)$ because he cannot receive any pensions $w_{t+2,3}$ from the firm in period t+2. He can only obtain the outside income b which accrues from his retirement. Finally, if he chooses not to shirk, he always enjoys the discounted utility stream $U(w_{t+1,2}-e^*) + (1+r)^{-1}U(w_{t+2,3}+b)$. Given these discounted utility streams, senior workers never shirk in period t+1 if and only if

$$U(w_{t+1,2}-e^*) + (1+r)^{-1}U(w_{t+2,3}+b) \geq (1-q)[U(w_{t+1,2}) + (1+r)^{-1}U(w_{t+2,3}+b)] + q[U(w_{t+1,2}) + (1+r)^{-1}U(b)],$$

where q is the probability of being caught. This constraint is rearranged as follows:

$$U(w_{t+1,2}-e^*) + (1+r)^{-1}qU(w_{t+2,3}+b) \geq U(w_{t+1,2}) + (1+r)^{-1}qU(b). \qquad (1)$$

We next discuss the no-shirking condition for junior workers to be satisfied in the lifetime labor contract offered to workers born in period t. If an employed junior worker chooses not to shirk, his discounted expected utility stream in period t is

$$U(w_{t1}-e^*) + (1+r)^{-1}l_{t+1,2}[U(w_{t+1,2}-e^*) + (1+r)^{-1}U(w_{t+2,3}+b)] + (1+r)^{-1}(1-l_{t+1,2})[U(s_{t+1,2}+a) + (1+r)^{-1}U(s_{t+2,3}+b)]. \qquad (2)$$

Here, the first term in (2) is the utility gain in the current period. The

matter if workers are employed or laid off in each point of time, the firm must offer at least the same level of discounted expected utility as that available from the outside opportunities of workers.[10] More specifically, the no-quit constraints to be satisfied by the lifetime labor contract offered to workers born in period t are given according to the age and the employment status of workers as follows: the no-quit constraint for junior workers employed (laid off) in period t, the no-quit constraint for senior workers employed (laid off) in period t+1, and the no-quit constraint for retired workers who are employed (laid off) as senior workers in period t+1. In fact, the no-quit constraints for workers retired in period t+2 automatically hold in the presence of the nonnegativity conditions of pensions ($w_{t+2,3} \geqq 0$ and $s_{t+2,3} \geqq 0$).[11] The no-quit constraint for senior workers laid off in period t+1 is also automatically valid because of the nonnegativity conditions of severance pays and pensions ($s_{t+1,2} \geqq 0$ and $s_{t+2,3} \geqq 0$).[12] Thus, in the subsequent analysis, we will omit these three no-quit constraints in each period.

However, we must specify the other three no-quit constrints in each period. The no-quit constraint for senior workers employed in period t+1 is represented by

$$U(w_{t+1,2}-e^*) + (1+r)^{-1}U(w_{t+2,3}+b) \geqq U(a) + (1+r)^{-1}U(b). \qquad (5)$$

The no-quit constraint for junior workers employed in period t is also written by

$$U(w_{t1}-e^*) + (1+r)^{-1}\{l_{t+1,2}[U(w_{t+1,2}-e^*) + (1+r)^{-1}U(w_{t+2,3}+b)] + (1-l_{t+1,2})[U(s_{t+1,2}+a) + (1+r)^{-1}U(s_{t+2,3}+b)]\} \geqq U(a) + (1+r)^{-1}U(a) + (1+r)^{-2}U(b). \qquad (6)$$

$$1 \geqq l_{t+1,2} \geqq 0. \tag{10}$$

The firm must now choose, for all t, its lifetime labor contracts to maximize the sum of the discounted values of profits subject to constraints (1) and (4)-(10). The sum of the discounted values of the firm's profits is represented by

$$\pi = \sum_{t=1}^{\infty} (1+r)^{1-t}[F(e^*l_{t1}L_t+e^*l_{t2}L_{t-1}) - w_{t1}l_{t1}L_t - s_{t1}(1-l_{t1})L_t$$
$$- w_{t2}l_{t2}L_{t-1} - s_{t2}(1-l_{t2})L_{t-1} - w_{t3}l_{t-1,2}L_{t-2} - s_{t3}(1-l_{t-1,2})L_{t-2}]. \tag{11}$$

Here, the firm is assumed to have infinite horizons, and the price of output is assumed to be constant and to be equal to 1. Note that the units of effective labor of junior (senior) workers in period t are $e^*l_{t1}L_t$ ($e^*l_{t2}L_{t-1}$).

We can now show that we need not consider any lifetime labor contract violating the no-shirking condition for junior or senior workers. To this end, let us notice that the optimal lifetime labor contracts which maximize (11) subject to (1) and (4)-(10) for all t can involve one of the following contract arrangements. One is a lifetime labor contract in which the firm employs both junior and senior workers; that is, $1 \geqq l_{t1} > 0$ and $1 \geqq l_{t2} > 0$. Another is an "early retirement contract" in which the firm employs only junior workers; that is, $1 \geqq l_{t1} > 0$ and $l_{t2} = 0$. The third one is a "strict seniority contract" in which the firm employs only senior workers; that is, $l_{t1} = 0$ and $1 \geqq l_{t2} > 0$. Now, we can easily see that a lifetime labor contract that violates the no-shirking condition for senior (junior) workers is always dominated by an early retirement (a strict seniority) contract. This is because the firm can pay less wages and severance pays in

Since $U' > 0$ and $w_{t1} > w_{t1} - e^*$, it is immediate from (12) that

$$l_{t+1,2}[U(w_{t+1,2}-e^*) + (1+r)^{-1}U(w_{t+2,3}+b)] + (1-l_{t+1,2})[U(s_{t+1,2}+a) + (1+r)^{-1}U(s_{t+2,3}+b)] - [U(a) + (1+r)^{-1}U(b)] \geqq 0. \quad (13)$$

Given $U(s_{t1}+a) \geqq U(a)$, it is found from inequality (13) that (7) is always satisfied in period t as long as (4) is valid in period t. (Q.E.D.)

Now, let us construct the Lagrangean

$$\begin{aligned}\mathcal{L} = \pi &+ \sum_{t=1}^{\infty}(1+r)^{1-t}\lambda_t \cdot [U(w_{t2}-e^*) + (1+r)^{-1}qU(w_{t+1,3}+b) - U(w_{t2}) \\ &- (1+r)^{-1}qU(b)] + \sum_{t=1}^{\infty}(1+r)^{1-t}\mu_t \cdot \{U(w_{t1}-e^*) \\ &+ (1+r)^{-1}q[l_{t+1,2}(U(w_{t+1,2}-e^*) + (1+r)^{-1}U(w_{t+2,3}+b)) \\ &+ (1-l_{t+1,2})(U(s_{t+1,2}+a) + (1+r)^{-1}U(s_{t+2,3}+b)) - U(w_{t1}) \\ &- (1+r)^{-1}q[U(a) + (1+r)^{-1}U(b)]\} + \sum_{t=1}^{\infty}(1+r)^{1-t}\phi_t \cdot [U(w_{t2}-e^*) \\ &+ (1+r)^{-1}U(w_{t+1,3}+b) - U(a) - (1+r)^{-1}U(b)] \\ &+ \sum_{t=1}^{\infty}(1+r)^{1-t}\psi_t \cdot [U(w_{t1}-e^*) + A_{t+1} - U(a) - (1+r)^{-1}U(a) \\ &- (1+r)^{-2}U(b)] + \sum_{t=1}^{\infty}(1+r)^{1-t}\xi_t \cdot [l_{t1}U(w_{t1}-e^*) + (1-l_{t1})U(s_{t1}+a) \\ &+ A_{t+1} - V) + \sum_{t=1}^{\infty}(1+r)^{1-t}\alpha_{t1}(1-l_{t1}) + \sum_{t=1}^{\infty}(1+r)^{1-t}\alpha_{t2}(1-l_{t2}), \quad (14)\end{aligned}$$

where λ_t, μ_t, ϕ_t, ψ_t, ξ_t, α_{t1}, and α_{t2} are the Lagrangean multipliers associated with (1), (4), (5), (6), (8), (9) and (10) in period t; and

$$A_{t+1} = (1+r)^{-1}\{l_{t+1,2}[U(w_{t+1,2}-e^*) + (1+r)^{-1}U(w_{t+2,3}+b)] + (1-l_{t+1,2})[U(s_{t+1,2}+a) + (1+r)^{-1}U(s_{t+2,3}+b)]\}. \quad (15)$$

time-invariant in the stationary state. Thus, to simplify the analysis, we will omit the time subscripts from both the firm's policy variables and the multipliers by assuming the stationary state.[15]

Several results can now be proved. The first two propositions are concerned with the relations between the utility levels of employed and laid off workers in each period of their lifetime.

Proposition 1. Suppose that workers are strictly risk averse. Then, in the second and the third period of their lifetime,

$$s_2 + a = s_3 + b \leq w_2 - e^*, \tag{25}$$

and

$$s_2 + a = s_3 + b \leq w_3 + b, \tag{26}$$

with equalities holding if the no-shirking condition for senior workers is not binding. Thus, in the second and the third period of the workers' lifetime, employed senior workers enjoy no less than the utility level of laid off senior workers; and laid off senior workers obtain the same utility level in these two periods.

Proposition 2. Suppose that workers are strictly risk averse. Then,

$$s_1 + a \leq w_1 - e^*, \tag{27}$$

with equality holding if the no-shirking condition for junior workers is not binding. Thus, in the first period of the workers' lifetime, employed junior workers enjoy no less than the utility level of laid off

(For example, see Shapiro and Stiglitz (1984).) However, some researchers suggest that implicit bonding through deferred payment schemes can exclude involuntary layoff (see Carmichael (1985) and the Introduction of Akerlof and Yellen (1986)). Recently, Akerlof and Katz (1986) have shown that deferred payment schemes cannot avoid the involuntary layoff of risk neutral workers. The result of Proposition 1 is consistent with that of Akerlof and Katz only if workers are strictly risk averse. This difference stems from the assumption of the Akerlof and Katz model that the firm does not give any severance pays to its laid off workers. Third, Alvi (1986) derives the involuntary layoff of risk averse workers from the one-period implicit contract model with the incentive-compatibility constraints on the workers' effort. Although the threat mechanism to shirking workers is different,[16] his conclusion does not contradict with ours. Finally, assuming that shirking and no-shirking workers have different layoff probabilities, Mookherjee (1986) shows that the effort incentives may be provided by the threat of involuntary retention rather than involuntary layoff in a wide variety of circumstances. In the next section, we will explore this problem by assuming that the firm can freely choose the threat to shirking workers.

The next proposition discusses whether junior or senior workers are really laid off.

Proposition 3. Suppose that workers are strictly risk averse. Then the firm can lay off only junior or senior workers. If neither the no-shirking condition for junior workers nor the no-shirking condition for senior workers is binding, then both junior and senior workers are fully employed.

shirking condition for junior workers is not binding. Thus, the firm determines its employment level such that the marginal productivity of workers is greater than or equal to the income from job opportunities outside of the firm plus the disutility effort of workers.

Proof. See Appendix.

Proposition 4 shows that underemployment can occur with deferred payment schemes if workers are strictly risk averse and if either the no-shirking condition for junior workers or the no-shirking condition for senior workers is binding. On the other hand, if workers are risk neutral, or if the shirking problem of both junior and senior workers can be avoided, the firm can set the efficient level of employment by providing complete income insurance to workers.

Let us mention some comments about Proposition 4. First, using the firm-specific seniority skills model with uncertainty about outside wage offers to workers, Ioannides and Pissarides (1983) conclude that the firm does not layoff all senior workers who receive an outside offer which is higher than the value of the marginal product of senior workers. This conclusion implies that there exists the overemployment of senior workers. Oswald (1984) also obtains the overemployment of senior workers in the absence of severance payments within the internal labor market model. In contrast, Proposition 4 shows that the underemployment of junior or senior workers can occur with the shirking problem on the workers' effort. Second, the efficiency wage model of Akerlof and Katz (1985) exhibits that the underemployment of risk neutral workers can emerge in the presence of deferred payment schemes. However, the result of Proposition 4 is consistent with their finding only if workers are

involuntary retention never occurs if all shirking workers are forced to leave the firm and are paid neither severance pays nor pensions. Thus, it may be thought that the conclusion of involuntary layoff and underemployment in the previous section critically depends on the assumption that the firm threatens shirking workers with contract termination.

One may also suspect that a lifetime labor contract with the threat of contract termination is always dominated by a lifetime labor contract with the threat of differences between the employment probabilities of shirking and no-shirking workers. The intuition behind this prediction is that the firm is forced to employ less policy variables in the former contract than in the latter contract. However, suppose that the firm must pay the same wages, severance pays and pensions to both shirking and no-shirking workers as long as the contract relation continues. Then, contract termination is a more stronger threat to shirking workers than involuntary layoff or involuntary retention. Thus, under this situation, we cannot determine which lifetime labor contract is Pareto superior.

Now, suppose that the firm offers a "generalized" lifetime labor contract which makes not only employment probabilities but also wages, severance pays and pensions contingent on whether workers shirk in the previous periods or not. Then, the lifetime labor contract with the threat of contract termination can be viewed as a special case of the "generalized" lifetime labor contract. The lifetime labor contract in the Mookherjee model can also be interpreted as a special case of the "generalized" lifetime labor contract. Thus, this generalization enables us to consider which cotract arrangements are optimal if the firm can choose the threat to shirking workers without restrictions.

previous section, this assumption need not be required, because shirking workers must always leave the firm under threat of contract termination.[20] Third, it is assumed that the firm can choose whether to retain shirking workers inside its labor pool. This assumption implies that the no-quit constraints for shirking workers need not be satisfied although some of these constraints are automatically valid. Fourth, we must distinguish the employment probabilities for senior workers according as they shirk or do not shirk in the previous period.[21,22] Let l_{t2} denote the employment probability in period t for senior workers who do not shirk in the previous period. We also introduce n_{t2} which denotes the employment probability in period t for senior workers who shirk in the previous period. Finally, we assume that the wages, severance payments and pensions for both senior and retired workers are contingent on whether they shirk in the previous periods or not.[23] Then, senior workers receive w_{t2} and s_{t2} as the wage and the severnce pay in period t if they do not shirk in the previous period; otherwise, workers obtain x_{t2} and y_{t2} as the wage and the severance pay in period t. Similarly, retired workers have six choices in period t; retired workers receive w_{t3} if they do not shirk in the previous two periods; x_{t3} if they shirk in the previous two periods; p_{t3} if they do not shirk in the first period, but they shirk in the second period; z_{t3} if they shirk in the first period, but they do not shirk in the second period; s_{t3} if they do not shirk in the first period, and they become laid off in the second period; and y_{t3} if they shirk in the first period, and they become laid off in the second period (see Fig. 2.).

An optimal lifetime labor contract offered by the firm to workers born in period t $\{w_{t+i,i+1}, s_{t+i,i+1}, x_{t+j,j+1}, y_{t+j,j+1}, p_{t+2,3}, z_{t+2,3}, L_t, l_{t1}, l_{t+1,2}, n_{t+1,2}\}$ $(i = 0, 1, 2;\ j = 1, 2;\ t = 1,\ldots,\infty)$ can now be derived from

$$1 \geqq l_{t+i,i+1} \geqq 0, \qquad i = 0, 1;\ t = 1,\ldots, \infty, \tag{36}$$

$$1 \geqq n_{t+1,2} \geqq 0, \qquad t = 1,\ldots, \infty, \tag{37}$$

$$w_{t+i,i} \geqq 0, \qquad i = 0, 1, 2;\ t = 1,\ldots, \infty, \tag{38}$$

$$s_{t+i,i+1} \geqq 0, \qquad i = 0, 1, 2;\ t = 1,\ldots, \infty, \tag{39}$$

$$x_{t+i,i+1} \geqq 0,\ y_{t+i,i+1} \geqq 0,\ p_{t+2,3} \geqq 0,\ z_{t+2,3} \geqq 0,$$
$$i = 1, 2;\ t = 1,\ldots, \infty. \tag{40}$$

Equation (29) represents the sum of the discounted values of the firm's profits. We need not consider any possibility of the workers' cheating in (29), because the no-shirking conditions, both for junior and for senior workers, rule out the possibility of the workers' cheating. Unlike the maximization problem in the previous section, three no-shirking conditions are required in each period. Constraint (30) ((31)) describes the no-shirking conditions for senior workers who *do not shirk* (*shirk*) in the previous period. When formalizing (30) and (31), we can neglect the quit behavior of shirking workers in the retirement period, for shirking workers never quit in the retirement period under the nonnegativity conditions of their pensions. Constraint (32) implies the no-shirking conditions for junior workers. Given the no-shirking conditions for senior workers, (30) and (31), we need not allow for any possibility of cheating of senior workers in (32). However, since the firm can choose whether to retain shirking junior workers as senior workers, we must consider the quit behavior of shirking junior workers in the second period of their lifetime. The right-hand side of (32) reflects this consideration. Besides the no-shirking conditions, feasible lifetime labor

labor contracts in the present section. These findings imply that a solution to maximization problem (29) is not dominated by any solution to the Mookherjee model or to the model of the previous section.

We first explore the properties of a solution to maximization problem (29) subject to (30)-(40) with the added restrictions that $w_{t2} = x_{t2}$, $s_{t2} = y_{t2}$, $w_{t3} = z_{t3}$, $s_{t3} = y_{t3}$, and $p_{t3} = x_{t3}$ in each period. As has been argued above, this kind of contract model is regarded as an extension of the Mookherjee model to the three-period framework with the layoff policy for junior workers. The optimal contracts to this maximization problem must satisfy the following proposition:

Proposition 5. Suppose that workers are strictly risk averse. Then the firm can lay off only junior or senior workers. If junior workers are laid off, the optimal lifetime labor contracts can yield the involuntary layoff and underemployment of junior workers. If senior workers are laid off, the optimal lifetime labor contracts can generate either the involuntary retention and overemployment or the involuntary layoff and underemployment of senior workers.

Proof. See Appendix.

Proposition 5 shows that the conclusion of the possibility of involuntary retention in the Mookherjee model is true only for senior workers. The reason for this result is that the firm cannot make the employment probability for junior workers contingent on whether they shirk in the previous period or not; and, as a result, the firm cannot use the layoff policy for junior workers as an incentive device. This finding also implies that the conclusion of the

$$s_{t3}: -L_{t-2} + (\mu_{t-2} + \psi_{t-2} + \xi_{t-2})U'(s_{t3}+b) = 0, \quad (46)$$

$$L_t: e^*l_{t1}F'(e^*l_{t1}L_t+e^*l_{t2}L_{t-1})$$
$$+ (1+r)^{-1}e^*l_{t+1,2}F'(e^*l_{t+1,1}L_{t+1}+e^*l_{t+1,2}L_t) - [w_{t1}l_{t1} + s_{t1}(1-l_{t1})$$
$$+ (1+r)^{-1}w_{t+1,2}l_{t+1,2} + (1+r)^{-1}s_{t+1,2}(1-l_{t+1,2})$$
$$+ (1+r)^{-2}w_{t+2,3}l_{t+1,2} + (1+r)^{-2}s_{t+2,3}(1-l_{t+1,2})] = 0, \quad (47)$$

$$l_{t1}: e^*L_tF'(e^*l_{t1}L_t+e^*l_{t2}L_{t-1}) - w_{t1}L_t + s_{t1}L_t + \xi_t \cdot [U(w_{t1}-e^*)$$
$$- U(s_{t1}+a)] - \alpha_{t1} = 0, \quad (48)$$

$$l_{t2}: e^*L_{t-1}F'(e^*l_{t1}L_t+e^*l_{t2}L_{t-1}) - w_{t2}L_{t-1} + s_{t2}L_{t-1} - (1+r)^{-1}w_{t+1,3}L_{t-1}$$
$$+ (1+r)^{-1}s_{t+1,3}L_{t-1} + [U(w_{t2}-e^*) + (1+r)^{-1}U(w_{t+1,3}+b) - U(s_{t2}+a)$$
$$- (1+r)^{-1}U(s_{t+1,3}+b)](\mu_{t-1} + \psi_{t-1} + \xi_{t-1}) - \alpha_{t2} = 0, \quad (49)$$

$$x_{t2}: \lambda_{t,s} \cdot [U'(x_{t2}-e^*) - U'(x_{t2})] - \delta_t\mu_{t-1} \cdot n_{t2}U'(x_{t2}-e^*) + \omega_{t2} = 0, \quad (50)$$

$$y_{t2}: -\delta_t\mu_{t-1} \cdot (1-n_{t2})U'(y_{t2}+a) + \theta_{t2} = 0, \quad (51)$$

$$x_{t3}: -\lambda_{t-1,s} \cdot U'(x_{t3}+b) + \omega_{t3} = 0, \quad (52)$$

$$y_{t3}: -\delta_t\mu_{t-2} \cdot (1-n_{t-1,2})U'(y_{t3}+b) + \theta_{t3} = 0, \quad (53)$$

$$p_{t3}: -\lambda_{t-1,w} \cdot U'(p_{t3}+b) + \zeta_t = 0, \quad (54)$$

$$z_{t3}: \lambda_{t-1,s} \cdot U'(z_{t3}+b) - \delta_{t-1}\mu_{t-2} \cdot n_{t-1,2}U'(z_{t3}+b) + \eta_t = 0, \quad (55)$$

$$n_{t2}: -[U(x_{t2}-e^*) + (1+r)^{-1}U(z_{t+1,3}+b) - U(y_{t2}+a)$$
$$- (1+r)^{-1}U(y_{t+1,3}+b)]\delta_t\mu_{t-1} - \beta_{t1} + \beta_{t2} = 0. \quad (56)$$

Here, $(1+r)^{-t}\lambda_{t+1,w}$, $(1+r)^{-t}\lambda_{t+1,s}$, $(1+r)^{1-t}\mu_t$, $(1+r)^{-t}\phi_{t+1}$, $(1+r)^{1-t}\psi_t$,

Proposition 6. In the stationary state, the results of Propositions 1-4 in the previous section still hold even if the firm can make wages, severance pays, pensions and employment policies contingent on whether workers shirk in the previous periods or not.

Proposition 6 implies that, even under the "generalized" contract model with the threat of differences between the employment probabilities of shirking and no-shirking workers, the workers' shirking problem can cause the involuntary layoff and underemployment of junior or senior workers if workers are strictly risk averse; in contrast, the workers' shirking problem never yield involuntary retention. This finding suggests that the worker moral hazard hypothesis provides some explanations for involuntary layoff and underemployment. Combining Propositions 5 and 6 also shows that the result of involuntary retention of the Mookherjee model stems from the assumption that the firm cannot make wages or severance payments for senior workers contingent on whether senior workers shirk in the previous period or not. On the other hand, this proposition ensures that the results in the previous section are still valid even though the firm can choose the threat to shirking workers without restrictions.

4. Conclusion

This paper has explored the two multi-period contract models in which the firm can employ layoff policies as well as deferred payment schemes to prevent workers from shirking. One is a model in which the firm threatens shirking

Appendix

The purpose of this appendix is to prove Propositions 1-5. Before proceeding to the proof, we obtain the following equations by omitting the time subscripts from (16)-(24):

$$w_1: -l_1L + \mu \cdot [U'(w_1-e^*) - U'(w_1)] + (\psi + \xi l_1)U'(w_1-e^*) = 0, \quad \text{(A1)}$$

$$s_1: -L + \xi \cdot U'(s_1+a) = 0, \quad \text{(A2)}$$

$$w_2: -l_2L + \lambda \cdot [U'(w_2-e^*) - U'(w_2)] + (\mu q l_2 + \phi + \psi l_2 + \xi l_2)U'(w_2-e^*) = 0, \quad \text{(A3)}$$

$$s_2: -L + (\mu q + \psi + \xi)U'(s_2+a) = 0, \quad \text{(A4)}$$

$$w_3: -l_2L + (\lambda q + \mu q l_2 + \phi + \psi l_2 + \xi l_2)U'(w_3+b) = 0, \quad \text{(A5)}$$

$$s_3: -L + (\mu q + \psi + \xi)U'(s_3+b) = 0, \quad \text{(A6)}$$

$$L: [l_1 + (1+r)^{-1}l_2]e^*F'(e^*l_1L+e^*l_2L) - [w_1l_1 + s_1(1-l_1) + (1+r)^{-1}w_2l_2 + (1+r)^{-1}s_2(1-l_2) + (1+r)^{-2}w_3l_2 + (1+r)^{-2}s_3(1-l_2)] = 0, \quad \text{(A7)}$$

$$l_1: e^*LF'(e^*l_1L+e^*l_2L) - w_1L + s_1L + \xi [U(w_1-e^*) - U(s_1+a)] - \alpha_1 = 0, \quad \text{(A8)}$$

$$l_2: e^*LF'(e^*l_1L+e^*l_2L) - w_2L + s_2L - (1+r)^{-1}w_3L + (1+r)^{-1}s_3L + [U(w_2-e^*) + (1+r)^{-1}U(w_3+b) - U(s_2+a) - (1+r)^{-1}U(s_3+b)](\mu q + \psi + \xi) - \alpha_2 = 0. \quad \text{(A9)}$$

Proof of Proposition 1:

We first show that (25) and (26) are derived from the first-order

which completes the proof of this lemma. (Q.E.D.)

Using (A13), (A14) and Lemma A1, we now complete the proof of Proposition 1.

Proof of Proposition 2:

We prove that (27) is obtained from the first-order conditions for w_1 and s_1. Rearranging (A1) and (A2) gives us

$$U'(w_1-e^*) = \xi^{-1}L - (\xi l_1)^{-1}\{\mu \cdot [U'(w_1-e^*) - U'(w_1)] + \psi \cdot U'(w_1-e^*)\}, \tag{A16}$$

$$U'(s_1+a) = \xi^{-1}L. \tag{A17}$$

Given $w_1-e^* < w_1$, $U'' < 0$, $\psi \geqq 0$, $\mu \geqq 0$, and $\xi \geqq 0$, it follows from (A16) and (A17) that

$$s_1 + a \leqq w_1 - e^*, \tag{A18}$$

with equality holding if neither the no-shirking condition for junior workers nor the no-quit constraint for employed junior workers is binding (i.e., $\mu = \psi = 0$). The remaining problem is to show the following lemma:

Lemma A2. The no-quit constraint for employed junior workers, (6), is automatically satisfied under the optimal stationary contract. Thus, the nonnegative multiplier ψ can always be set equal to zero.

Proof. Using (A15) and (A18), it is seen that

$$U(w_1-e^*) + (1+r)^{-1}\{l_2[U(w_2-e^*) + (1+r)^{-1}U(w_3+b)] + (1-l_2)[U(s_2+a) + (1+r)^{-1}U(s_3+b)]\} \geqq U(s_1+a) + (1+r)^{-1}\{l_2[U(a) + (1+r)^{-1}U(b)] + (1-l_2)[U(s_2+a) + (1+r)^{-1}U(s_3+b)]\} \geqq U(a) + (1+r)^{-1}U(a) + (1+r)^{-2}U(b),$$

$$e^*LF'(e^*l_1L+e^*l_2L) - (e^* + a)L - \alpha_2 = 0. \quad \text{(A21)}$$

It is immediate from (A20) and (A21) that

$$\alpha_1 = \alpha_2 = L[e^*F'(e^*l_1L+e^*l_2L) - (e^* + a)]. \quad \text{(A22)}$$

Substituting (A19) into (A22) yields

$$\alpha_1 = \alpha_2 = [l_1 + (1+r)^{-1}l_2]^{-1}L[s_1 + (1+r)^{-1}s_2 + (1+r)^{-2}s_3] > 0, \quad \text{(A23)}$$

which implies that $l_1 = 1$ and $l_2 = 1$.

Proof of Proposition 4:

We first examine the relation between the marginal productivity of workers and the opportunity cost of labor using the optimal conditions for contract arrangements about senior workers. It follows from Proposition 1 that

$$w_2 - e^* \geq s_2 + a, \quad \text{(A24)}$$

$$w_3 + b \geq s_3 + b, \quad \text{(A25)}$$

with equalities holding if the no-shirking condition for senior workers is not binding (i.e., $\lambda = 0$). Given (A24), (A25) and the strict concavity of the utility function of workers, we see

$$U(w_2-e^*) + (1+r)^{-1}U(w_3+b) - U(s_2+a) - (1+r)^{-1}U(s_3+b)$$
$$\leq U'(s_2+a)(w_2 - e^* - s_2 - a) + (1+r)^{-1}U'(s_3+b)(w_3 - s_3), \quad \text{(A26)}$$

with equality holding if the no-shirking condition for senior workers is not

(2) If junior workers are laid off (i.e., $\alpha_1 = 0$), then $e^*F'(e^*l_1L+e^*l_2L) \geq e^* + a$, with equality holding if the no-shirking condition for junior workers is not binding (i.e., $\mu = 0$).

Proof of Proposition 5:

We first prove that the involuntary layoff and underemployment of junior workers can occur if junior workers are laid off. For this purpose, we derive the first-order conditions with respect to w_{t1}, s_{t1}, and l_{t1} for maxmization problem (29) subject to (30)-(40) with the added restrictions that $w_{t2} = x_{t2}$, $s_{t2} = y_{t2}$, $w_{t3} = z_{t3}$, $s_{t3} = y_{t3}$, and $p_{t3} = x_{t3}$ in each period:

$$w_{t1}: -l_{t1}L_t + \mu_t \cdot [U'(w_{t1}-e^*) - U'(w_{t1})] + (\psi_t + \xi_t \cdot l_{t1})U'(w_{t1}-e^*) = 0, \tag{A31}$$

$$s_{t1}: -L_t + \xi_t \cdot U'(s_{t1}+a) = 0, \tag{A32}$$

$$l_{t1}: e^*L_tF'(e^*l_{t1}L_t+e^*l_{t2}L_{t-1}) - w_{t1}L_t + s_{t1}L_t + \xi_t \cdot [U(w_{t1}-e^*) - U(s_{t1}+a)] = 0, \tag{A33}$$

where $(1+r)^{1-t}\mu_t$, $(1+r)^{1-t}\psi_t$, and $(1+r)^{1-t}\xi_t$ are the nonnegative multipliers associated with (32), (34), and (35). Note that the nonnegative multiplier associated with the constraint of $1 > l_{t1}$ becomes zero in (A33) because junior workers are laid off. Now, applying the procedure of the proof of Proposition 2, we see from (A31) and (A32) that

$$w_{t1} - e^* \geq s_{t1} + a. \tag{A34}$$

Similarly, using the procedure of the proof of Proposition 4, we find from

If $\mu_{t-1} > 0$, then (A38) and (A39) give us $\beta_{t1} > \beta_{t2} \geq 0$, which implies that $n_{t2} = 1$. Now, application of the procedure of the proof of Proposition 4 to (A36) and (A37) can lead to

$$e^{*}F'(e^{*}l_{t1}L_{t}+e^{*}l_{t2}L_{t-1}) < e^{*} + a, \tag{A40}$$

which contradicts (A35). If $\mu_{t-1} = 0$, we can again obtain (A40) using the procedure of the proof of Proposition 4. These arguments show that, if senior workers are laid off in period t, then

$$U(w_{t2}-e^{*}) + (1+r)^{-1}U(w_{t+1,3}+b) \geq U(s_{t2}+a) + (1+r)^{-1}U(s_{t+1,3}+b). \tag{A41}$$

Now, applying the procedure of the proof of Proposition 3 with (A41), we can verify that senior workers are fully employed if junior workers are laid off. Similarly, we can also prove that junior workers are fully employed if senior workers are laid off.

Finally, in this additionally constrained maximization problem (29), we cannot exclude the possibility that the optimal lifetime labor contracts can generate the involuntary retention and overemployment of senior workers. This finding completes the proof of Proposition 5.

7. Relaxation of this assumption does not affect any results in the subsequent analysis.

8. The present model cannot exclude the possibility that junior workers are laid off ($1 > l_{t1} \geq 0$). The reason is that the firm views junior and senior workers as heterogeneous because of the "no-shirking conditions" argued below. Thus, it should not be surprising that the firm benefits from employing more senior workers than junior workers. Then, the firm will desire to retain part of future senior workers as laid off junior workers if the firm cannot hire any senior workers from the outside labor market.

9. We can view "b" as public pension benefits.

10. The no-quit constraints are also incorporated into the models developed by Mookherjee (1986) and Meyer (1987). In the present paper, we assume that all workers have identical opportunities outside of the firm, and these common opportunities are known to both firms and workers. Thus, we abstract from the adverse selection problems analyzed by Geanakoplos and Ito (1981), Ioannides and Pissarides (1983), Kahn (1985), Moore (1985), and Mookherjee (1988).

11. Workers are assumed to retire in the third period of their lifetime irrespective of whether they work inside the firm or outside the firm. The no-quit constraints for workers retired in period t+2 are then

$$U(w_{t+2,3}+b) \geq U(b) \text{ and } U(s_{t+2,3}+b) \geq U(b),$$

which are never binding except $w_{t+2,3} = 0$ or $s_{t+2,3} = 0$.

12. The no-quit constraint for senior workers laid off in period t+1 is

$$U(s_{t+1,2}+a) + (1+r)^{-1}U(s_{t+2,3}+b) \geq U(a) + (1+r)^{-1}U(b),$$

which is never binding except $s_{t+1,2} = s_{t+2,3} = 0$.

22. In the subsequent analysis, "do not shirk" means that workers work or become laid off.

23. See note 21.

24. The no-quit constraint for no-shirking senior workers who are laid off is always satisfied under the nonnegativity conditions of severance pays and pensions. It is also verified from the procedure similar to the proof of Lemma 1 that the no-quit constraint for no-shirking junior workers who are laid off is always valid.

25. In this setting, (30) and (31) reduce to the same constraints; and the right-hand side of (32) is simplified because the firm always chooses to retain shirking workers inside its labor pool. However, to induce employed senior workers not to shirk, we must still make their pensions contingent on whether they work or shirk; that is, $w_{t3} \neq p_{t3}$.

26. If $n_{t2} = 0$, then the values of x_{t2}, x_{t3}, and z_{t3} have no effects on the optimal lifetime labor contracts to be implemented actually. Thus, we can freely choose these values in each period.

27. As in the previous section, this assumption implies that we do not discuss either an "early retirement contract" or a "strict seniority contract".

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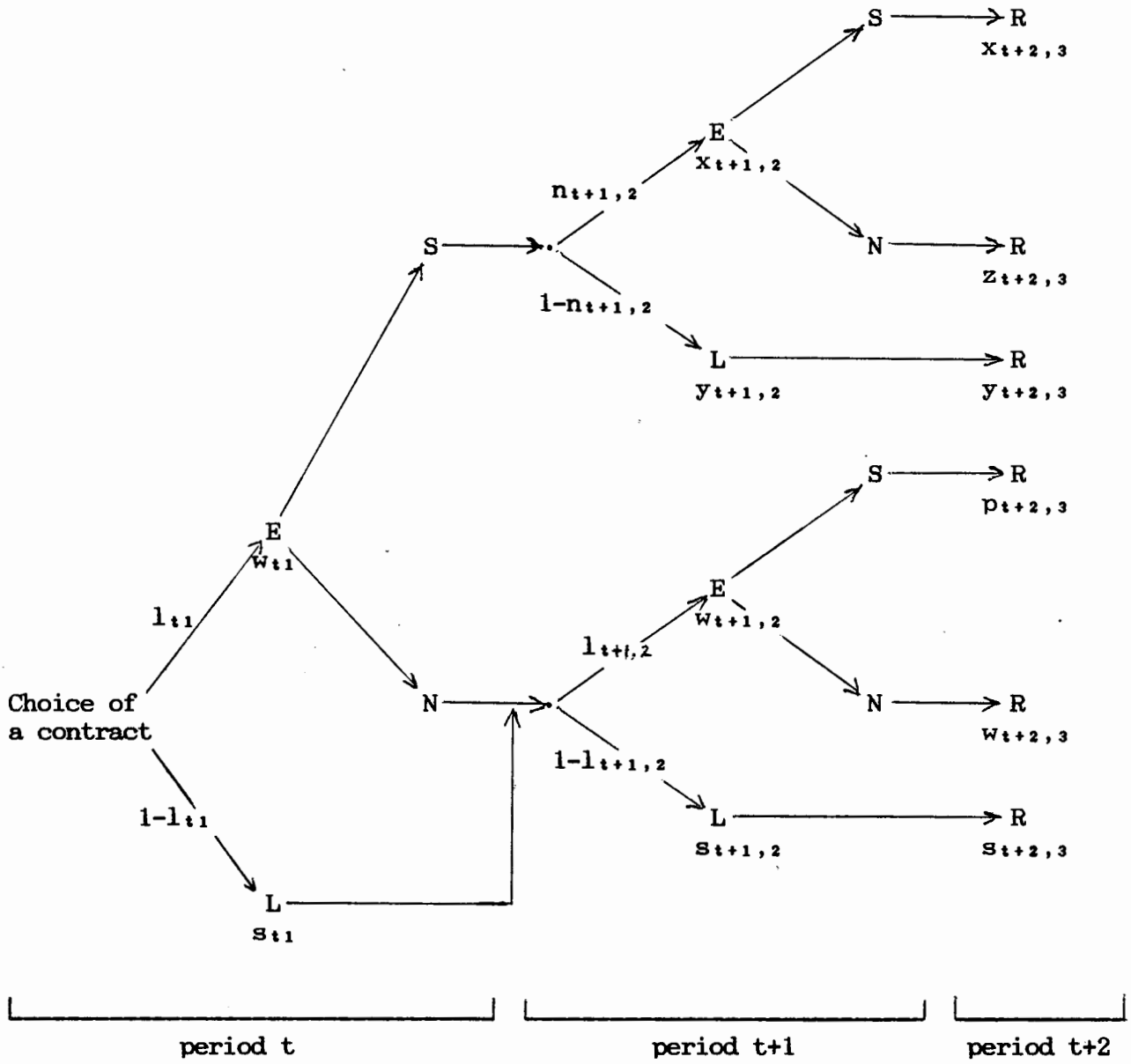

Fig. 2. Lifetime labor contract with the differences between the employment probabilities of shirking and no-shirking workers. E: employed state; L: laid off state; S: shirking; N: no-shirking; and R: retired state.