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WAGE AND EMPLOYMENT FLUCTUATIONS

IN A CONTRACTUAL ECONOMY

Hiroshi Osano

CONTENTS

Chapter 1

Introduction

1. Introduction

The past one and a half decades have witnessed a growing interest in contract theories of various kinds. One strand of the literature has focused on the workings of the labor market, and has discussed whether contractual equilibria will exhibit the commonly claimed inefficiencies associated with real-world adjustments in employment. The representative examples are found in the implicit labor contract theory originated from Baily (1974) and Azariadis (1975) and in the efficiency wage theory pioneered by Shapiro and Stiglitz (1984). These theories are based on the ideas that labor is generally not traded in an auction labor market between anonymous trades, and that the employment relationship is relatively long-term. In these views, wage stickiness and inefficient unemployment prevail as an outcome of risk-sharing arrangements between firms and workers or moral hazard problems of workers. In spite of these developments, a lot of problems remain to be solved with the contract theory from both a theoretical and an empirical point of view. The purpose of this thesis is to discuss these remaining problems extensively.

The Azariadis-Baily implicit contract theory relies on the assumption that a worker does not have any ex-post opportunities outside the firm of his ex-ante contract. If this assumption does not hold, the worker may quit the firm when he enjoys higher expected utiltiy by joining another job outside the firm. Chapter 2 aims to account for the possibility of interfirm labor mobility. Specifically, we extend an implicit labor contract model with bargaining which allows for the ex-post interfirm mobility of workers within a multi-sector economy. The main concern of this chapter is with investigation of the qualitative properties of the model such as stability. The results may be summarized by the following: The implicit contracts system has its

organizational stability in the sense that the stationary equilibrium is globally stable. This conclusion suggests that the employment system of implicit labor contracts is maintained as a stable one within the general equilibrium framework.

In the standard efficiency wage model developed by Shapiro and Stiglitz (1984), firms try to eliminate the workers' interest to shirk on their jobs by paying a wage in excess of market-clearing and by terminating their contract relations if firms detect their worekrs in shirking. Since firms select their employment levels in response to the wage above market clearing, the efficiency wage model predicts underemployment with involuntary layoff. One of the criticisms to the efficiency wage model is that the efficiency wage model does not tell us why firms and workers negotiate the contract arrangements with the threat of contract termination. To solve this problem, Chapter 3 explores two multi-period contract models with endogenous monitoring in which firms can use layoff policies as an incentive device in combination with deferred payment schemes. One is a model in which firms threaten shirking workers with contract termination. The other is a model where wage and layoff policies are allowed to depend on whether or not workers are caught shirking in the previous periods. The results obtained in both of these models show (i) that the threat of contract termination is an optimal instrument to overcome the worker moral hazard problem even if threat policies are endogenously determined, and (ii) that the workers' incentive to shirk can yield strict involuntary layoff and inefficiently high unemployment (underemployment) if workrs are strictly risk averse. The results also exhibit that involuntary retention may arise only if wage policies are not allowed to depend on whether or not workers are caught shirking in the previous periods. Furthermore, if the layoff in this model is interpreted as

the transfer of workers among firms or within firms, the result of involuntary layoff can provide a rationale for the transfer system of workers in Japanese large firms.

Apart from the worker's side issues of the contract theory, there remain several problems to justify the critical assumptions on the firm's behavior in the contract theory. One of the crucial assumtions is that the firm is committed to an agreed upon contract until the beginning of the next contracting period. If this assumption is violated, the firm may default the ex-ante contracxt on an unfavourable state in which the wage rate exceeds the marginal product of labor. Chapter 4 examines a role of reputation in an implicit labor contract model where firms cannot commit themselves to their contract arrangements. In contrast to the recent literature on reputation in the industrial organization, we show that an optimal contract under symmetric information enforces efficient behavior on firms irrespective of the presence of reputational problems. On the other hand, even though firms are risk neutral, we prove that an optimal contract under asymmetric information can involve underemployment and involuntary unemployment in the presence of reputational problems. We also shed light the question why laid off workers cannot receive full amount of severance pay.

Recently, several researchers have paid attention to the inefficiency which arises from dynamic labor contracts under asymmetric information (see Laffont and Tirole [1988] and Hart and Tirole [1988]). Chapter 5 discusses the distortion of employement within a two-period, asymmetric information contracting model in which an exogenous demand shock is serially correlated and is known only to firms. The obtained results show that serial correlations of the state of nature can cause not only underemployment but also overemployment even when overemployment never occurs in the context of a

static, asymmetric information contracting model.

Although integration of imperfect product-market competition and labor contracts may be called by reality, very few researchers consider such interactions simultaneously. Nevertheless, it is clear that product market strategies such as entry, exit or predation could affect labor contract issues. In Chapter 6, an incumbent firm uses its contracting arrangements with its union workers to signal its cost type and to deter the entry of a potential entrant who does not know the incumbent's cost type. The analysis shows that, whether an equilibrium is separating or pooling, the signaling process causes the same kind of distortions in employment and prices, and no distortions in wages and severance pays. The distortions in employment and prices are summarized as follows: if an optimal employment level of the low-cost incumbent in the absence of the threat of entry is large enough, the signaling causes overemployment and a downward distortion in price; otherwise, the signaling may result in underemployment and an upward distortion in price.

In the last two chapters, we turn our attention to the empirical and the macroeconomic implications of the contracting approach. Much effort has not been made to test the contract model even though a few attempts have been made in the efficiency model (see Krueger and Summers [1988]). Chapter 7 estimates an implicit contract model with data in the Japanese labor market using the approach developed in Osano and Tsutsui [1985][1986] in the bank loan market. The empirical results suggest that implicit contract relations in real terms are not rejected in the Japanese labor market. This finding gives evidence (i) that a certain degree of observed wage rigidity reflects the outcome of efficient risk-sharing arrangements between firms and worekrs; and (ii) that real disturbances have more impact on output and employment levels than nominal disturbances.

Chapter 8 tests a real business cycle model with effcient long-term contracts (the efficient long-term contract model) against a standard real business cycle model (the intertemporal substitution model). In the former model, employment and real wages are determined by bilateral dynamic bargaining between firms and worekrs. In the latter model, employment and real wages are determined instead by the dynamic optimization of households within the competitive market framework. Our theoretical argument shows that the intertemporal subsitution model is nested within the efficient long-term contract model if labor input adjustments are made by means of work sharing alone. We then estimate each model using aggregate Japanese data. Our results show that the data are consistent with the efficient long-term contract model, but are inconsistent with the intertemporal subsitution model. This finding provides some support in favor of real business cycle models with efficient long-term contracts.

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Chapter 2

The Structural Stability of an Implicit

Labor Contract System in the Multi-Sector Economy

2. The Structural Stability of an Implicit Labor Contract System in the Multi—Sector Economy

2-1. Introduction

A great deal of attention has been paid to the implicit labor contract theory explored by Azariadis (1975) and Baily (1974). It is assumed, in the theory, (i) that the firm maximizes its expected profits subject to the constraint that workers are guaranteed to attain an expected utility level being at least equal to the one offered outside the firm, and (ii) that workers have no ex—post employment opportunity elsewhere in the economy after being contract with the firm. The implicit labor contract theory characterized with these assumptions has reached remarkable conclusions that follow: First, in the absence of the state contingent commodity market, the risk neutral firm and its risk averse workers have mutual incentives to enter into an implicit labor contract which makes both better off to the competitive auction labor contract. Second, the wage stickiness prevails as an outcome of the implicit labor contract regardless of uncertainty. Third, full employment is not always realized by the implicit labor contract in which each worker has utility of leisure or a right to receive unemployment insurance benefits.

However, a lot of problems remain to be solved with the standard implicit labor contract theory from a theoretical point of view. First, the theory has no explicit explanation for how the worker's reservation utility level is determined. Negishi (1979) assumes that it turns out to be the utility level maintained in the competitive auction contract. This implicitly takes a position that all the quasi rents are passed to the firm. This is equivalent to assuming that workers are indifferent to choose which of implicit labor contracts and competitive auction contracts. It may be instructive to provide a story of internal bargaining between the firm and its workers with regard to the determination of the reservation utility level.

The second problem arises from the assumption that every worker cannot move to another firm once he makes a contract with one firm.[1] If we live in the economy consisting

of a variety of firms, such a restrictive assumption may lead to a situation in which there remain differentials in reservation utility levels among different firms. This being the case, it is natural for workers to have motivation to move to another firm that offers a higher reservation utility level.

In view of the present stage of the study, this chapter aims to provide an implicit labor contract model with a multi–sector economy. The model allows for the bargaining between the manager and workers within each firm,[2] and then considers the interfirm mobility of workers who move one firm to another when they can enjoy a higher expected utility level by doing so. The major concern is to illucidate the implications of the bargaining game within each firm and to examine the structural stability of workers' movements in the implicit contract model.

This chapter is organized as follows. The next section is devoted to specifying a bargaining model in the temporary equilibrium in which the number of workers associated with a firm is given constant. The bargaining game employed here is the two–person cooperative game due to Nash. Section 2–3 introduces a dynamic mobility model in which the labor pool associated with a firm expands or contracts according as the firm offers workers an expected utility level over or below the average expected utility one of a society. In this model, worker's movement continues until the contractual equilibrium, in which workers can enjoy the same expected utility level irrespective of firms, is established. Our final interest is in showing the stability of the contractual equilibrium. Finally section 2–4 briefly gives concluding remarks.

2–2. The Description of the Temporary Equilibrium

A. The optimal contract for the fixed, worker's utility level.

Let us consider an m–goods economy in which the i–th output, Y_i, is produced in the sector i. To simplify the notation, we will focus on a representative firm in each sector, so that the firm of the sector i is called 'the firm i'. The production function of the firm i is

represented as

$$Y_i = F_i(N_i), \tag{1}$$

where N_i stands for labor input employed in the firm i. F_i is assumed to be twice continuously differentiable, strictly increasing and strictly concave in N_i.

To avoid too much complication, the small country assumption will be employed throughout this chapter, so output prices are fixed exogenously. The output prices, however, fluctuate according to the state of nature. Let the price of the commodity i denote $P_i(s)$ in state s. The state of nature is assumed to have a known stationary probability distribution $\{\sigma(s); \Sigma_{s=1}^{S}\sigma(s) = 1, \sigma(s) > 0, s = 1,...,S\}$ in any period.

Workers are assumed to be homogeneous and to be each endowed with one unit of labor power, which is supplied inelastically. This means that workers have no utility of leisure. The utility function of each worker is then written as

$$u = U(c_1,...,c_m), \tag{2}$$

where c_j is his consumption of the commodity j. The consumption program of the worker is now formalized as follows:

$$\underset{\{c_1(s),...,c_m(s)\}}{\text{Max}} \ U(c_1(s),...,c_m(s)), \tag{3}$$

$$\text{sub. to} \quad \Sigma_{j=1}^{m} P_j(s)c_j(s) \leq I(s),$$

$$c_1(s),...,c_m(s) \geq 0.$$

Here $c_j(s)$ is his consumption of the commodity j at state s and I(s) is his income at state s.

Let us assume that $U(c_1,...,c_m)$ is strictly increasing in c_j (j = 1,...,m). The indirect utility function $V(P(s), I(s))$ derived from (3) can then be shown to be real−valued continuous on the set $\{P(s), I(s) | P(s) > 0, I(s) \geq 0\}$ and strictly increasing in I(s) for fixed P(s) > 0, where $P(s) = (P_1(s),...,P_m(s))$.[3] It will also be assumed that $V(P(s), I(s))$ is strictly concave and twice continuously differentiable in I(s) for fixed P(s). The concavity assumption ensures that workers have strictly risk averse preferences with respect to I(s).

Let L_i be the number of the labor pool of the firm i. The tuple $[w_i(1),..,w_i(s),...,w_i(S);$

$n_i(1),...,n_i(s),...,n_i(S)]$ will then represent the labor contract of the firm i with L_i to the effect that the firm i will employ $n_i(s)$ workers at wage $w_i(s)$ when state s occurs. To put it in another way, $n_i(s)$ workers will be employed in the firm i at state s while $[L_i-n_i(s)]$ workers will be laid off. In average, $n_i(s)/L_i$ is the probability of being employed in the firm i at state s and $(1-n_i(s)/L_i)$ is that of being laid off. The expected utility level of workers belonging to the labor pool of the firm i is thus expressed as

$$\Sigma_{s=1}^{S}[\frac{n_i(s)}{L_i}V(P(s), w_i(s)) + (1 - \frac{n_i(s)}{L_i})V(P(s), b)]\sigma(s),$$

where b is the level of unemployment insurance benefits. On the other hand, the expected profits of the firm i are written as

$$\Pi_i = \Sigma_{s=1}^{S} [P_i(s)F_i(n_i(s)) - w_i(s)n_i(s)]\sigma(s).$$

For the time being, let us take a situation in which the labor pool of each firm is fixed. The firm i then plans to maximize its expected profits with respect to $[w_i(1),...,w_i(s),...,w_i(S); n_i(1),...,n_i(s),...,n_i(S)]$ subject to the constraint that it is able to secure labor force only from its own labor pool and it promises an expected utility level at least equal to v_i. More formally, the optimal choice can be obtained by solving the following problem:

$$\text{Max } \Pi_i = \text{Max } \Sigma_{s=1}^{S} [P_i(s)F_i(n_i(s)) - w_i(s)n_i(s)]\sigma(s), \qquad (4)$$
$$\{w_i(1),...,w_i(S)\}$$
$$\{n_i(1),...,n_i(S)\}$$

$$\text{sub. to} \quad L_i \geq n_i(s), \qquad (5)$$

$$\Sigma_{s=1}^{S}[\frac{n_i(s)}{L_i}V(P(s), w_i(s)) + (1 - \frac{n_i(s)}{L_i})V(P(s), b)]\sigma(s) \leq v_i. \qquad (6)$$

The necessary and sufficient conditions for the maximal solution to the problem are given by the Kuhn–Tucker condition.[4] That is,

$$P_i(s)F_i'(n_i(s)) - w_i(s) - \mu_{i1}(s) + \frac{\mu_{i2}}{L_i}[V(P(s), w_i(s)) - V(P(s), b)] = 0, \qquad (7)$$
$$s = 1,...,S,$$

$$-n_i(s) + \frac{\mu_{12} n_i(s)}{L_i} V_2(P(s), w_i(s)) = 0, \qquad s = 1,...,S, \qquad (8)$$

$$\mu_{11}(s)[L_i - n_i(s)] = 0, \qquad \mu_{11}(s) \geq 0, \qquad s = 1,...,S, \qquad (9)$$

$$\mu_{12}\{\Sigma_{s=1}^S [\frac{n_i(s)}{L_i} V(P(s), w_i(s)) + (1 - \frac{n_i(s)}{L_i}) V(P(s), b)] \sigma(s) - v_i\} = 0, \quad \mu_{12} \geq 0, \qquad (10)$$

where $\mu_{11}(s)$ and μ_{12} are the nonnegative multipliers corresponding to inequalities (5) and (6); and $V_2(P, w_i) = \partial V(P, w_i)/\partial w_i > 0$.

In what follows, unemployment insurance benefits are assumed to be set equal to zero. Given that $V(P, I)$ has been assumed to be concave with respect to $I \geq 0$, this implies that the optimal labor contract of each firm is of the full employment type.[5] It can also be shown that inequality (6) is satisfied with equality because $\mu_{12} > 0$ from (8). The conditions (7)–(10) are thus simplified as follows:

$$n_i(s) = L_i, \qquad\qquad s = 1,...,S, \qquad (11)$$

$$-L_i + \mu_{12} V_2(P(s), w_i(s)) = 0, \qquad s = 1,...,S, \qquad (12)$$

$$\Sigma_{s=1}^S V(P(s), w_i(s))\sigma(s) = v_i. \qquad (13)$$

Since $V_{22}(P, w_i) = \partial^2 V(P, w_i)/\partial w_i^2 < 0$, there exists from (12) an inverse function W of $V_2(P, w_i)$ with respect to w_i such that

$$w_i(s) = W(P(s), L_i/\mu_{12}), \qquad s = 1,...,S, \qquad (14)$$

where

$$W_2(P(s), L_i/\mu_{12}) = \partial W(P(s), L_i/\mu_{12})/\partial(L_i/\mu_{12})$$

$$= [V_{22}(P(s), L_i/\mu_{12})]^{-1} < 0. \qquad (15)$$

The optimal employment contract of the firm i is now characterized by (11), (13) and (14). Substituting (14) into (13), we obtain

$$\Sigma_{s=1}^S V(P(s), W(P(s), L_i/\mu_{12}))\sigma(s) - v_i = 0. \qquad (16)$$

The expected profits of the firm i, Π_i, are expressed by inserting (11) and (14) into (4) as

$$\Pi_i - \Sigma^S_{s=1}[P_i(s)F_i(L_i) - W(P(s), L_i/\mu_{i2})L_i]\sigma(s) = 0. \qquad (17)$$

B. The distributive bargaining between the firm and its workers

Let us begin with the derivation of the bargain–possibility frontier depicting a trade–off relation between the worker's expeced utility level and the firm's expected profits in each firm. Since W is a function of μ_{i2}, (16) and (17) can be viewed as a simultaneous equations system of μ_{i2} and Π_i relative to v_i and L_i. Combining (16) and (17), we formally write the optimum value of Π_i by

$$\Pi_i = \phi_i(v_i; L_i). \qquad (18)$$

Given L_i, the ϕ_i function in (18) corresponds to the bargain–possibility frontier of the firm which is the efficient combination of the worker's expected utility level and the firm's expected profits of the firm i.

This argument indicates that the properties of the bargain–possibility frontier can be investigated through (16) and (17). Totally differentiating (16) and (17) with respect to μ_{i2}, Π_i and v_i, we have

$$\begin{bmatrix} -\Sigma^S_{s=1}[V_2(s)W_2(s)\dfrac{L_i}{(\mu_{i2})^2}]\sigma(s) & 0 \\[4mm] -\Sigma^S_{s=1}[W_2(s)(\dfrac{L_i}{\mu_{i2}})^2]\sigma(s) & 1 \end{bmatrix} \begin{bmatrix} d\mu_{i2} \\[4mm] d\Pi_i \end{bmatrix} = \begin{bmatrix} 1 \\[4mm] 0 \end{bmatrix} dv_i, \qquad (19)$$

where $V_2(s) = V_2(P(s), w_i(s))$ and $W_2(s) = W_2(P(s), L_i/\mu_{i2})$. Applying Cramer's rule to (19) yields

$$\frac{d\mu_{i2}}{dv_i} = -\frac{1}{\Sigma^S_{s=1}[V_2(s)W_2(s)\dfrac{L_i}{(\mu_{i2})^2}]\sigma(s)} > 0, \qquad (20)$$

$$\frac{d\Pi_i}{dv_i} = - \frac{\Sigma^S_{s=1}[W_2(s)(\frac{L_i}{\mu_{i2}})^2]\sigma(s)}{\Sigma^S_{s=1}[V_2(s)W_2(s)\frac{L_i}{(\mu_{i2})^2}]\sigma(s)} < 0. \tag{21}$$

The signs of (20) and (21) follow from $V_2 > 0$ and $W_2 < 0$. Equation (21) implies that the bargain possibility frontier of the firm i, $\Pi_i = \phi_i(v_i; L_i)$, is a strictly decreasing function of v_i.

We will next show that the bargain–possibility frontier of the firm i is a strictly concave function of v_i. Note from (12) that

$$V_2(s)W_2(s)\frac{L_i}{(\mu_{i2})^2} = W_2(s)\frac{(L_i)^2}{(\mu_{i2})^3}. \tag{22}$$

Substituting (22) into (21) generates

$$\frac{d\Pi_i}{dv_i} = -\mu_{i2}. \tag{23}$$

Differentiating (23) with respect to v_i, we know

$$\frac{d^2\Pi_i}{dv_i^2} = -\frac{d\mu_{i2}}{dv_i}, \tag{24}$$

which turns out to be negative from (20).

The foregoing arguments lead us to state that there exists a bargain–possibility frontier of the firm i between the worker's expected utility level (v_i) and the firm's expected profits (Π_i), which is convex in the payoff space. This is depicted by the ϕ_i curve in Fig. 1.

We are now ready to discuss the distributive bargaining problem between the manager and workers within the firm i. This is equivalent to determining the combination of v_i and Π_i on the bargain–possibility frontier of the firm i. To this end, we will employ the simple bargaining model due to Nash.

In applying the Nash bargaining solution to our model, we are required to specify

disagreement payoffs which could be achieved in the absence of bargaining agreements. These are commonly attained by the alternative labor contract which would be concluded if no bargain were struck. Since the labor pool of each sector is fixed in the present stage of our analysis, the most natural alternative labor contract is realized as the ex—post auction one arranged in each sector with the fixed labor pool. Such a contract is of the full employment type with the property such that workers are paid the ex—post marginal productivity of labor in each sector. This is because workers have no utility of leisure and receive no unemployment insurance benefits. The disagreement payoffs of the firm and its workers are thus characterized as follows:

$$\hat{\Pi}_i = \Sigma^S_{s=1}[P_i(s)F_i(L_i) - P_i(s)F'_i(L_i)L_i]\sigma(s), \tag{25}$$

$$\hat{v}_i = \Sigma^S_{s=1} V(P(s), P_i(s)F'_i(L_i))\sigma(s). \tag{26}$$

From the assumptions on the production and utility functions, it is found that $\hat{\Pi}_i > 0$ and $\hat{v}_i > EV(P(s), 0)$. It can also be recognized that the ex—post auction labor contract $(n_i(s) = L_i, w_i(s) = P_i(s)F'_i(L_i))$ does not satisfy the necessary and sufficient conditions for the maximal solution to (4) unless $V(P, w_i)$ has a quite peculiar form.[6] This suggests that there is no harm in confining our analysis to the case in which there exists an implicit labor contract strictly Pareto—superior to the ex—post auction one when the labor pool of each sector is fixed. In other words, we can suppose that the point $(\hat{v}_i, \hat{\Pi}_i)$ denoted as W in Fig. 1 is located inside the bargain—possibility frontier set and not on the bargain—possibility frontier.

Now, it is well known that Nash's fixed threat solution maximizes the Nash product $(v_i-\hat{v}_i)(\Pi_i-\hat{\Pi}_i)$ subject to the bargain—possibility frontier of the firm i, $\Pi_i = \phi_i(v_i; L_i)$ (See Harsanyi (1977)). Since the bargain—possibility set of the firm i has been shown to be convex, the bargaining problem in the firm i is guaranteed to have a unique solution as represented by the point N in Fig. 1. The formal solution is obtained by substituting (18) into the Nash product and maximizing it with respect to v_i. The necessary and sufficient

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condition to this problem is[7]

$$\hat{\Pi}_i - \hat{\Pi}_i + (v_i - \hat{v}_i)\frac{d\phi_i}{dv_i} = 0. \tag{27}$$

Given $d\phi_i/dv_i = -\mu_{12}$ from (23), rearranging (27) yields

$$\mu_{12} - \frac{\Pi_i - \hat{\Pi}_i}{v_i - \hat{v}_i} = 0. \tag{28}$$

It is easily found from adding (28) to (16) and (17) that μ_{12}, Π_i and v_i are simultaneously determined relative to the labor pool L_i.

Some remarks are in order. First, equation (28) implies that the slope of the straight line connecting the point $W(\hat{v}_i, \hat{\Pi}_i)$ and $N(v_i^*, \Pi_i^*)$ in Fig. 1 is equal to the absolute value of the tangent of ϕ_i at the point N. Second, the second term of the right–hand side of (28) is interpreted as a measure indicating relative bargaining power between the firm and its workers (See Aoki (1980) and Miyazaki (1984)). It follows finally from the property of the Nash solution that

$$v_i > \hat{v}_i = \Sigma_{s=1}^{S} V(P(s), P_i(s)F_i'(L_i))\sigma(s), \tag{29}$$

$$\Pi_i > \hat{\Pi}_i = \Sigma_{s=1}^{S}[P_i(s)F_i(L_i) - P_i(s)F_i'(L_i)L_i]\sigma(s). \tag{30}$$

The temporary equilibrium has now been fully described by the bargaining outcome equations between the manager and workers in each firm ((16), (17), (25), (26) and (28)) relative to a given labor pool allocation.

2–3. The Interfirm Mobility of Workers and Its Stability

We are now in a position to consider the interfirm mobility of workers. To begin with the analysis, note that all workers belong to the labor pool of some firm when workers have no utility of leisure and receive no unemployment insurance benefits. This implies

$$\Sigma_{i=1}^{m} L_i = \bar{L}, \tag{31}$$

where $\bar{L}$ denotes total labor supply in this economy. $\bar{L}$ is assumed to be constant in any

period.

Let us assume that the labor movement arises gradually and that L_i increases (decreases) if v_i is higher (lower) than the average expected utility level of workers in the whole economy.[8] These assumptions lead to the following expression:

$$\dot{L}_i = \alpha \cdot [v_i - \frac{1}{m} \Sigma^m_{j=1} v_j], \qquad i = 1,...,m-1, \tag{32}$$

where α is a positive parameter representing the extent of labor mobility and the dot is the time derivative. Note that v_i $(i = 1,...,m)$ in (32) are determined in the temporary equilibrium, for given L_i. Combining (31) and (32) yields

$$\dot{L}_m = -\Sigma^{m-1}_{i=1} \dot{L}_i$$

$$= -\alpha \cdot (v_m - \frac{1}{m} \Sigma^m_{j=1} v_j), \tag{33}$$

which shows that we need not specify the movement of the labor pool of the firm m.

The arguments mentioned above reveal that the dynamic process of L_i $(i = 1,...,m)$ is completely described by (31) and (32). Corresponding to this path of L_i, a sequence of the temporary equilibria is settled. The problem to be solved is now whether such a sequence of the temporary equilibria asymptotically converges into the unique contractual equilibrium in which there does not exist any differences of expected utility levels among workers:

$$v_i - \frac{1}{m} \Sigma^m_{j=1} v_j = 0, \qquad i = 1,...,m-1. \tag{34}$$

The stationary values of μ_{i2}, v_i, Π_i, $\hat{v}_i$, $\hat{\Pi}_i$ and L_i $(i = 1,...,m)$ are fully determined from these equations. Note that, if the contractual equilibrium is attained, then (32)–(34) imply

$$v_m - \frac{1}{m} \Sigma^m_{j=1} v_j = 0. \tag{35}$$

Before examining the stability of the contractual equilibrium, it is required to prove the uniqueness of the temporary equilibrium and then to investigate the effect of L_i on v_i in the temporary equilibrium. To this end, we totally differentiate the system (16), (17) and (28) with (25) and (26). Then we obtain

$$
\begin{bmatrix}
-\Sigma_{s=1}^{S}[V_2(s)W_2(s)\dfrac{L_i}{(\mu_{i2})^2}]\sigma(s) & 0 & -1 \\[2em]
-\Sigma_{s=1}^{S}[W_2(s)(\dfrac{L_i}{\mu_{i2}})^2]\sigma(s) & 1 & 0 \\[2em]
1 & & -\dfrac{1}{v_i-\hat{v}_i} \quad \dfrac{\Pi_i-\hat{\Pi}_i}{(v_i-\hat{v}_i)^2}
\end{bmatrix}
\begin{bmatrix}
d\mu_{i2} \\[2em]
d\Pi_i \\[2em]
dv_i
\end{bmatrix}
$$

$$
=
\begin{bmatrix}
-\Sigma_{s=1}^{S}[V_2(s)W_2(s)\dfrac{1}{\mu_{i2}}]\sigma(s) \\[2em]
\Sigma_{s=1}^{S}[P_i(s)F_i' - W_2(s)\dfrac{L_i}{\mu_{i2}} - w_i(s)]\sigma(s) \\[2em]
\dfrac{(v_i-\hat{v}_i)\{\Sigma_{s=1}^{S}[P_i(s)F_i''L_i]\sigma(s)\} + (\Pi_i-\hat{\Pi}_i)\{\Sigma_{s=1}^{S}[\hat{V}_2(s)P_i(s)F_i'']\sigma(s)\}}{(v_i - \hat{v}_i)^2}
\end{bmatrix}
dL,
$$

$$\tag{36}$$

where $\hat{V}_2(s) = V_2(P(s), P_i(s)F_i')$. Since the matrix of the left–hand side in (36) can be verified to be a P–matrix,[9] (μ_{i2}, v_i, Π_i) have a unique value for given L_i. Therefore, the uniqueness of the temporary equilibrium is established.

We next turn to clarifying the effect of L_i on v_i. Applying the Cramer's rule to (36) yields

$$
\frac{dv_i}{dL_i} = -\frac{1}{|J|}\{\Sigma_{s=1}^{S}[V_2(s)W_2(s)\frac{L_i}{(\mu_{i2})^2}]\sigma(s)\}\{\frac{\Sigma_{s=1}^{S}[P_i(s)F_i' - w_i(s)]\sigma(s)}{v_i - \hat{v}_i}
$$

$$
+ \frac{(v_i-\hat{v}_i)[\Sigma_{s=1}^{S}P_i(s)F_i''L_i\sigma(s)] + (\Pi_i-\hat{\Pi}_i)[\Sigma_{s=1}^{S}\hat{V}_2(s)P_i(s)F_i''\sigma(s)]}{(v_i - \hat{v}_i)^2} - \frac{\mu_{i2}}{L_i}\},
$$

$$i = 1,...,m,\tag{37}$$

where

$$|J| = -\left\{\Sigma^S_{s=1}[V_2(s)W_2(s)\frac{L_i}{(\mu_{i2})^2}]\sigma(s)\right\}\frac{\Pi_i - \hat{\Pi}_i}{(v_i - \hat{v}_i)^2} - \frac{\Sigma^S_{s=1}[W_2(s)(\frac{L_i}{\mu_{i2}})^2]\sigma(s)}{v_i - \hat{v}_i} + 1 > 0.[10]$$

(38)

Note from (25) and (28) that

$$\frac{\Sigma^S_{s=1}[P_i(s)F'_i - w_i(s)]\sigma(s)}{v_i - \hat{v}_i} - \frac{\mu_{i2}}{L_i} = 0.$$

(39)

Thus rearrangement of (37) with (39) leads to

$$\frac{dv_i}{dL_i} = -\frac{1}{|J|}\frac{\Sigma^S_{s=1}[V_2(s)W_2(s)\frac{L_i}{(\mu_{i2})^2}]\sigma(s)}{(v_i - \hat{v}_i)^2}\left\{(v_i - \hat{v}_i)[\Sigma^S_{s=1}P_i(s)F''_i L_i\sigma(s)]\right.$$
$$+ (\Pi_i - \hat{\Pi}_i)[\Sigma^S_{s=1}\hat{V}_2(s)P_i(s)F''_i\sigma(s)]\Big\} < 0,[11] \quad i = 1,...,m.$$

(40)

Equation (40) indicates that a rise in the labor pool of the firm i decreases the expected utility level of workers belonging to the firm i.[12]

Now, we proceed to exploring the global stability of the contractual equilibrium. Let us introduce the following distance function

$$D = \Sigma^m_{i=1}\frac{1}{2\alpha}(v_i - \frac{1}{m}\Sigma^m_{j=1}v_j)^2,$$

(41)

where α has been defined in (32) and $(v_1,...,v_m)$ are determined in the temporary equilibrium relative to $(L_1,...,L_m)$. In view of (34) and (35), the function D is always positive unless the contractual equilibrium is attained. Differentiating (41) with respect to time generates

$$\dot{D} = -\frac{1}{\alpha}\Sigma^m_{i=1}[(v_i - \frac{1}{m}\Sigma^m_{j=1}v_j)(\frac{dv_i}{dL_i}\cdot\dot{L}_i - \frac{1}{m}\Sigma^m_{j=1}\frac{dv_j}{dL_j}\cdot\dot{L}_j)]$$

$$= -\frac{1}{\alpha}\Sigma^m_{i=1}[(v_i - \frac{1}{m}\Sigma^m_{j=1}v_j)\cdot\frac{dv_i}{dL_i}\cdot\dot{L}_i]$$

2-12

$$-\frac{1}{\alpha m}[\Sigma^m_{j=1}\frac{dv_j}{dL_j}\cdot\dot{L}_j][\Sigma^m_{i=1}(v_i-\frac{1}{m}\Sigma^m_{j=1}v_j)]. \qquad (42)$$

Since $\Sigma^m_{i=1}(v_i-\frac{1}{m}\Sigma^m_{j=1}v_j)=0$, (42) reduces to

$$\dot{D}=-\frac{1}{\alpha}\Sigma^m_{i=1}[(v_i-\frac{1}{m}\Sigma^m_{j=1}v_j)\cdot\frac{dv_i}{dL_i}\cdot\dot{L}_i]. \qquad (43)$$

Substituting (32) and (33) into (43), we have

$$\dot{D}=\Sigma^m_{i=1}(v_i-\frac{1}{m}\Sigma^m_{j=1}v_j)^2\cdot\frac{dv_i}{dL_i}. \qquad (44)$$

Thus it follows from (34), (35), (40) and (44) that D always turns out to be negative unless the contractual equilibrium is realized. These arguments reveal that D is a Lyapunov function. Our dynamic process is therefore quasi–stable.

Our final problem for verifying the global stability is to show the uniqueness of the contractual equilibrium. Consider the following equation system

$$v_i-\frac{1}{m}\Sigma^m_{j=1}v_j=0, \qquad j=1,...,m-1, \qquad (34')$$

where $(v_1,...,v_m)$ are determined in the temporary equilibrium relative to $(L_1,...,L_m)$. Given that $L_m=\bar{L}-\Sigma^{m-1}_{j=1}L_j$, the Jacobian matrix of the left–hand side in (34') with respect to L_i $(i=1,..., m-1)$ is described as follows:

$$\begin{bmatrix} (1-\frac{1}{m})\frac{dv_1}{dL_1}+\frac{1}{m}\cdot\frac{dv_m}{dL_m} & -\frac{1}{m}\cdot\frac{dv_2}{dL_2}+\frac{1}{m}\cdot\frac{dv_m}{dL_2} & \cdots & -\frac{1}{m}\cdot\frac{dv_{m-1}}{dL_{m-1}}+\frac{1}{m}\cdot\frac{dv_m}{dL_{m-1}} \\ -\frac{1}{m}\cdot\frac{dv_1}{dL_1}+\frac{1}{m}\cdot\frac{dv_m}{dL_m} & (1-\frac{1}{m})\frac{dv_2}{dL_2}+\frac{1}{m}\cdot\frac{dv_m}{dL_2} & \cdots & -\frac{1}{m}\cdot\frac{dv_{m-1}}{dL_{m-1}}+\frac{1}{m}\cdot\frac{dv_m}{dL_{m-1}} \\ \vdots & \vdots & \ddots & \vdots \\ -\frac{1}{m}\cdot\frac{dv_1}{dL_1}+\frac{1}{m}\cdot\frac{dv_m}{dL_m} & -\frac{1}{m}\cdot\frac{dv_2}{dL_2}+\frac{1}{m}\cdot\frac{dv_m}{dL_2} & \cdots & (1-\frac{1}{m})\frac{dv_{m-1}}{dL_{m-1}}+\frac{1}{m}\cdot\frac{dv_m}{dL_{m-1}} \end{bmatrix}. \qquad (45)$$

The Jacobian Matrix (45) can be proved to be an N–P matrix,[13] so that the solution $(L_1,..,L_m)$ to equations system (31) and (34") is uniquely determined. Since the temporary equilibrium has been shown to be uniquely determined relative to $(L_1,..., L_m)$, this result guarantees the uniqueness of the contractual equilibrium. Combining the quasi–stability and the uniqueness of the contractual equilibrium, we can state that the contractual equilibrium is globally stable.

2–4. Concluding Remarks

An attempt has been made to extend an implicit contract model with bargaining which allows for the ex–post interfirm mobility of workers in the multi–sector economy. Our main concern is with investigation of whether the final outcome of implicit contracts with workers' movement can realize the contractual equilibrium in which there does not remain any differences of workers' expected utility levels irrespective of firms.

The structure of the model has been characterized as follows.

(1) In each temporary equilibrium, it is supposed that the distributive bargaining on the organizational rent accruing from the resulting implicit labor contracts is specified with the given available labor pool as a two–person cooperative game due to Nash.

(2) After these contracts have been realized in each temporary equilibrium, workers can gradually move into the labor pool of another firm when they can enjoy a higher expected utility level by doing so.

(3) As a result of the expansion or contraction of the labor pool associated with a firm, another temporary equilibrium will be established relative to a new array of labor allocation.

(4) A sequence of temporary equilibria will continue until workers can enjoy the same expected utility level regardless of firms. The contractual equilibrium will be attained by the final outcome of such a sequence.

Our main result may be summarized by the following: The implicit labor contracts

system in the multi–sector economy has its organizational stability in the sense that the contractual equilibrium is globally stable. This conclusion suggests that the employment system of implicit labor contracts is maintained as a stable one within the general equilibrium framework.

A few remarks for further research are appropriate. First, the present chapter has limited the analysis to a small country economy, so that the endogenous price determination has not been explored. The relaxation of the assumption may yield fairly different conclusions as to the variability of the implicit labor contracts system. Second, our analysis has not directly studied the effects of unemployment insurance benefits. It seems to be interesting to examine how a change in unemployment insurance benefits affects the layoff behavior and the agent's welfare level in the contractual economy.

Appendix

This appencix provides the proof that the Jacobian matrix (45) is an N-P matrix. Consider the following i-th order principal minor of the Jacobian matrix (45):

$$
A^{(i)}_{12\ldots i} =
\begin{vmatrix}
(1-\frac{1}{m})\frac{dv_1}{dL_1}+\frac{1}{m}\frac{dv_m}{dL_m} & -\frac{1}{m}\frac{dv_2}{dL_2}+\frac{1}{m}\frac{dv_m}{dL_m} & \cdots & -\frac{1}{m}\frac{dv_i}{dL_i}+\frac{1}{m}\frac{dv_m}{dL_m} \\
-\frac{1}{m}\frac{dv_1}{dL_1}+\frac{1}{m}\frac{dv_m}{dL_m} & (1-\frac{1}{m})\frac{dv_2}{dL_2}+\frac{1}{m}\frac{dv_m}{dL_m} & \cdots & -\frac{1}{m}\frac{dv_i}{dL_i}+\frac{1}{m}\frac{dv_m}{dL_m} \\
\vdots & \vdots & \ddots & \vdots \\
-\frac{1}{m}\frac{dv_1}{dL_1}+\frac{1}{m}\frac{dv_m}{dL_m} & -\frac{1}{m}\frac{dv_2}{dL_2}+\frac{1}{m}\frac{dv_m}{dL_m} & \cdots & (1-\frac{1}{m})\frac{dv_i}{dL_i}+\frac{1}{m}\frac{dv_m}{dL_m}
\end{vmatrix}
$$

The value of $A^{(i)}_{12\ldots i}$ is computated as follows:

$$
A^{(i)}_{12\ldots i} =
\begin{vmatrix}
(1-\frac{1}{m})\frac{dv_1}{dL_1} & -\frac{1}{m}\frac{dv_2}{dL_2}+\frac{1}{m}\frac{dv_m}{dL_m} & \cdots & -\frac{1}{m}\frac{dv_i}{dL_i}+\frac{1}{m}\frac{dv_m}{dL_m} \\
-\frac{1}{m}\frac{dv_1}{dL_1} & (1-\frac{1}{m})\frac{dv_2}{dL_2}+\frac{1}{m}\frac{dv_m}{dL_m} & \cdots & -\frac{1}{m}\frac{dv_i}{dL_i}+\frac{1}{m}\frac{dv_m}{dL_m} \\
\vdots & \vdots & \ddots & \vdots \\
-\frac{1}{m}\frac{dv_1}{dL_1} & -\frac{1}{m}\frac{dv_2}{dL_2}+\frac{1}{m}\frac{dv_m}{dL_m} & \cdots & (1-\frac{1}{m})\frac{dv_i}{dL_i}+\frac{1}{m}\frac{dv_m}{dL_m}
\end{vmatrix}
$$

$$
+\frac{1}{m}\frac{dv_m}{dL_m}
\begin{vmatrix}
1 & -\frac{1}{m}\frac{dv_2}{dL_2}+\frac{1}{m}\frac{dv_m}{dL_m} & \cdots & -\frac{1}{m}\frac{dv_i}{dL_i}+\frac{1}{m}\frac{dv_m}{dL_m} \\
1 & (1-\frac{1}{m})\frac{dv_2}{dL_2}+\frac{1}{m}\frac{dv_m}{dL_m} & \cdots & -\frac{1}{m}\frac{dv_i}{dL_i}+\frac{1}{m}\frac{dv_m}{dL_m} \\
\vdots & \vdots & \ddots & \vdots \\
1 & -\frac{1}{m}\frac{dv_2}{dL_2}+\frac{1}{m}\frac{dv_m}{dL_m} & \cdots & (1-\frac{1}{m})\frac{dv_i}{dL_i}+\frac{1}{m}\frac{dv_m}{dL_m}
\end{vmatrix}
$$

$$m \begin{vmatrix} (1-\frac{1}{m})\frac{dv_1}{dL_1} & -\frac{1}{m}\frac{dv_2}{dL_2}+\frac{1}{m}\frac{dv_m}{dL_m} & \cdots & -\frac{1}{m}\frac{dv_1}{dL_1}+\frac{1}{m}\frac{dv_m}{dL_m} \\[2ex] 0 & \frac{m-2}{m-1}\frac{dv_2}{dL_2}+\frac{1}{m-1}\frac{dv_m}{dL_m} & \cdots & -\frac{1}{m}\frac{dv_1}{dL_1}+\frac{1}{m-1}\frac{dv_m}{dL_m} \\[1ex] \vdots & \vdots & \ddots & \vdots \\[1ex] 0 & -\frac{1}{m-1}\frac{dv_2}{dL_2}+\frac{.1}{m-1}\frac{dv_m}{dL_m} & \cdots & \frac{m-2}{m-1}\frac{dv_1}{dL_1}+\frac{1}{m-1}\frac{dv_m}{dL_m} \end{vmatrix}$$

$$+\ \frac{1}{m}\frac{dv_m}{dL_m}\begin{vmatrix} 1 & -\frac{1}{m}\frac{dv_2}{dL_2}+\frac{1}{m}\frac{dv_m}{dL_m} & \cdots & -\frac{1}{m}\frac{dv_1}{dL_1}+\frac{1}{m}\frac{dv_m}{dL_m} \\[2ex] 0 & \frac{dv_2}{dL_2} & \cdots & 0 \\[1ex] 0 & 0 & \cdots & 0 \\[1ex] \vdots & \vdots & \ddots & \vdots \\[1ex] 0 & 0 & \cdots & \frac{dv_1}{dL_1} \end{vmatrix}$$

$$(1-\frac{1}{m})\frac{dv_1}{dL_1}\begin{vmatrix} (1-\frac{1}{m-1})\frac{dv_2}{dL_2}+\frac{1}{m-1}\frac{dv_m}{dL_m} & -\frac{1}{m-1}\frac{dv_3}{dL_3}+\frac{1}{m-1}\frac{dv_m}{dL_m} & \cdots & -\frac{1}{m-1}\frac{dv_1}{dL_1}+\frac{1}{m-1}\frac{dv_m}{dL_m} \\[2ex] -\frac{1}{m-1}\frac{dv_2}{dL_2}+\frac{1}{m-1}\frac{dv_m}{dL_m} & (1-\frac{1}{m-1})\frac{dv_3}{dL_3}+\frac{1}{m-1}\frac{dv_m}{dL_m} & \cdots & -\frac{1}{m-1}\frac{dv_1}{dL_1}+\frac{1}{m-1}\frac{dv_m}{dL_m} \\[1ex] \vdots & \vdots & \ddots & \vdots \\[1ex] -\frac{1}{m-1}\frac{dv_2}{dL_2}+\frac{1}{m-1}\frac{dv_m}{dL_m} & -\frac{1}{m-1}\frac{dv_3}{dL_3}+\frac{1}{m-1}\frac{dv_m}{dL_m} & \cdots & (1-\frac{1}{m-1})\frac{dv_1}{dL_1}+\frac{1}{m-1}\frac{dv_m}{dL_m} \end{vmatrix}$$

$$\frac{dv_2}{dL_2}\ \frac{dv_3}{dL_3}\ \cdots\ \frac{dv_1}{dL_1}\ \frac{dv_m}{dL_m}\ .$$

Continuing the computation procedure, we obtain

$$A^{(i)}_{12..i} = (1- \frac{1}{m})\frac{dv_1}{dL_1}(1- \frac{1}{m-1})\frac{dv_2}{dL_2} \cdots (1- \frac{1}{m-i+3})\frac{dv_{i-2}}{dL_{i-2}}$$

$$\times \begin{vmatrix} (1- \frac{1}{m-i+2})\frac{dv_{i-1}}{dL_{i-1}} + \frac{1}{m-i+2}\frac{dv_m}{dL_m} & -\frac{1}{m-i+2}\frac{dv_i}{dL_i} + \frac{1}{m-i+2}\frac{dv_m}{dL_m} \\ -\frac{1}{m-i+2}\frac{dv_{i-1}}{dL_{i-1}} + \frac{1}{m-i+2}\frac{dv_m}{dL_m} & (1- \frac{1}{m-i+2})\frac{dv_i}{dL_i} + \frac{1}{m-i+2}\frac{dv_m}{dL_m} \end{vmatrix}$$

$$+ \frac{1}{m} \Sigma^{i-2}_{j=1}[(\frac{dv_j}{dL_j})^{-1} \cdot \frac{dv_m}{dL_m} \Pi^i_{k=1}(\frac{dv_k}{dL_k})]$$

$$= (1- \frac{1}{m})\frac{dv_1}{dL_1} (1- \frac{1}{m-1})\frac{dv_2}{dL_2} \cdots (1- \frac{1}{m-i+3})\frac{dv_{i-2}}{dL_{i-2}}$$

$$\times \{ (1- \frac{2}{m-i+2})\frac{dv_{i-1}}{dL_{i-1}}\frac{dv_i}{dL_i} + \frac{1}{m-i+2}\frac{dv_m}{dL_m}(\frac{dv_{i-1}}{dL_{i-1}} + \frac{dv_i}{dL_i}) \}$$

$$+ \frac{1}{m} \Sigma^{i-2}_{j=1}[(\frac{dv_j}{dL_j})^{-1} \cdot \frac{dv_m}{dL_m} \Pi^i_{k=1}(\frac{dv_k}{dL_k})]$$

$$= \frac{m-i}{m} \Pi^i_{k=1}(\frac{dv_k}{dL_k}) + \frac{1}{m} \Sigma^i_{j=1}[(\frac{dv_j}{dL_j})^{-1} \cdot \frac{dv_m}{dL_m} \Pi^i_{k=1}(\frac{dv_k}{dL_k})] . \qquad (A1)^{14/}$$

It follows from (40) and (A1) that

$$\text{sgn } A^{(i)}_{12..i} = (-1)^i . \qquad (A2)$$

Applying the similar procedure to the other i-th order principal minors of the Jacobian matrix (45), we can show that (A2) can be obtained for all i. Therefore, it is found that the Jacobian matrix (45) is an N-P matrix.

Notes

1. Several recent researches, however, have attempted to relax this assumption. Removing the immobility assumption of workers directly, Akerlof and Miyazaki (1980) show that implicit labor contracts may not be viable since the firm has a strong incentive to reduce the size of its initial labor pool. On the other hand, Harris and Holmstrom (1982) and Holmstrom (1981)(1983) succeed in establishing that an implicit contract emerges at equilibrium even without mobility costs when a multi–period contractual framework is considered. For other related studies, see Burdett and Mortensen (1980), Cothren (1983) and Frank (1983), which ingeniously integrate the implicit contract and the job search theory. Also see Polemarchakis (1979).

2. For the application of the bargaining model to the firm theory, see Aoki (1980)(1982), McDonald and Solow (1981), Miyazaki (1984) and Osborne (1984).

3. It can also be proved that $V(P, w_i)$ is strictly increasing in P for fixed $w_i \geq 0$. See Diewert (1974).

4. The proof for the sufficiency is shown in Kagawa and Kuga (1985).

5. See the proof for Proposition 1(i) in Polemarchakis (1979).

6. The ex–post auction labor contract could be a maximal solution to the program (4) for some L_i if $v_i = \hat{v}_i$. However, this occurs only in the case of a limited class of indirect utility functions, so that the possibility is rare. We are therefore permitted to assume to exclude such a peculiar class of indirect utility functions in the following analysis.

7. We focus on an interior solution case.

8. Since the firm cannot prevent its workers from leaving its labor pool, equation (32) can be justified if $v_i < \frac{1}{m}\Sigma^m_{j=1} v_j$. On the other hand, the firm can deter new workers from entering its labor pool. Thus, if $v_i > \frac{1}{m}\Sigma^m_{j=1} v_j$, it is required to examine whether the firm i has an incentive to increase its labor pool. Note 12 will show that we obtain an affirmative answer to this problem.

9. Note that $V_2(s) > 0$, $W_2(s) < 0$, $v_i - \hat{v}_i > 0$ from (29) and $\Pi_i - \hat{\Pi}_i > 0$ from (30). For a P–matrix, see Nikaidô (1968).

10. See note 9.

11. See note 9 and $F''_i < 0$.

12. It also follows from solving (36) that the effect of L_i on Π_i is written as

$$\frac{d\Pi_i}{dL_i} = \frac{1}{|J|}\left\{\left[1 - \frac{\Sigma_{s=1}^{S}[V_2(s)W_2(s)\frac{L_i}{\mu_{i2}}]\sigma(s)}{v_i - \hat{v}_i}\right]\frac{\Pi_i - \hat{\Pi}_i}{L_i} - \Sigma_{s=1}^{S}[W_2(s)\frac{L_i}{\mu_{i2}}]\sigma(s)\right.$$

$$+ \frac{\Sigma_{s=1}^{S}[W_2(s)(\frac{L_i}{\mu_{i2}})^2]\sigma(s)}{(v_i - \hat{v}_i)^2}[(v_i - \hat{v}_i)\Sigma_{s=1}^{S}[P_i(s)F''_i L_i]\sigma(s)$$

$$\left. + (\Pi_i - \hat{\Pi}_i)\Sigma_{s=1}^{S}[\hat{V}_2(s)P_i(s)F''_i]\sigma(s)]\right\}. \tag{N1}$$

A careful inspection reveals that the right–hand side of (N1) turns out to be positive. The firm, therefore, has a positive incentive to increase its own labor pool. See note 8.

13. The proof can be shown in Appendix. For an N–P matrix, see Nikaidô.

14. Note that $\Pi_{k=1}^{i}(\frac{dv_k}{dL_k}) = \frac{dv_1}{dL_1}\frac{dv_2}{dL_2}\cdots\frac{dv_i}{dL_i}$.
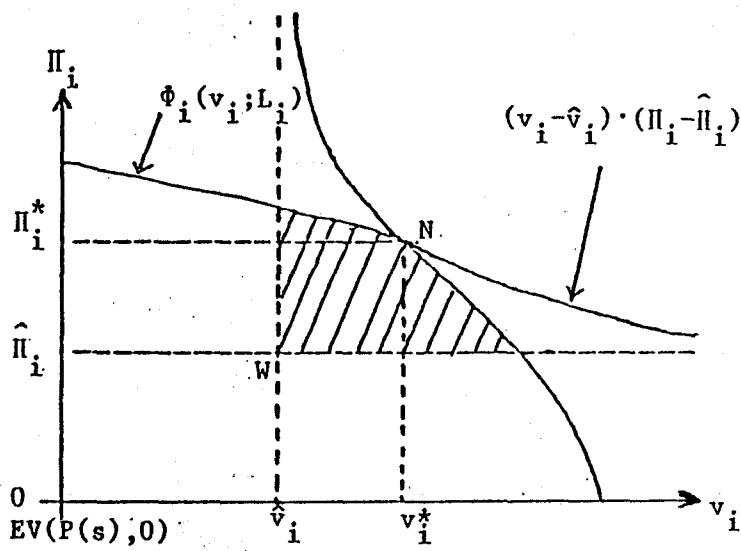
Fig.1. The distributive bargaining between the manager and
workers within the firm i

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Chapter 3

Contract Termination, Endogenous Monitoring, and Involuntary Unemployment

3. Contract Termination, Endogenous Monitoring, and Involuntary Unemployment

3-1. Introduction

In most firms, the management needs an effective device for inducing workers not to shirk because labor contracts cannot specify all the aspects of the worker's performance although workers have some discretion about their performance. Recently, the analyses of Shapiro and Stiglitz [1984], Yellen [1984], and others called the "efficiency wage theory" have explored the implications of the worker moral hazard problem (see the introduction of Akerlof and Yellen [1986] and Stiglitz [1987] for the related literature). In these studies, firms try to eliminate the workers' interest to shirk on their jobs by paying a wage in excess of market-clearing and by terminating their contract relations if firms detect their workers in shirking. Since firms select their employment levels in response to the wage above market-clearing, the efficiency wage model predicts underemployment with involuntary layoff.[1] However, there remain several criticisms that the efficiency wage model artificially restricts the set of possible contracts to be signed between firms and workers.

One of the most serious criticisms is concerned with the assumption that contracts of the efficincy wage model must be of the termination type, in which workers receive an agreed wage as long as their performance in the past has been satisfactory but get dismissed if it has not. Since these termination contracts are not legally enforceable on either firms or workers, one may suspect that contract termination is an optimal incentive scheme to overcome the worker moral hazard problem if firms have several incentive devices to prevent workers from shirking.

The recent labor contract literature, therefore, has tried to develop this problem in various circumstances. Kahn and Huberman [1988] have

considered two classes of contracts: "up-or-out" employment contracts and "full" employment contracts. "Up-or-out" employment contracts imply that firms set a wage higher than opportunity cost to induce their workers to invest in firm-specific human capital, and fire a worker if he does not make the grade. "Full" employment contracts mean that workers are fully employed, but have no incentive to invest in firm specific human capital. Comparing "up-or-out" employment contracts with "full" employment contracts, Kahn and Huberman have provided a rationale for "up-or-out" employment contracts. MacLeod and Malcomson [1989] have modeled self-enforcing implicit contracts as perfect equilibrium strategies in a repeated game between a firm and a worker. Although the worker's performance level is assumed not to be verified in court, MacLeod and Malcomson allow contract arrangements such as wages, severance pays and firing decisions to depend on the worker's performance level. In this setting, they have shown that any acheivable stationary allocation can be implemented by a contract without severance pays or bondings, particularly by a termination contract. The economic rationale for their result is that severance pays or bonds increase the loss to the worker from dismisal, but induce the firm to default on the implicit contract. Okuno-Fujiwara [1989] has constructed an implicit long-term contract model using the concept of "norm equilibrium". The norm equilibrium concept is based on the view that a social norm works as an enforcement mechanism because society punishes a deviator from the prevailing social norm and rewards members who follow it. Okuno-Fujiwara has verified that a termination contract is an equilibrium contract in the social norm equilibrium if the corporate norm is that all workers evaluate the fellow workers' effort correctly and report them honestly.

The first purpose of this chapter is to show that any optimal contract

arrangements can be implemented by a termination contract in a context

different from those three papers. In particular, we discuss this work

without relying on the framework restricted by repeated games or social norms

because we must make do with a simple contract form in the game theoretical

situation. To acheive our aim, this chapter constructs a multi-period

contract model with endogenous monitoring in which both the firm's wage and

employment policies are allowed to depend on the worker's performance level in

the previous periods. Since the probability of catching a worker shirking is

endogenously determined, we must analyze interactions between the choice of a

threat to shirking workers and the choice of monitoring technology.

The model of this chapter has a certain amount in the recent work of

Mookherjee [1986]. Mookherjee [1986, section 3] has developed a two-period

contract model in which firms can use their employment policies as an

incentive device in combination with their wage policies.[2] In his model,

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 can

be better provided through involuntary retention in a wide variety of

circumstances: the effort incentives may be provided by the threat of

involuntary retention rather than involuntary layoff in later periods.[3]

The Mookherjee model, however, leaves open several questions about the

threat to shirking workers. One limitation is that firms cannot freely choose

a threat to shirking workers since shirking workers receive the same wages and

severance payments as no-shirking workers. Thus, it is highly interesting to

explore whether the result of involuntary retention would be still valid if

firms were able to choose their threat to shirking workers without restricting their wage policies. The second purpose of this chapter is to consider whether the workers' shirking problem provides a satisfactory explanation for involuntary layoff and underemployment if firms can freely choose their threat to shirking workers.

Most Japanese large firms have a common practice that, even though they have a lifetime employment system, they transfer a number of their senior workers to jobs in their affiliated firms or jobs in their own where these senior workers do not contribute to any production (mado-giwa zoku); and those transferred workers must usually make do with lower wages than no-transferred workers. If the layoff of senior workers in our model is viewed as the transfer of senior workers mentioned above, the possibility of the involuntary layoff of senior workers implies that the worker moral hazard hypothesis provides a rationale for such a transfer system. Hence, the question of whether the involuntary layoff of senior workers occurs in our model is equivalent to the question of whether the transfer of senior workers among firms or within firms is a useful incentive device to overcome the worker moral hazard problem in Japanese large firms.

This chapter is organized as follows. Section 3-2A describes a multi-period, worker moral hazard model in which the firm uses employment policies as an incentive device in combination with deferred payment schemes and threatens shirking workers with contract termination. Section 3-2B extends the model of section 3-2A to a more comprehensive model where both the firm's wage and employment policies are allowed to depend on the worker's performance level in the previous periods. Section 3-3 characterizes the stationary optimal contract arrangements of these two models. Section 3-4 contains conclusions and some directions for future research.

3-2. The Model

A. Lifetime Labor Contracts with the Threat of Contract Termination

Let us assume that a firm employs both junior and senior workers. The production function of the firm is written by $F(N_{t1}, N_{t2})$, where N_{t1} stands for the units of effective labor of junior workers in period t and N_{t2} the units of effective labor of senior workers in period t. The production function $F(\cdot, \cdot)$ is increasing and strictly concave in its arguments. It is assumed that output is zero if any of the two arguments of the production function is zero.

Workers are assumed to live three periods and to work for the first two periods. In the first period, they join a firm as junior workers; and in the second, they become senior workers if they decide to stay with the firm. The utility function of workers is additively separable over time, so that their lifetime utility is the sum of their utility discounted in each period. The utility in each period is represented by $U(w-e)$, where w is an income received and e is the level of effort on the jobs measured by effective labor units. The utility function $U(w-e)$ is an increasing and concave function of $w-e$. Since capital markets are not available to workers, all current income is consumed.

Workers choose whether to work or shirk in each period. Workers who shirk provide zero units of effective labor to the firm; on the other hand, workers who work provide a fixed positive level of effective labor units, $e^* > 0$.

The firm has imperfect ability to monitor shirking, and must incur monitoring costs per employed junior worker, $C_1(q_{t1})$, and monitoring costs per employed senior worker, $C_2(q_{t2})$. Here, q_{t1} (q_{t2}) is the probability that shirking junior (senior) workers are caught in period t. These monitoring

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cost functions are defined on the range [0, 1], and are assumed to be $C_1(0) = 0$, $C_1'(q_{t,1}) > 0$ and $C_1''(q_{t,1}) > 0$ ($i = 1, 2$).

The key point of our analysis is how the firm treats a worker who is caught shirking. In this subsection, we assume that, if a worker is caught shirking, he will be forced to leave the firm and be paid neither severance payments nor pensions.[4] We also assume that workers will be unable to return to the firm once the firm detects their shirking and fires them.[5]

The firm offers a lifetime labor contract $\{w_{t,1}, w_{t+1,2}, s_{t+1,2}, w_{t+2,3}, s_{t+2,3}, L_t, l_{t+1}, q_{t,1}, q_{t+1,2}\}$ 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, and employs all of them as junior workers with a wage $w_{t,1}$.[6] If a junior worker shirks and gets caught shirking with probability $q_{t,1}$, he is fired and is paid neither severance pays nor 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 $l_{t+1}L_t$ senior workers with a wage $w_{t+1,2}$, and lays off $(1 - l_{t+1})L_t$ senior workers with a severance pay $s_{t+1,2}$.[7] If an employed senior worker shirks and gets caught shirking with probability $q_{t+1,2}$, 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.

In the subsequent analysis, we will 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. Thus, l_{t+1} will be restricted in the range [0, 1]. This restriction is justified from the assumption that junior workers acquire firm-specific seniority skills.[8] We will also assume away partial promotions to simplify the analysis. However, as will be discussed in the next section,

relaxation of this assumption does not affect any essential results obtained in this chapter.

The firm has a reputation for honesty and does not cheat on its potential contractual promises. On the other hand, workers do not precommit to staying with the firm in any point of time. Thus, the firm must design lifetime labor contracts so as to prevent the undesirable turnover of workers in addition to the undesirable shirking of workers. This implies that lifetime labor contracts offered by the firm must satisfy several constraints.

One is concerned with "no-shirking conditions". If a junior (senior) worker shirks in period t, all junior (senior) workers shirk in period t because of the homogeneity of junior (senior) workers. Then junior (senior) workers do not contribute to any production of the output of the firm in period t even though they receive their wages from the firm. Thus, if the firm desires to prevent a junior (senior) worker from shirking in period t, the firm must offer a lifetime labor contract which satisfies the "no-shirking condition" that induces all junior (senior) workers not to shirk in period t.

We first characterize the no-shirking condition for senior workers to be satisfied in the lifetime labor contract offered to workers born in period t. 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, his discounted utility stream is given by $U(w_{t+1,2})$ + $(1+r)^{-1}U(w_{t+2,3}+b)$, 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

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

where $q_{t+1,2}$ is their probability of being caught. This constraint is rewritten by

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

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 a junior worker chooses not to shirk, his discounted expected utility stream in period t is

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

Here, the first term in (2) indicates utility gains in the current period. The second term in (2) represents discounted expected utility gains from the next period onward if the firm employs the worker in the next period. The final term in (2) expresses discounted expected utility gains from the next period onward if the firm lays off the worker in the next period. Note that "a" is the income obtained from job opportunities outside of the firm. On the other hand, if a junior worker chooses to shirk, his discounted expected utility stream is written by

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

$$+ (1+r)^{-1}U(b)].\qquad(3)$$

Here, the first term in (3) gives utility gains in the current period. The second term in (3) indicates discounted expected utility gains from the next period onward if the worker is not caught shirking. Note that the worker never shirks in the second period of his lifetime because of the no-shirking condition for senior workers, (1). The final term in (3) represents discounted expected utility gains from the next period onward if the worker is caught shirking. Note that the worker who shirks cannot return to the firm throughout the subsequent periods. Comparing (2) with (3), we can derive the following no-shirking condition for junior workers in period t:

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

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

$$+ (1+r)^{-1}q_{t,1}[U(a) + (1+r)^{-1}U(b)].\qquad(4)$$

Other constraints to be satisfied by feasible lifetime labor contracts are the no-quit constraints for senior and retired workers. These constraints imply that, no 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 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 always hold because of the nonnegativity conditions of pensions ($w_{t+2,3} \geqq 0$

and $s_{t+2,3} \geq 0$).[11] The no-quit constraint for senior workers laid off in period t+1 is also automatically valid owing to the nonnegativity conditions of severance pays and pensions ($s_{t+1,2} \geq 0$ and $s_{t+2,3} \geq 0$).[12] Thus, in the subsequent analysis, we will omit these three no-quit constraints in each period. However, we must specify the no-quit constraint for senior workers employed in each period. The constraint in period t+1 is

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

Note that employed senior workers never cheat in (5) as long as the no-shirking condition for senior workers is valid in each period.

Besides the no-quit constraints, the lifetime labor contract offered to workers born in period t must also give each junior worker an expected utility level at least as large as the exogenous reservation level V (= U(a) + $(1+r)^{-1}U(a)$ + $(1+r)^{-2}U(b)$) so that junior workers are willing to sign the contract with the firm. This reservation utility constraint in period t is

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

Notice that junior workers never cheat in (6) as long as the no-shirking conditions, both for junior workers and for senior workers, hold in each period.

Finally, we must allow for the feasibility constraints of employment and monitoring probabilities. First, since the size of the senior workforce in period t+1 can be no larger than the junior workforce in period t, we require the following condition:

$$1 \geq l_{t+1} \geq 0. \tag{7}$$

Second, the probabilities that shirking workers are caught in period t are restricted to the following interval:

$$1 \geqq q_{t1} \geqq 0, \tag{8}$$

$$1 \geqq q_{t2} \geqq 0. \tag{9}$$

The firm now chooses an optimal sequence of lifetime labor contracts by maximizing the sum of the discounted values of profits subject to constraints (1) and (4)-(9). The sum of the discounted values of the firm's profits is represented by

$$\pi = \sum_{t=1}^{\infty} (1+r)^{1-t} [F(e^*L_t, e^*l_tL_{t-1}) - w_{t1}L_t - w_{t2}l_tL_{t-1} - s_{t2}(1-l_t)L_{t-1}$$
$$- w_{t3}l_{t-1}L_{t-2} - s_{t3}(1-l_{t-1})L_{t-2} - C_1(q_{t1})L_t - C_2(q_{t2})l_tL_{t-1}]. \tag{10}$$

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

B. Lifetime Labor Contracts with the Threat of Differences between the Employment Probabilities of Shirking and No-Shirking Workers

In this subsection, we will extend the multi-period contract model of the previous subsection to a more "generalized" one in which both wage and employment policies are allowed to depend on whether or not workers are caught shirking in the previous periods. This extension helps us discuss which contract arrangements are optimal if the firm can freely choose a threat to shirking workers.

We now modify the model of the previous subsection by imposing the following assumptions. First, it is assumed that not only workers who do not shirk or do not get caught shirking but also workers who get caught shirking

can choose whether to stay with the firm or leave the firm.[13] In the previous subsection, this assumption is unnecessary because shirking workers must always leave the firm under the threat of contract termination once they are caught shirking. It is also assumed that, even if the firm catches a number of workers shirking, the firm can choose whether to induce them to leave the firm by adjusting its wage and employment policies. This assumption implies that the no-quit constraints for workers caught shirking need not be satisfied although some of these constraints are valid.[14]

Second, the probability of being employed for senior workers is allowed to depend on whether or not they are caught shirking in the previous period. Let l_t denote the probability of being employed in period t for senior workers who do not shirk or do not get caught shirking in the previous period.[15] We also introduce n_t which denotes the probability of being employed in period t for senior workers who are caught shirking in the previous period (see Fig. 2).

Finally, we assume that wages, severance payments and pensions, both for senior workers and for retired workers, are contingent on whether or not they are caught shirking in the previous periods (see Fig. 2). Then, senior workers receive w_{t2} and s_{t2} as a wage and a severnce pay in period t if they do not shirk or do not get caught shirking in the previous period; otherwise, workers obtain x_{t2} and y_{t2} as a wage and a severance pay in period t. Similarly, retired workers have six choices in period t; retired workers receive w_{t3} if they do not shirk or do not get caught shirking in the first period, and they do not shirk or do not get caught shirking while employed in the second period; s_{t3} if they do not shirk or do not get caught shirking in the first period, and they get laid off in the second period; p_{t3} if they do not shirk or do not get caught shirking in the first period, but they get

caught shirking in the second period; z_{t3} if they get caught shirking in the

first period, but they do not shirk or do not get caught shirking while

employed in the second period; y_{t3} if they get caught shirking in the first

period, and they get laid off in the second period; x_{t3} if they get caught

shirking in both of the previous two periods.

An optimal lifetime labor contract offered by the firm to workers born in

period t $\{w_{t+i,i+1}, s_{t+j,j+1}, x_{t+j,j+1}, y_{t+j,j+1}, p_{t+2,3}, z_{t+2,3}, L_t, l_{t+1},$
$n_{t+1}, q_{t+k,k+1}\}$ $(i = 0, 1, 2;\ j = 1, 2;\ k = 0, 1;\ t = 1,\ldots,\ \infty)$ can now be

derived from the following "generalized" maximization problem:

$$\pi = \sum_{t=1}^{\infty} (1+r)^{1-t}[F(e^*L_t,\ e^*l_tL_{t-1}) - w_{t1}L_t - w_{t2}l_tL_{t-1} - s_{t2}(1-l_t)L_{t-1}$$
$$- w_{t3}l_{t-1}L_{t-2} - s_{t3}(1-l_{t-1})L_{t-2} - C_1(q_{t1})L_t - C_2(q_{t2})l_tL_{t-1}],$$

(11)

sub. to

$$U(w_{t+1,2}-e^*) + (1+r)^{-1}q_{t+1,2}U(w_{t+2,3}+b) \geqq U(w_{t+1,2})$$
$$+ (1+r)^{-1}q_{t+1,2}U(p_{t+2,3}+b), \qquad t = 1,\ldots,\ \infty,$$

(12)

$$U(x_{t+1,2}-e^*) + (1+r)^{-1}q_{t+1,2}U(z_{t+2,3}+b) \geqq U(x_{t+1,2})$$
$$+ (1+r)^{-1}q_{t+1,2}U(x_{t+2,3}+b), \qquad t = 1,\ldots,\ \infty,$$

(13)

$$U(w_{t1}-e^*) + (1+r)^{-1}q_{t1}\{l_{t+1}[U(w_{t+1,2}-e^*) + (1+r)^{-1}U(w_{t+2,3}+b)]$$
$$+ (1-l_{t+1})[U(s_{t+1,2}+a) + (1+r)^{-1}U(s_{t+2,3}+b)]\} \geqq U(w_{t1})$$
$$+ (1+r)^{-1}q_{t1} \cdot \text{Max} \{n_{t+1}[U(x_{t+1,2}-e^*) + (1+r)^{-1}U(z_{t+2,3}+b)]$$
$$+ (1-n_{t+1})[U(y_{t+1,2}+a) + (1+r)^{-1}U(y_{t+2,3}+b)],\ U(a) + (1+r)^{-1}U(b)\},$$

$$t = 1,\ldots,\ \infty,$$

(14)

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

$$t = 1,\ldots,\ \infty,$$

(15)

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

$$+ (1-l_{t+1})[U(s_{t+1,2}+a) + (1+r)^{-1}U(s_{t+2,3}+b)]\} \geqq V,$$

$$t = 1,\ldots, \infty, \qquad (16)$$

$$1 \geqq l_{t+1} \geqq 0, \qquad t = 1,\ldots, \infty, \qquad (17)$$

$$1 \geqq n_{t+1} \geqq 0, \qquad t = 1,\ldots, \infty, \qquad (18)$$

$$1 \geqq q_{t+1,i+1} \geqq 0, \qquad i = 0, 1; \; t = 1,\ldots, \infty, \qquad (19)$$

$$w_{t+i,i+1} \geqq 0, \qquad i = 0, 1, 2; \; t = 1,\ldots, \infty, \qquad (20)$$

$$s_{t+i,i+1} \geqq 0, \qquad i = 1, 2; \; t = 1,\ldots, \infty, \qquad (21)$$

$$x_{t+i,i+1} \geqq 0, \; y_{t+i,i+1} \geqq 0, \; p_{t+2,3} \geqq 0, \; z_{t+2,3} \geqq 0,$$

$$i = 1, 2; \; t = 1,\ldots, \infty. \qquad (22)$$

The objective function, (11), represents the sum of the discounted values of the firm's profits. We need not consider any possibility of workers' cheating in (11), since the no-shirking conditions, both for junior workers and for senior workers, rule out the possibility of their cheating.

Unlike the maximization problem presented in the previous subsection, we must specify three no-shirking conditions in each period. Constraint (12) ((13)) describes the no-shirking conditions for senior workers who *do not shirk or do not get caught shirking* (*get caught shirking*) in the previous period. When formalizing (12) and (13), we can neglect in the retirement period the quit behavior of workers caught shirking because they never quit in the retirement period under the nonnegativity conditions of their pensions. Constraint (14) implies the no-shirking conditions for junior workers. Given the no-shirking conditions for senior workers, (12) and (13), we can rule out any possibility of the cheating of senior workers in (14). However, if the firm catches a number of junior workers shirking, the firm may induce them to

leave the firm by adjusting its wage and employment policies. Thus, we must
consider their quit behavior in the second period of their lifetime. The
right-hand side of (14) reflects this consideration.

Besides the no-shirking conditions, feasible lifetime labor contracts
must be constrained by the no-quit constraints for *no-shirking employed senior
workers*, (15). As has been discussed in the previous subsection, the
nonnegativity conditions of severance pays and pensions allow us to omit the
no-quit constraints for retired workers who do not shirk in the previous
periods, and the no-quit constraints for laid off senior workers who do not
shirk in the first period. Thus, we have only to specify the no-quit
constraints for no-shirking employed senior workers, (15).[16]

Other constraints to be satisfied by feasible lifetime labor contracts
are the reservation utility constraints, (16), which ensure that the firm
gives each contracting worker an expected utility level at least as large as
the exogenous reservation level V (= U(a) + (1+r)$^{-1}$U(a) + (1+r)$^{-2}$U(b)).
Finally, constraints (17)-(19) are the feasibility constraints of employment
and monitoring probabilities whereas constraints (20)-(22) are the nonnegative
constraints on wages, severance payments and pensions.

Setting $p_{t+2,3} = 0$, $y_{t+j,j+1} = 0$ (j = 1, 2), and $n_{t+1,2} = 0$ for all t,[17]
we can view the class of lifetime labor contracts presented in the previous
subsection as a special case of the class of lifetime labor contracts
introduced in this subsection. This finding implies that a solution to
"generalized" maximization problem (11) is not dominated by any solution to
maximizaion problem (10). Furthermore, since the probability of catching a
worker shirking is endogenously determined, the choice of a threat depends on
the choice of monitoring technology. We must, therefore, solve maximization
problems (10) and (11) explicitly to develop the relations between the

solutions to these two maximization problems.

3-3. Analysis

We now characterize optimal sequences of lifetime labor contracts to the two maximization problems specified in the previous section. We begin with deriving the first-order conditions for an optimal sequence of lifetime labor contracts to maximization problem (10) subject to constraints (1) and (4)-(9) for all t, and given an initial lifetime labor contract $\{w_{01}, w_{12}, s_{12}, w_{23}, s_{23}, L_0, l_1, q_{01}, q_{12}\}$. To simplify the analysis, we will restrict our attention to the positive employment level of senior workers, thereby ignoring the nonnegative constraint in (7), $l_t \geq 0$. We also omit the nonnegative constraints in (8) and (9), $q_{t1} \geq 0$ and $q_{t+1,2} \geq 0$, because $q_{t1} = 0$ ($q_{t+1,2} = 0$) violates no-shirking condition (1) ((4)).[18]

Now, let us construct the Lagrangean

$$
\mathcal{L} = \pi + \sum_{t=1}^{\infty} (1+r)^{1-t}\lambda_t \cdot [U(w_{t2}-e^*) + (1+r)^{-1}q_{t2}U(w_{t+1,3}+b) - U(w_{t2})
$$

$$
- (1+r)^{-1}q_{t2}U(b)] + \sum_{t=1}^{\infty} (1+r)^{1-t}\mu_t \cdot \{U(w_{t1}-e^*) + q_{t1}A_{t+1} - U(w_{t1})
$$

$$
- (1+r)^{-1}q_{t1}[U(a) + (1+r)^{-1}U(b)]\} + \sum_{t=1}^{\infty} (1+r)^{1-t}\phi_t \cdot [U(w_{t2}-e^*)
$$

$$
+ (1+r)^{-1}U(w_{t+1,3}+b) - U(a) - (1+r)^{-1}U(b)]
$$

$$
+ \sum_{t=1}^{\infty} (1+r)^{1-t}\xi_t \cdot [U(w_{t1}-e^*) + A_{t+1} - V] + \sum_{t=1}^{\infty} (1+r)^{1-t}\alpha_t \cdot (1-l_t)
$$

$$
+ \sum_{t=1}^{\infty}\sum_{i=1}^{2} (1+r)^{1-t}\kappa_{t1} \cdot (1-q_{t1}). \tag{23}
$$

where λ_t, μ_t, ϕ_t, ξ_t, α_t, and κ_{t1} (i = 1, 2) are the Lagrangean multipliers associated with (1) and (4)-(9) in period t; and

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

$$+ (1-l_{t+1})[U(s_{t+1,2}+a) + (1+r)^{-1}U(s_{t+2,3}+b)]\}. \qquad (24)$$

Then the first-order conditions in period t are

$$w_{t1}: \quad -L_t + \mu_t \cdot [U'(w_{t1}-e^*) - U'(w_{t1})] + \xi_t \cdot U'(w_{t1}-e^*) = 0, \qquad (25)$$

$$w_{t2}: \quad -l_t L_{t-1} + \lambda_t \cdot [U'(w_{t2}-e^*) - U'(w_{t2})] + (\mu_{t-1} \cdot q_{t-1,1}l_t + \phi_t$$
$$+ \xi_{t-1} \cdot l_t)U'(w_{t2}-e^*) = 0, \qquad (26)$$

$$s_{t2}: \quad -L_{t-1} + (\mu_{t-1} \cdot q_{t-1,1} + \xi_{t-1})U'(s_{t2}+a) = 0, \qquad (27)$$

$$w_{t3}: \quad -l_{t-1}L_{t-2} + (\lambda_{t-1} \cdot q_{t-1,2} + \mu_{t-2} \cdot q_{t-2,1}l_{t-1} + \phi_{t-1}$$
$$+ \xi_{t-2} \cdot l_{t-1})U'(w_{t3}+b) = 0, \qquad (28)$$

$$s_{t3}: \quad -L_{t-2} + (\mu_{t-2} \cdot q_{t-2,1} + \xi_{t-2})U'(s_{t3}+b) = 0, \qquad (29)$$

$$L_t: \quad e^*F'(e^*L_t, e^*l_tL_{t-1}) + (1+r)^{-1}e^*l_{t+1}F'(e^*L_{t+1}, e^*l_{t+1}L_t) - C_1(q_{t1})$$
$$- (1+r)^{-1}C_2(q_{t+1,2})l_{t+1}- [w_{t1} + (1+r)^{-1}w_{t+1,2}l_{t+1}$$
$$+ (1+r)^{-1}s_{t+1,2}(1-l_{t+1}) + (1+r)^{-2}w_{t+2,3}l_{t+1} + (1+r)^{-2}s_{t+2,3}(1-l_{t+1})]$$
$$= 0, \qquad (30)$$

$$l_t: \quad e^*L_{t-1}F'(e^*L_t, e^*l_tL_{t-1}) - C_2(q_{t2})L_{t-1} - w_{t2}L_{t-1} + s_{t2}L_{t-1}$$
$$- (1+r)^{-1}w_{t+1,3}L_{t-1} + (1+r)^{-1}s_{t+1,3}L_{t-1} + [U(w_{t2}-e^*)$$
$$+ (1+r)^{-1}U(w_{t+1,3}+b) - U(s_{t2}+a) - (1+r)^{-1}U(s_{t+1,3}+b)](\mu_{t-1} \cdot q_{t-1,1}$$
$$+ \xi_{t-1}) - \alpha_t = 0, \qquad (31)$$

$$q_{t1}: \quad -C_1'(q_{t1})L_t + (1+r)^{-1}\mu_t \cdot \{ l_{t+1}[U(w_{t+1,2}-e^*) + (1+r)^{-1}U(w_{t+2,3}+b)]$$
$$+ (1-l_{t+1})[U(s_{t+1,2}+a) + (1+r)^{-1}U(s_{t+2,3}+b)] - [U(a)$$
$$+ (1+r)^{-1}U(b)]\} - \kappa_{t1} = 0, \qquad (32)$$

$$q_{t2}: \quad -C_2'(q_{t2})l_tL_{t-1} + (1+r)^{-1}\lambda_t \cdot [U(w_{t+1,3}+b) - U(b)] - \kappa_{t2} = 0, \qquad (33)$$

where $U'(x) = dU/dx$, $F'(x) = dF/dx$ and $C_i'(q_{ti}) = dC_i/dq_{ti}$ (i = 1, 2).

We next turn to the analysis of "generalized" maximization problem (11) subject to (12)-(22). As has been assumed in maximization problem (10), we will drop the nonnegative constraints of employment, wages, severance pays, and pensions for no-shirking workers. Thus, we will neglect the nonnegative constraint of the employment of senior workers ($l_t \geq 0$) in (17) and the nonnegative constraints of wages, severance pays, and pensions in (20) and (21). We will also omit the nonnegative constraints of monitoring probabilities ($q_{t1} \geq 0$ and $q_{t2} \geq 0$) because $q_{t1} = 0$ ($q_{t2} = 0$) violates no-shirking condition (14) ((12) and (13)). On the other hand, the nonnegative constraints for shirking workers are essential for the discussion of which threat is the most effective scheme as an incentive device. Hence, we will allow for all the constraints in (18) and (22) in the following analysis.

Then the first-order conditions in period t are

w_{t1}: $-L_t + \mu_t \cdot [U'(w_{t1}-e^*) - U'(w_{t1})] + \xi_t \cdot U'(w_{t1}-e^*) = 0$, (34)

w_{t2}: $-l_t L_{t-1} + \lambda_{tw} \cdot [U'(w_{t2}-e^*) - U'(w_{t2})] + (\mu_{t-1} \cdot q_{t-1,1}l_t + \phi_t$

$\qquad + \xi_{t-1} \cdot l_t)U'(w_{t2}-e^*) = 0$, (35)

s_{t2}: $-L_{t-1} + (\mu_{t-1} \cdot q_{t-1,1} + \xi_{t-1})U'(s_{t2}+a) = 0$, (36)

w_{t3}: $-l_{t-1}L_{t-2} + (\lambda_{t-1,w} \cdot q_{t-1,2} + \mu_{t-2} \cdot q_{t-2,1}l_{t-1} + \phi_{t-1}$

$\qquad + \xi_{t-2} \cdot l_{t-1})U'(w_{t3}+b) = 0$, (37)

s_{t3}: $-L_{t-2} + (\mu_{t-2} \cdot q_{t-2,1} + \xi_{t-2})U'(s_{t3}+b) = 0$, (38)

L_t: $e^*F'(e^*L_t, e^*l_tL_{t-1}) + (1+r)^{-1}e^*l_{t+1}F'(e^*L_{t+1}, e^*l_{t+1}L_t) - C_1(q_{t1})$

$\qquad - (1+r)^{-1}C_2(q_{t+1,2})l_{t+1} - [w_{t1} + (1+r)^{-1}w_{t+1,2}l_{t+1}$

$\qquad + (1+r)^{-1}s_{t+1,2}(1-l_{t+1}) + (1+r)^{-2}w_{t+2,3}l_{t+1} + (1+r)^{-2}s_{t+2,3}(1-l_{t+1})]$

$$= 0, \tag{39}$$

l_t: $e^* L_{t-1} F'(e^* L_t, e^* l_t L_{t-1}) - C_2(q_{t2})L_{t-1} - w_{t2}L_{t-1} + s_{t2}L_{t-1}$

$\qquad - (1+r)^{-1}w_{t+1,3}L_{t-1} + (1+r)^{-1}s_{t+1,3}L_{t-1} + [U(w_{t2}-e^*)$

$\qquad + (1+r)^{-1}U(w_{t+1,3}+b) - U(s_{t2}+a) - (1+r)^{-1}U(s_{t+1,3}+b)](\mu_{t-1} \cdot q_{t-1,1}$

$$\qquad + \xi_{t-1}) - \alpha_t = 0, \tag{40}$$

q_{t1}: $-C_1'(q_{t1})L_t + (1+r)^{-1}\mu_t \cdot \{l_{t+1}[U(w_{t+1,2}-e^*) + (1+r)^{-1}U(w_{t+2,3}+b)]$

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

$\qquad - \delta_{t+1}[n_{t+1}(U(x_{t+1,2}-e^*) + (1+r)^{-1}U(z_{t+2,3}+b))$

$\qquad + (1-n_{t+1})(U(y_{t+1,2}+a) + (1+r)^{-1}U(y_{t+2,3}+b))] - (1-\delta_{t+1})[U(a) +$

$$\qquad + (1+r)^{-1}U(b)]\} - \kappa_{t1} = 0, \tag{41}$$

q_{t2}: $-C_2'(q_{t2})l_t L_{t-1} + (1+r)^{-1}\lambda_{tw} \cdot [U(w_{t+1,3}+b) - U(b)]$

$$\qquad - (1+r)^{-1}\lambda_{ts} \cdot [U(z_{t+1,3}+b) - U(x_{t+1,3}+b)] - \kappa_{t2} = 0, \tag{42}$$

x_{t2}: $\lambda_{ts} \cdot [U'(x_{t2}-e^*) - U'(x_{t2})] - \delta_t \mu_{t-1} \cdot q_{t-1,1}n_t U'(x_{t2}-e^*) + \omega_{t2}$

$$= 0, \tag{43}$$

$$y_{t2}: \ -\delta_t \mu_{t-1} \cdot q_{t-1,1}(1-n_t)U'(y_{t2}+a) + \theta_{t2} = 0, \tag{44}$$

$$x_{t3}: \ -\lambda_{t-1,s} \cdot q_{t-1,2}U'(x_{t3}+b) + \omega_{t3} = 0, \tag{45}$$

$$y_{t3}: \ -\delta_{t-1}\mu_{t-2} \cdot q_{t-2,1}(1-n_{t-1})U'(y_{t3}+b) + \theta_{t3} = 0, \tag{46}$$

$$p_{t3}: \ -\lambda_{t-1,w} \cdot q_{t-1,2}U'(p_{t3}+b) + \xi_t = 0, \tag{47}$$

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

$$= 0, \tag{48}$$

n_t: $-[U(x_{t2}-e^*) + (1+r)^{-1}U(z_{t+1,3}+b) - U(y_{t2}+a)$

$$\qquad - (1+r)^{-1}U(y_{t+1,3}+b)]\delta_t \mu_{t-1} \cdot q_{t-1,1} - \beta_{t1} + \beta_{t2} = 0. \tag{49}$$

Here, $(1+r)^{-t}\lambda_{t+1,w}$, $(1+r)^{-t}\lambda_{t+1,s}$, $(1+r)^{1-t}\mu_t$, $(1+r)^{-t}\phi_{t+1}$, and $(1+r)^{1-t}\xi_t$ are the nonnegative multipliers associated with (12)-(16); $(1+r)^{-t}\alpha_{t+1}$ is the nonnegative multiplier associated with the constraint $1 \geqq l_{t+1}$ in (17); $(1+r)^{-t}\beta_{t+1,1}$ and $(1+r)^{-t}\beta_{t+1,2}$ are the nonnegative multipliers associated with (18); $(1+r)^{1-t-i}\kappa_{t+1,i+1}$ is the nonnegative multiplier associated with the constraint $1 \geqq q_{t+1,i+1}$ in (19) (i = 0, 1); $(1+r)^{1-t-i}\omega_{t+1,i+1}$, $(1+r)^{1-t-i}\theta_{t+1,i+1}$, $(1+r)^{-t-i}\xi_{t+2}$, and $(1+r)^{-t-i}\eta_{t+2}$ (i = 1, 2) are the nonnegative multipliers associated with (22); and δ_t is defined as $\delta_t = 1$ if $n_t[U(x_{t2}-e^*) + (1+r)^{-1}U(z_{t+1,3}+b)] + (1-n_t)[U(y_{t2}+a) + (1+r)^{-1}U(y_{t+1,3}+b)] > U(a) + (1+r)^{-1}U(b)$, and as $\delta_t = 0$ if $n_t[U(x_{t2}-e^*) + (1+r)^{-1}U(z_{t+1,3}+b)] + (1-n_t)[U(y_{t2}+a) + (1+r)^{-1}U(y_{t+1,3}+b)] \leqq U(a) + (1+r)^{-1}U(b)$.

In the subsequent analysis, we will omit time subscripts from both the firm's policy variables and the multipliers by assuming the stationary state.[19] This can be justified from the finding that the solutions to our lifetime labor contract models are time-invariant in the stationary state because all the parameters of these models are invariant with respect to time.

We are now in a position to compare optimal stationary lifetime labor contracts derived from (34)-(49) with those derived from (25)-(33). Proposition 1 provides the relation between these optimal stationary lifetime labor contracts.

Proposition 1. In the stationary state, any solution to be actually implemented in "generalized" maximization problem (11) is attained as a solution to maximization problem (10).

To understand the implications of Proposition 1 more clearly, suppose a stationary lifetime labor contract: (i) $(w_1, w_2, s_2, w_3, s_3, L, l, q_1, q_2,$

λ_w, μ, ϕ, ξ, α, κ_1, κ_2) are determined from (12), (14)-(17), (19), and (34)-(42), (ii) $(y_2, y_3, p_3, n_2, \beta_1) = (0, 0, 0, 0, 0)$, and (iii) $(x_2, x_3, z_3, \lambda_s, \omega_2, \theta_2, \omega_3, \theta_3, \zeta, \eta, \beta_2)$ are adjusted so as to satisfy (13), (22), and (43)-(49). From the construction, the stationary contract satisfies the optimal conditions for "generalized" maximization problem (11). On the other hand, as has already been argued at the end of subsection 2-2, this contract is included in the class of lifetime labor contracts with the threat of contract termination. This finding is summarized as the following corollary.

Corollary 1. Suppose that the firm's wage and employment policies are allowed to be contingent on the workers' performance in the previous periods. Then, any acheivable optimal allocation is implemented by a termination contract.

Let us mention some comments about Corollary 1. First, one might 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 one. However, Corollary 1 shows that these extra degrees of freedom in designing punishments are not valuable. This conclusion relies on the assumption that no-shirking workers are certain to avoid punishments. Under this situation, it is an undominated response for the firm to make the strongest punishment to shirking workers (i) because the firm can save monitoring costs, and (ii) because the expected utility level of no-shirking workers does not depend on the choice of a threat directly. Given that contract termination is the strongest threat when severance pays and pensions must be nonnegative, it is an optimal

strategy for the firm to threaten shirking workers with contract termination.

Second, the recent work of Kahn and Huberman [1988] has provided a rationale for the threat of contract termination by comparing termination contracts with full employment contracts. MacLeod and Malcomson [1989] have proved that any acheivable allocation is implemented by a termination contract in perfect equilibria of a repeated game. Okuno-Fujiwara [1989] has also shown that a termination contract is an equilibrium contract in "norm equilibria" based on a reinterpretation of "Nash equilibria". However, the setting of Kahn and Huberman is rather different from ours because in their model, all workers shirk in the full employment contracts. Unlike MacLeod and Malcomson or Okuno-Fujiwara, our result does not depend on the concept of either perfect equilibria or norm equilibria. In addition, although these authors restrict their attention to wage contracts with exogenous monitoring, we have derived our result from the more general model in which the firm adjusts not only its wage policies but also its employment and monitoring policies to eliminate the workers' incentive to shirk.

Given Proposition 1, we now focus our attention on equations system (25)-(33), and obtain several results about another characteristics of the optimal solutions to our contract models.

Proposition 2. Suppose that workers are strictly risk averse. If senior workers are laif off, then

$$s_2 + a = s_3 + b < w_2 - e^*, \tag{50}$$

$$s_2 + a = s_3 + b < w_3 + b. \tag{51}$$

Furthermore,

$$e^*F'(e^*L, e^*1L) > a + e^* + C_2(q_2). \tag{52}$$

Proof. See Appendix.

Several remarks about Proposition 2 are in order. First, in this model, the firm lays off senior workers if the firm has a large number of junior workers in comparison with the net marginal productivity of senior workers. Hence, some readers might think that the possibility of the layoff of senior workers depends on the assumption that all junior workers are promoted to senior workers. However, if nonpromoted junior workers are more likely to shirk than senior workers, it is not optimal for the firm to offer a lifetime labor contract with partial promotions.[20] Furthermore, as shown in Oswald [1984], workers who are not promoted may choose to go to outside job opportunities. Then, if the firm is allowed to pay severance payments to workers who are not promoted, we can identify the rate of being promoted as the rate of being laid off. These discussions verify that the result of Proposition 2 does not necessarily depend on the assumption that partial promotions are assumed away.

Second, Carmichael [1985] criticizes the efficiency wage theory because deferred payment schemes might eliminate involuntary unemployment with the workers' shirking problem. Akerlof and Katz [1989] have recently concluded that deferred payment schemes cannot avoid involuntary unemployment. The reason is that deferred payment schemes do not prevent workers from shirking early in their careers even though they may prevent workers from shirking late in their careers. As discussed in Akerlof and Katz, Proposition 2 implies that the involuntary layoff and underemployment of senior workers always emerges even with deferred payment schemes if senior workers are laid off. However, the result of the involuntary layoff of senior workers in this chapter depends on the feature of our model that the no-shirking condition for

senior workers restricts the wage of senior workers, but not the severance pay of senior workers. Thus, to prevent senior workers from shirking, the wage of senior workers must be higher than the severance pay of senior workers in our model. The involuntary layoff always yields underemployment because the firm need not use the employment level as an instrument of income insurance in the presence of severance payments.

Third, in the former version of this chapter [1988], we have assumed that monitoring technology is exogenous; and we have only obtained the weaker result that the involuntary layoff and underemployment of senior workers occurs with deferred payment schemes if and only if the no-shirking condition for senior workers is binding. However, if the firm can choose the probability of catching a worker shirking, the firm does not wish to spend any monitoring costs unless no-shirking conditions are binding. On the other hand, if the firm did not spend any monitoring costs, no-shirking conditions are violated, so that workers do not work. Thus, if monitoring technology is endogenous, the no-shirking condition for senior workers must be satisfied with strict inequality. As a result, the involuntary layoff and underemployment of senior workers always occurs in the optimal contracts in this endogenous monitoring model if senior workers are laid off.

Finally, even though most Japanese large firms have a lifetime employment system, they transfer a number of their senior workers to jobs of their affiliated firms or jobs of their own in which these senior workers do not contribute to any production; and those transferred workers must usually make do with lower wages than no-transferred workers. If the rate of being laid off in this model is identified with the rate of being transferred to those jobs, Proposition 2 provides a rationale for this transfer system as a useful incentive device to overcome the worker moral hazard problem.

We now proceed to discuss the differences between the results of the present model and the worker moral hazard model of Mookherjee [1986]. In Mookherjee [1986, section 3], he assumes that shirking workers are still employed with some probabilities inside the firm and are paid the same wages and severance pays as no-shirking workers. The only difference between the contract arrangements of shirking and no-shirking workers is their employment probability in the next period. Using this set-up, Mookherjee shows that the worker moral hazard hypothesis may yield involuntary retention rather than involuntary layoff; that is, there is no reason to expect that incentives will be necessarily provided through involuntary layoff. It is easy to see that these results are inconsistent with the results derived from our "generalized" lifetime labor contract model.

To understand the reason for this inconsistency, we explore the properties of a solution to "generalized" maximization problem (11) subject to (12)-(22) with the added restrictions that $w_2 = x_2$, $s_2 = y_2$, $w_3 = z_3$, $s_3 = y_3$, and $p_3 = x_3$ for all t.[21] This contract model can be regarded as an extension of the Mookherjee model to a three-period framework with endogenous monitoring.[22] A stationary solution to this maximization problem satisfies the feature described by the following proposition:

Proposition 3. Suppose that workers are strictly risk averse, and that shirking workers are still employed with some probabilities inside the firm and are paid the same wages and severance pays as no-shirking workers. In the stationary state, if senior workers are laid off, the involuntary *retention* (*layoff*) and *overemployment* (*underemployment*) of senior workers can occur if the proportion of laid off senior workers is *greater* (*smaller*) than 1/2.

Proof. Applying the procedure of the proof of Proposition 1 of Mookherjee

[1986, p.743] to this additionally constrained "generalized" maximization

problem (12), we can prove that the optimal lifetime labor contracts can

generate the involuntary *retention* (*layoff*) and *overemployment*

(*underemployment*) of senior workers if the proportion of laid off workers is

greater (*smaller*) than 1/2.

Proposition 3 suggests that the involuntary retention of senior workers

is possible in some circumstances. The intuition behind the differences

between the results of Propositions 2 and 3 can be explained as follows. In

the model of Proposition 3, the firm cannot adjust wage policies independently

of employment policies to threaten shirking senior workers. This is because

wages, severance pays and pensions are not allowed to depend on whether or not

workers are caught shirking. If the proportion of laid off senior workers is

greater than 1/2, then there are more laid off senior workers than employed

senior workers, so that involuntary retention has smaller effects on the

expected utility of no-shirking senior workers than involuntary layoff. Thus,

it is an optimal response for the firm to punish shirking senior workers by

involuntary retention. Conversely, if the proportion of laid off senior

workers is smaller than 1/2, it is optimal to punish shirking senior workers

by involuntary layoff. In the model of Proposition 2, however, we assume that

wages, severance pays, and pensions are allowed to depend on whether or not

workers are caught shirking in the previous periods. The firm can thus

independently adjust wage policies to alleviate the incentive of workers to

shirk. As a result, retained senior workers become better off than laid off

senior workers because the firm must offer higher wages to retained senior

workers to prevent them from shirking. Underemployment then coexists with

involuntary layoff since the firm need not use employment policies as an

insurance device.

Mookherjee [1986] also analyzes, in his Section 2, a model in which workers' wages and severance pays are allocated to depend on their current and past performance. Even in this case, he shows that involuntary retention is possible. This result is due to his assumption that no-shirking workers cannot always attain good performance: the workers' performance level is uncertain. If no-shirking workers always produce good performance as assumed in the standard efficiency wage model, we can verify that there exists no involuntary retention in Mookherjee's Section 2 model. Furthermore, even if the workers' performance level is uncertain, we may predict that involuntary retention does not occur if the extent of uncertainty is small.

3-4. Conclusion

This chapter has explored two multi-period contract models with endogenous monitoring 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 workers with contract termination. The other is a more general model where the firm can freely choose a threat to shirking workers by making wage and employment policies contingent on whether or not workers are caught shirking in the previous periods. The results obtained in both of these models have shown (i) that any acheivable optimal allocation can be implemented by a termination contract even if the firm's wage and employment policies are allowed to depend on whether or not workers are caught shirking, and (ii) that the workers' incentive to shirk can yield strict involuntary layoff and underemployment if workers are strictly risk averse. The possibility of strict involuntary layoff also provides a rationale for the transfer system of senior workers among firms or within

firms in Japanese large firms. Furhtermore, these results have verified that the conclusion of involuntary retention of Mookherjee [1986] depends on his assumptions (i) that wages or severance pays are not allowed to be contingent on whether or not workers are caught shirking in the previous periods, or (ii) that no-shirking workers cannot always attain good performance.

Much work remains to be done. First, the conclusion of this chapter suggests that the threat of contract termination is an optimal scheme to overcome the worker moral hazard hypothesis in a wide variety of circumstances if no-shirking workers can always attain good performance. However, if the worker's performance level is uncertain, this conclusion suffers from some modifications. Second, we have not embedded our contract models into a market equilibrium setting in which the payoffs in outside opportunities are endogenous. Thus, it is fairly interesting to extend our contract models into this direction.

Appendix

The purpose of this appendix is to prove Propositions 1 and 2. Since we focus on the stationary state, we omit time subscripts from all the variables and the multipliers which appear in the objective functions, the constraints and the first-order conditions presented in the text.

Proof of Proposition 1:

We first show that it is an undominated response for the firm to set $p_3 = 0$ and $y_2 = y_3 = 0$ in "generalized" maximization problem (11). Suppose that a stationary lifetime labor contract involves $p_3 > 0$ or $y_2 > 0$ or $y_3 > 0$. If we set $p_3 = y_2 = y_3 = 0$, this relaxes constraint (12) or (14), but neither has any direct effects on the objective function nor violates any other constraints. This finding implies that any stationary lifetime labor contract is weakly dominated by a stationary lifetime labor contract with $p_3 = y_2 = y_3 = 0$ in "generalized" maximization problem (11).

We next prove that in "generalized" maximization problem (11), equations (41) and (42) reduce to (32) and (33), respectively. We divide the discussion into the following three cases.

(I) $\mu = 0$.

If $\mu = 0$, it is immediate from (41) that

$$-C_1'(q_1)L - \kappa_1 = 0,$$

which contradicts $C_1' > 0$ and $\kappa_1 \geqq 0$.

(II) $\mu > 0$ and $\delta = 0$.

In this case, $\delta = 0$ implies that (41) reduces to (32). Furthermore, it follows from (48) with $\delta = 0$ that

$$\lambda_s q_2 U'(z_3 + b) + \eta = 0. \tag{A1}$$

Now, it is found from (13) that

$$(1+r)^{-1}q_2[U(z_3+b) - U(x_3+b)] \geqq U(x_2) - U(x_2-e^*) > 0,$$

which yields

$$z_3 > x_3 \geqq 0. \qquad (A2)$$

Since η is the nonnegative multiplier associated with $z_3 \geqq 0$, it is immediate from (A1) and (A2) with $q_2 > 0$ that $\lambda_s = 0$. Thus, (42) reduces to (33) because we can identify λ_w with λ.

(III) $\mu > 0$ and $\delta = 1$.

Suppose that $U(x_2-e^*) + (1+r)^{-1}U(z_3+b) > U(y_2+a) + (1+r)^{-1}U(y_3+b)$. Then it follows from (49) with $\mu > 0$, $\delta = 1$ and $q_1 > 0$ that

$$\beta_2 > \beta_1 \geqq 0. \qquad (A3)$$

Since β_2 is the nonnegative multiplier associated with $n \geqq 0$, (A3) implies $n = 0$. Given the definition of δ with $n = 0$, it is seen from $\delta = 1$ that

$$U(y_2+a) + (1+r)^{-1}U(y_3+b) > U(a) + (1+r)^{-1}U(b),$$

which contradicts $y_2 = y_3 = 0$. Hence, we must have $U(x_2-e^*) + (1+r)^{-1}U(z_3+b)$ $\leqq U(y_2+a) + (1+r)^{-1}U(y_3+b)$. Then, for any $n \in [0, 1]$, we obtain

$$n[U(x_2-e^*) + (1+r)^{-1}U(z_3+b)] + (1-n)[U(y_2+a) + (1+r)^{-1}U(y_3+b)]$$
$$\leqq U(y_2+a) + (1+r)^{-1}U(y_3+b)$$
$$= U(a) + (1+r)^{-1}U(b), \qquad (A4)$$

where the final inequality follows from $y_2 = y_3 = 0$. However, inequality (A4) contradicts $\delta = 1$.

We have now found that, in a stationary solution to "generalized"

maximization problem (11), the system of equations (34)-(42) reduces to the
same form as the system of equations (25)-(33). Repeating the similar
argument, we can also show that constraint (14) reduces to (4) in a stationary
solution to "generalized" maximization problem (11) because only $\delta = 0$ is
consistent with the optimal conditions for the solution. Since it is an
undominated response for the firm to set $p_3 = 0$, this finding implies that the
system of constraints (12), (14)-(17) and (19) reduces to the system of
constraints (1) and (4)-(9) in a stationary solution to "generalized"
maximization problem (11). Hence, the subsystem of the optimal conditions for
a stationary solution to "generalized" maximization problem (11), made up of
(34)-(42) with (12), (14)-(17) and (19), has the same form as the optimal
conditions for a stationary solution to maximization problem (10).
Proposition 1 is thus proved because, given no-shirking conditions (12)-(14),
only the subsystem of the optimal conditions consisting of (34)-(42) with
(12), (14)-(17) and (19) determines a profile of lifetime contract
arrangements to be actually implemented; on the other hand, the subsystem of
the optimal conditions consisting of (43)-(49) with (13), (18) and (22) merely
gives a threat to shirking workers not to be really implemented.

Proof of Proposition 2:

Given Proposition 1, we can restrict our attention to (25)-(33). We
first show that (50) and (51) are derived from the first-order conditions for
w_2, s_2, w_3, s_3 and q_2. Rearranging (26)-(29) yields

$$U'(w_2-e^*) = [\mu q_1 + 1^{-1}\phi + \xi]^{-1}\{L - 1^{-1}\lambda[U'(w_2-e^*) - U'(w_2)]\},$$

$$\tag{A5}$$

$$U'(w_3+b) = [1^{-1}\lambda q_2 + \mu q_1 + 1^{-1}\phi + \xi]^{-1}L, \tag{A6}$$

$$U'(s_2+a) = U'(s_3+b) = (\mu q_1 + \xi)^{-1}L. \tag{A7}$$

Given $(\lambda, \mu, \phi, \xi) \geq 0$, $w_2 > w_2 - e^*$, and the assumption that U is strictly concave ($U'' < 0$), it is found from (A5) and (A7) that

$$s_2 + a = s_3 + b \leq w_2 - e^*, \tag{A8}$$

with strict inequality holding if and only if either the no-shirking condition for senior workers or the no-quit condition for employed senior workers is effective (i.e., $\lambda > 0$ or $\phi > 0$). Similarly, it follows from (A6) and (A7) with $q_2 > 0$ that

$$s_2 + a = s_3 + b \leq w_3 + b, \tag{A9}$$

with strict inequality holding if and only if either the no-shirking condition for senior workers or the no-quit condition for employed senior workers is effective (i.e., $\lambda > 0$ or $\phi > 0$).

The remaining problem is to prove that $\lambda > 0$ always holds. To this end, we rewrite (33) as

$$C_2'(q_2)1L + \kappa_2 = (1+r)^{-1}\lambda [U(w_3+b) - U(b)]. \tag{A10}$$

Since (12) implies that w_3 must always be positive, it is immediate that

$$U(w_3+b) - U(b) > 0. \tag{A11}$$

Inspecting (A10) with $C_2' > 0$, $\kappa_2 \geq 0$ and (A11), we see that $\lambda > 0$ must always hold. Given (A8) and (A9), this result completes the proof for (50) and (51).

We now turn to verifying (52). Using (50), (51) and the strict concavity of the utility function of workers, we have

$$U(w_2 - e^*) + (1+r)^{-1}U(w_3+b) - U(s_2+a) - (1+r)^{-1}U(s_3+b)$$
$$< U'(s_2+a)(w_2 - e^* - s_2 - a) + (1+r)^{-1}U'(s_3+b)(w_3 - s_3). \tag{A12}$$

Rearranging (A12) with (A7) gives us

$$U(w_2-e^*) + (1+r)^{-1}U(w_3+b) - U(s_2+a) - (1+r)^{-1}U(s_3+b)$$

$$< (\mu q_1 + \xi)^{-1}L[w_2 - e^* - s_2 - a + (1+r)^{-1}(w_3 - s_3)]. \qquad (A13)$$

Combining (31) and (A13) yields

$$e^*F'(e^*L, e^*1L) - C_2(q_2) - [w_2 - s_2 + (1+r)^{-1}(w_3 - s_3)]$$

$$+ w_2 - e^* - s_2 - a + (1+r)^{-1}(w_3 - s_3) - (L)^{-1}\alpha > 0, \qquad (A14)$$

which reduces to

$$e^*F'(e^*L, e^*1L) > e^* + a + (L)^{-1}\alpha + C_2(q_2)$$

$$\geq e^* + a + C_2(q_2).$$

Notes

1. Underemployment means that the marginal product of labor is greater than the workers' opportunity cost of labor. Involuntary layoff means that employed workers are better off than laid off workers.

2. For the related literature, see Alvi [1988] and Kahn and Mookherjee [1988] in which the worker moral hazard problem is discussed using single-period, asymmetric information contracting models with incentive-compatibility constraints.

3. Involuntary retention means that laid off workers are better off than employed workers.

4. This assumption is used in the standard efficiency wage model such as Shapiro and Stiglitz [1984].

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

6. In this framework, the firm can hire junior workers and then immediately lay off a number of them. However, we rule out this possibility because the notion seems to be of questionable importance. The same assumption is also used in Ioannides and Pissarides [1983], Oswald [1984], and Mookherjee [1986].

7. As mentioned in the introduction, the probability of being laid off, $(1-l_{t+1})$, may be interpreted as the probability of being transferred to jobs in affiliated firms or jobs in the firm's own where senior workers do not contribute to any production.

8. We assume that junior workers can acquire firm-specific seniority skills even though they shirk. This assumption would not be unrealistic since workers can learn firm-specific seniority skills even if they do not work so hard.

9. We may 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 this chapter, 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], 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 given by $U(w_{t+2,3}+b) \geqq U(b)$ and $U(s_{t+2,3}+b) \geqq U(b)$, which are never binding unless $w_{t+2,3} = 0$ or $s_{t+2,3} = 0$.

12. The no-quit constraint for senior workers laid off in period t+1 is $U(s_{t+1,2}+a) + (1+r)^{-1}U(s_{t+2,3}+b) \geqq U(a) + (1+r)^{-1}U(b)$, which is never binding unless $s_{t+1,2} = s_{t+2,3} = 0$.

13. In the subsequent analysis, "workers who do not shirk or do not get caught shirking" includes laid off workers.

14. In any optimal solution, workers do not shirk as long as the no-shirking conditions, both for junior workers and for senior workers, hold in each period. Thus, even though we rule out the no-quit constraints for workers caught shirking, this does not affect any results obtained in this paper.

15. See note 7.

16. See note 14.

17. 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.

18. Dickens, Katz, Lang and Summers [1989] have recently shown that firms

should not spend any resources on monitoring if workers may pay firms an explicit bond or fee upon taking a job. However, since we assume away up-front bonds, their result does not hold in this paper.

19. The results obtained here are essentially unaffected by this assumption.

20. Suppose a lifetime labor contract in which not all of the junior workers are promoted whereas all of the senior workers are employed. If the rate of being promoted is ψ, then the numbers of junior and senior workers in this contract are $L+(1-\psi)L$ and ψL, respectively. Now, suppose a lifetime labor contract in which the firm employs L' ($= L+(1-\psi)L$) junior workers and promotes all of them, but lays off $2(1-\psi)L$ senior workers. The difference between the profits of these two contracts is

$$-2(1-\psi)L[(1+r)^{-1}s_1 + (1+r)^{-2}s_2] - r(1+r)^{-1}(1-\psi)L[C_1(q_1) + w_1]$$
$$+ (1-\psi)L(1+r)^{-2}w_P, \tag{N1}$$

where w_P is a pension paid to nonpromoted workers in the lifetime labor contract with partial promotions. If (N1) is positive, it is optimal for the firm to offer a lifetime labor contract with layoffs instead of a lifetime labor contract with partial promotions. This possibility is likely to happen if nonpromoted workers have more incentive to shirk than senior workers.

21. In this setting, (12) and (13) reduce to the same constraints; and the right-hand side of (14) is simplified because the firm does not induce shirking workers to leave the firm. To prevent employed senior workers from shirking, we still make their pensions contingent on whether they are caught shirking; that is, $w_3 \neq p_3$. However, Proposition 3 does not depend on this assumption.

22. In fact, Mookherjee [1986] assumes that the workers' performance level is uncertain, and that the probability of good performance depends on whether the

worker works or shirks. Thus, the model presented in this section should be interpreted as an extension of the Mookherjee model as long as the workers' performance level is certain. We will discuss the role of the assumption about the uncertainty of the workers' performance level at the end of this section.
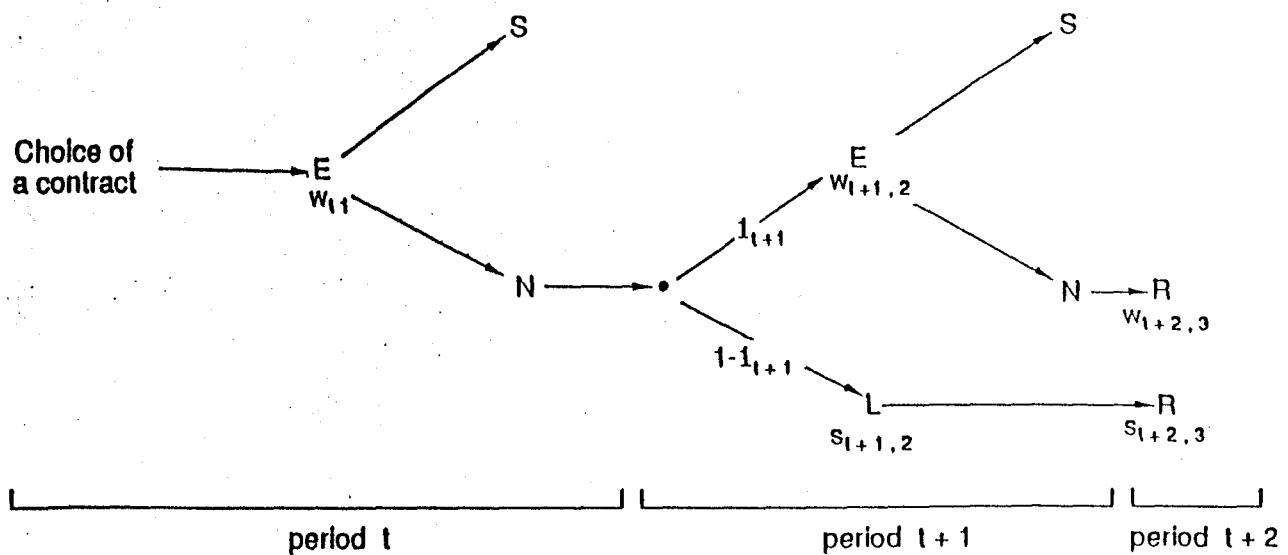
Fig. 1. Lifetime Labor Contracts with the Threat of Contract Termination.
E: state in which the worker is employed; L: state in which the worker is
laid off; S: state in which the worker is caught shirking; N: state in
which·the worker works or does not get caught shirking; R: state in which
the worker is retired.

Choice of
a contract

S — R
$x_{t+2,3}$

E
$x_{t+1,2}$

n_{t+1}

S

N — R
$z_{t+2,3}$

$1-n_{t+1}$

L — R
$y_{t+1,2}$ $y_{t+2,3}$

E
w_{tt}

S — R
$p_{t+2,3}$

E
$w_{t+1,2}$

1_{t+1}

N — R
$w_{t+2,3}$

$1-1_{t+1}$

L — R
$s_{t+1,2}$ $s_{t+2,3}$

N

period t   period t + 1   period t + 2
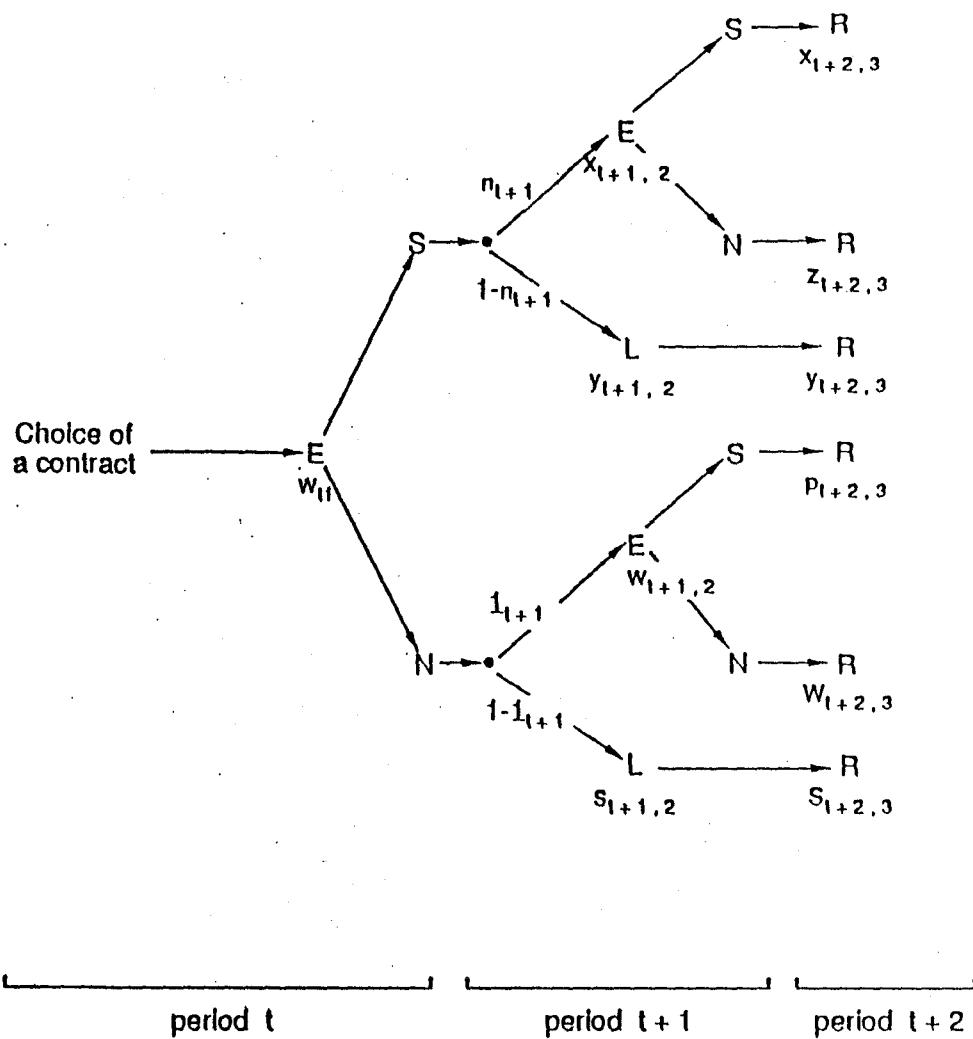
Fig. 2. Lifetime Labor Contracts with the Threat of Differences
between the Employment Probabilities of Shirking Workers and
No-Shirking Workers. E: state in which the worker is employed;
L: state in which the worker is laid off; S: state in which the
worker is caught shirking; N: state in which the worker works or
does not get caught shirking; R: state in which the worker is
retired.

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Chapter 4

Implicit Contracts and Reputations

4. Implicit Contracts and Reputations

4-1. Introduction

A great deal of attention has been paid to the implicit contract theory since Azariadis (1975) and Baily (1974). The basic idea of this theory is that less risk-averse firms find it profitable to offer sticky wages to more risk-averse workers and to insure them against fluctuations in the the firm's product demand. In this view, wage stickiness prevails as an outcome of risk-sharing arrangements against fluctuations in the firm's product demand. Unfortunately, if firms and workers have symmetric information about the state of the world, the implicit contract theory cannot explain underemployment which is not predicted by the standard Walrasian model. Several authors, however, have recently shown that this conclusion is no longer true once firms are assumed to have better information than workers about the state of the world. In particular, Grossman and Hart (1981) (1983) and Hart (1983) reach remarkable conclusions that unemployment will be greater in the implicit contract model than in the Walrasian model if firms are risk averse under asymmetric information.

In spite of these developments, much effort has not been made to justify the two critical assumptions of the implicit contract theory: (1) The firm is committed to any agreed-upon contracts until the beginning of the next contracting period, and (2) the worker is not permitted to move any ex-post job opportunities outside the firm of his ex-ante contract. If the first assumption is violated, the firm may default the ex-ante contract in some unfavorable states where the wage rate exceeds the marginal product of labor. On the other hand, if the second assumption does not hold, the worker may quit the firm when he enjoys higher utility by joining another work outside the

firm.

To justify these two assumptions, we might think of possibility of legal enforceability. Nevertheless, about the legal basis of contracts, we observe in reality that contracts are enforceable on firms, and not on workers; in other words, the bondage and discipline of labor is not lawful. Furthermore, contracts are not enforceable on firms either if they are written in the implicit form.

Several recent papers have recognized that care of both firms and workers in building their reputations under repeated contracts plays the role of a private device for assuring contract performance in the absence of legal enforcement (see Carmichael (1984) and Wilson (1986)). This private mechanism relies upon the values of repeated contracts to firms and workers as a means of preventing nonperformance.

If both firms and workers realize the role of reputation for enforcing contractual promises, these two contracting agents arrange the labor contracts so as to motivate themselves to honor their promises. Then it is not surprising if an optimal labor contract is strongly impinged by the nature of the reputational mechanism. It thus becomes important to discuss whether an optimal contract is efficient under the reputational mechanism. If the reputational mechanism cannot fully assure the efficiency of an optimal contract, we further need to ask whether an optimal contract causes underemployment or overemployment. The recent work of Newbery and Stiglitz (1987) has examined the problem of firm's reputation. However, to avoid complexity, they restrict their analysis to the class of linear implicit contracts. Furthermore, they assume that the reputation cost (or the value of repeated contracts to firms) is independent of what contract arrangements are made between the firm and the workers.

The purpose of this chapter is to explore a role of firm's reputation in the contractual labor market where the firm cannot commit itself to any agreed-upon contracts. In contrast to Newbery and Stiglitz, we discuss the class of general implicit contracts and scrutinize the case that reputation cost is dependent on the contract arrangements. We consider a long-term contract model in which, if the firm defaults the contract arrangements, the firm acquires a bad reputation and cannot make any contracts in subsequent periods. The worker is assumed to behave as if he knows the production function of the firm. Once the firm offers a long-term contract, the worker puts himself in the position of the firm, thereby calculating whether the firm's benefits gained from honoring the contract are greater than the costs involved. The long-term contract can then be organized so as not to be defaulted by the firm. The similar kind of reputational mechanism has been dealt with the literature on the quality choice of products (see Klein and Leffler (1981), Shapiro (1982) (1983) and Allen (1984)).[1]

The plan of this chapter is as follows. Section 4-2 develops a long-term contract model under symmetric information where the realization of the state of the world becomes known to both firms and workers. The striking result in this section is that reputation by itself enforces efficient behavior on firms even though the firm cannot commit themselves to any agreed-upon contracts; in particular, an optimal contract is characterized by the efficient level of employment. This finding differs from the results of the recent articles on reputational markets because their results suggest that reputation by itself will not restore efficiency (see Carmichael (1984) and Wilson (1986)).

Section 4-3 discusses a long-term contract model under asymmetric information in which firms have better information than workers about the state of the world. We assume throughout this section that firms are risk

neutral under the environment based on Grossman and Hart (1983). Using this framework, Grossman and Hart show that no distortion exists if firms can commit themselves to implement any agreed-upon contracts. In contrast, we can prove that care of firms in building their reputations involves the possibility of underemployment unless firms can commit themselves to implemenmt any agreed-upon contracts. Furthermore, if underemployment occurs, an optimal contract in the reputational market provides the amount of severance pay which is not enough to ensure risk-averse workers from the risk of layoff. This result implies that under the optimal contract workers prefer being employed to being laid off. Our analysis therefore leads to equilibria in which there are both inefficiently high unemployment (underemployment) and involuntary unemployment.

In the standard implicit contract model with severance pay, workers are indifferent about whether they are to be rationed or laid off. To explain the phenomenon of involuntary unemployment, Moore (1985) allows workers to have better ex-ante information about their spot market opportunities; but he finds a tendency towards involuntary retentions rather than involuntary layoffs. Mookherjee (1986) explores the alternative hypothesis that firms cannot perfectly observe effort decisions of employed workers in the long-term contract relation. However, he concludes that unobservability of worker effort is unlikely to provide a robust explanation of involuntary layoffs in the long-term contract. In contrast, our result suggests that care of firms in building their reputations provides a theoretical explanation of involuntary layoffs.[2]

The final section contains some concluding comments and discusses future research.

4-2. The Symmetric Information Model

Consider a (representative) firm which employs one worker at most. The output or revenue of the worker in each period is given by an independently and identically distributed random variable, s, if he is employed. Let F be a distribution function of s that satisfies $F(\underline{s}) = 0$ and $F(\bar{s}) = 1$ for $\underline{s} < \bar{s}$. The distribution function F has a continuous density function f(s), which is positive for $\underline{s} \leq s \leq \bar{s}$.

At the beginning of each period before s is not realized, neither actual production nor employment occurs. At the end of each period after s is realized, production and employment can be carried out if a labor contract has been signed. If production does occur, the firm employs the worker and produces output s. If production does not occur, the firm lays off the worker and produces no output.

The worker has no consumption good endowment, but he supplies one unit of labor inelastically in each period. Since he has no access to the capital market, he consumes whatever he earns in each period. If the worker is employed, his utility is $U(Y-R)$; and if he is unemployed, his utility is $U(Y')$. Here, U is a von Neumann-Morgenstern utility function; $Y(Y')$ is worker's income when he is employed (unemployed); and R represents worker's disutility of effort, which is assumed to be $\underline{s} \leq R \leq \bar{s}$. The utility function U is defined and twice differentiable on R_+. It is assumed that $U' > 0$ and $U'' < 0$ on R_+. Thus the worker has risk averse preferences.

In what follows, we assume that both the firm and the worker know the probability distribution function F and the utility function U. It is particularly assumed in this section that everyone will observe output s at the end of each period.

The model is an infinite-horizon one starting with period 0. At the beginning in period 0, the firm decides whether to sign an infinite-horizon long-term contract with the worker. In general, we can consider nonstationary long-term contracts instead of stationary ones. However, little can be said about nonstationary long-term contracts. Thus we will focus our attention on stationary long-term contracts consisting of a set of functions, [w(s), y(s), L(s); $\underline{s} \leq s \leq \bar{s}$]. These contracts indicate for each state (1) whether the worker is employed (L(s) = 1) or unemployed (L(s)) = 0);[3] and (2) that he receives wages w(s) if employed, and severance pay y(s) if not employed.

Under stationary long-term contracts, the present value of stream of expected profits of the firm is described by

$$r^{-1} \cdot E \{ L(s)[s - w(s)] - [1 - L(s)]y(s)\}, \qquad (1)$$

where r is a discount rate and E an expectation operator. The present value of stream of expected utility of the worker is also written in the form

$$r^{-1} \cdot E \{ L(s)U(w(s) - R) + [1 - L(s)]U(y(s))\}. \qquad (2)$$

Once the worker signs a contract with the firm, he is assumed to be unable to work anywhere else outside the firm at the ex-post date in each period; in other words, he cannot join any contracts with the other firms until the beginning in the next period. This presumption can be justified if the worker incurs mobility costs when moving to the other firms at the ex-post date in each period.

On the other hand, the firm is not committed to any agreed-upon contracts: The firm may default on the agreed-upon contract at the end of each

period. If a firm defaults on the agreed-upon contract, then the news becomes known to workers through market surveys, conversations with friends, and so on. The simplest way to model the information-dissemination process is to assume that, until the beginning in the next period, all workers are informed whether the firm defaults on the contract.[4] In this process, if a firm ever violates the agreed-upon contract, the firm acquires a bad reputation because the news the firm cheats becomes widely known. Once a firm has a bad reputation, workers expect that the firm will default on the ex-ante contract. Thus the cheating firm cannot make any ex-ante contracts in subsequent periods under the assumed information-dissemination process.

In the analysis that follows, the firm is assumed to shut down its operation after breaking the contract.[5] The firm then finds it profitable to maintain the reputation of honoring contracts if and only if, at the end of each period, the firm enjoys a greater present value of stream of expected profits under the long-term contract than under the shutdown.

We now proceed to examine an optimal stationary long-term contract which maximizes the firm's present value of stream of expected profits, (1), subject to (i) the reservation utility constraint and (ii) the reputational constraint that prevents the firm from defaulting the contract.

We begin with considering the two constraints of the firm's maximization problem. We first introduce the reservation utility constraint which forces the firm to match or exceed market offers in order to retain workers in each period. This constraint is

$$r^{-1} \cdot E \{ L(s)U(w(s) - R) + [1 - L(s)]U(y(s)) \} \geq \bar{V}, \qquad (3)$$

where $\bar{V}$ is a market-determined present value of stream of expected utility of

workers.

We next discuss the reputational constraint which induces the firm to honor the contractual relation. We find from the previous argument that the firm prefers to maintain the reputation of honoring contracts if and only if, at the end of each period, the firm enjoys a greater present value of stream of expected profits from being on the long-term contract than from stopping operation. Given stationarity, at the end of each period, the present value from being on the long-term contract is evaluated as follows:

$$\pi(s) = \{L(s)[s-w(s)] - [1-L(s)]y(s)\}$$
$$+ r^{-1}(1-r) \cdot E\{L(s)[s-w(s)] - [1-L(s)]y(s)\}, \qquad (4)$$

where the first term represents the ex-post single-period profits realized at the end of the period, and the second term is the present value of stream of expected profits from the next period onward if the firm continues the contract relation.[6] Note that specification (4) is valid for both $L(s) = 0$ and $L(s) = 1$.

The reputational constraint can now be described using (4): The firm finds it more profitable to honor the contract if and only if, for each state,

$$L(s)[s-w(s)] - [1-L(s)]y(s)$$
$$+ r^{-1}(1-r) \cdot E\{L(s)[s-w(s)] - [1-L(s)]y(s)\} \geqq 0. \qquad (5)$$

We assume throughout that the firm desires to continue in the contract relation if it is indifferent to the firm whether to default or not.

Farmer (1985) and Kahn and Scheinkman (1985), incorporating a bankruptcy constraint into the implicit contract model, lead us to the interesting

conclusion that limited liability generates underemployment under asymmetric information. Their bankruptcy constraint implies that, in any state of nature, the ex-post loss of the firm can be no greater than the collateral of the firm which is exogenously given. It might be thought that reputational constraint (5) is similar to such a limited liability type. However, this view is rather misleading because reputational constraint (5) includes those terms of future expected profit stream which depend on the endogenous contract arrangements determined between the firm and the worker. Furthermore, since the worker is risk neutral in Farmer and the firm adjusts the labor input by work sharing alone in Kahn and Scheinkman, the worker is indifferent to the distribution of payment across states of nature; thus the unemployment is always voluntary. On the other hand, in our model, the worker is risk averse and the firm is allowed to layoff the worker, so that the possibility of involuntary unemployment can be accounted for.

Now, the firm's maximization problem with respect to $[w(s), y(s), L(s); \underline{s} \leqq s \leqq \bar{s}]$ is

$$\text{Max } r^{-1} \cdot E \{ L(s)[s - w(s)] - [1 - L(s)]y(s) \}, \tag{6}$$

subject to (3), (5), and $L(s) = 0$ or 1.

We are in a position to characterize an optimal stationary long-term contract by solving maximization problem (6). If the firm always honors the contract, the firm can drop reputational constraint (5). As proved in Grossman and Hart (1983), an optimal stationary long-term contract then turns out to be the first-best one: (i) worker's marginal utility of income is fixed across all states of nature, i.e. $w(s) - R = y(s) = U^{-1}(r\bar{V})$, where U^{-1} is an inverse function of U, and (ii) the rule of employment is efficient, i.e. the

firm employs the worker if and only if the output of the worker, s, is greater than or equal to worker's disutility of effort, R.

However, if the firm has some possibility of defaulting on the contract, it is not straightforward to see whether contracting parties choose as the best strategy the efficient rule of employment. Nevertheless, we can prove that an optimal contract satisfies the efficient rule of employment. Suppose that unemployment (i.e. $L(s) = 0$) occurs for a state s' in which $s' > R$. Then the firm's profits in s' are $-y(s')$. Increase $L(s')$ to 1, and adjust $w(s')$ so that the firm's profits at s' remain constant. This procedure is expressed in the form

$$s' - w(s') = -y(s'), \tag{7}$$

which verifies that reputational constraint (5) is not violated. However, worker's expected utility must increase because

$$U(y(s')) = U(w(s') - s')$$
$$< U(w(s') - R). \tag{8}$$

The final inequality is due to the assumption that $s' > R$. These findings lead to an ex-ante Pareto improvement, thus contradicting the optimality of the contract. Conversely, suppose that the worker is employed (i.e. $L(s) = 1$) for a state s'' in which $s'' < R$. Reduce $L(s'')$ to 0, and adjust $w(s'')$ so that the firm's expected profits in s'' remain constant. This procedure can also yield an ex-ante Pareto improvement, which contradicts the optimality of the contract.

We therefore establish the following proposition.

Proposition 1: Even if the firm cannot commit themselves to any agreed-upon contracts, an optimal contract under symmetric information attains the efficient level of employment; that is, the firm employs the worker if and only if the output of the worker, s, is greater than or equal to worker's disutility of effort, R.

This proposition implies that no inefficient employment (i.e. underemployment or overemployment) occurs under symmetric information even though the firm cannot commit themselves to any agreed-upon contracts.[7] However, the recent literature has told us that reputation by itself will not enforce efficient behavior. For example, Klein and Leffler (1981), Shapiro (1982) (1983) and Allen (1984) show that reputational mechanisms are not sufficient to assure high quality supply in the product quality market. To see why the implication of Proposition 1 differs from that of the earlier literature, we must recognize that, in our model, moral hazard is not created by the decision whether to employ the worker but by the decision whether to default on the long-term contract. Our reputational mechanism assures the efficiency of employment under symmetric information because adjustments of wages and severance pay are enough to induce the firm to commit themselves to the long-term contract.[8]

4-3. The Asymmetric Information Model

We now consider the case where output s is observed only by the firm alone. However, we assume throughout this section that everyone can observe

whether the worker is employed in each period; that is, whether $L(s) = 0$ or 1.

Grossman and Hart (1981)(1983) and Hart (1983) discuss the properties of labor contracts under the asymmetric information model in which both the firm and the worker can commit themselves to an agreed-upon contract.[9] Their main results are summarized as follows. (1) If the firm is risk neutral, an optimal contract is the first-best one: (i) The worker's income remains fixed in all states irrespective of his employment status, and (ii) the employment rule is efficient, or in other words, the worker is employed if and only if the output of the worker, s, is greater than or equal to worker's disutility of effort, R. (2) If the firm is risk averse, an optimal contract can involve underemployment: The worker is laid off for some of the states in which the output of the worker, s, is greater than worker's disutility of effort, R.

In what follows, to focus on the role of reputation in the contract market where the firm is not committed to any agreed-upon contracts, we will maintain the assumption that the firm is risk neutral. We can then prove in the later analysis that, as shown in the literature mentioned above, an optimal labor contract has neither underemployment nor overemployment if the first-best contract satisfies the reputational constraint.

Since the worker cannot observe output s, contract arrangements cannot be constructed so as to depend on the true state. Instead, the firm is asked to report output s_r at the end of each period. Stationary long-term contracts are then specified as a function of s_r; that is, wages $w(s_r)$, severance pay $y(s_r)$ and employment state $L(s_r)$. Given this communication mechanism, an incentive-compatible contract $[w(s), y(s), L(s); \underline{s} \leq s \leq \overline{s}]$ is one such that the firm is always prepared to tell the truth namely (see Hart (1983))

$$s = \operatorname*{argmax}_{s_r} \{ L(s_r)[s - w(s_r)] - [1 - L(s_r)]y(s_r) \}. \tag{9}$$

In general, the firm will have an incentive to lie: The firm will report output s, which is not true. Fortunately, we can use the "revelation principle", which restricts our attention to the set of truthtelling contracts (see Harris and Townsend (1981) and Myerson (1978)). In other words, without loss of generality, we are allowed to confine our analysis to the set of contracts under which the firm always wishes to report the true state. We must therefore develop the properties of truthtelling contracts in order to discuss how an optimal contract is arranged under asymmetric information.

We begin with examining the wage rule of truthtelling contracts. For this purpose, let $N = \{s \mid L(s) = 1\}$ ($M = \{s \mid L(s) = 0\}$) be the set of states in which the worker is employed (unemployed). The optimality for truthtelling requires that $w(s)$ equals a constant w on N and $y(s)$ a constant y on M. The reason can be explained as follows. If $w(s') > w(s'')$ where s', $s'' \in N$, the firm will pretend that $s = s''$ even when $s = s'$. This is because, by doing so, the firm can reduce wages without sacrificing employment. Thus, $w(s)$ has to be constant on N to ensure that truthtelling is optimal. In a similar way, it can be proved that $y(s)$ has to be constant on M. Truthtelling contracts in effect specify two wages: wages w on the set of employment states, N, and severance pay y on the set of unemployment states, M.

We next investigate the employment rule of truthtelling contracts. Since the profits of the firm are $(s - w)$ on N and $-y$ on M, the firm gains more profits from employing than from laying off the worker if $s - w \geq -y$, and vice versa if $s - w < -y$. Truthtelling is thus optimal if and only if $N = \{s \mid L(s) = 1\} = \{s \mid s - w \geq -y\}$ and $M = \{s \mid L(s) = 0\} = \{s \mid s - w < -y\}$. Let $k = w - y$. The foregoing argument implies that truthtelling contracts satisfy the following employment rule: $N = \{s \mid s \geq k\}$ and $M = \{s \mid s < k\}$.

Truthtelling contracts are now characterized by two numbers: y, severance pay the worker receives when unemployed, and k, an extra amount the firm has to pay to employ him. From these two variables, wages the worker earns when employed are calculated using $w = k + y$; and the employment rule is determined such that the firm employs the worker if and only if $s \geq k$.

Given the properties of truthtelling contracts, we can reformulate firm's maximization problem (6). Since the firm's profits are $s - k - y$ ($\equiv s - w$) on $N = \{s \mid s \geq k\}$ and $-y$ on $M = \{s \mid s < k\}$, the present value of stream of firm's expected profits (6) is rewritten in the form

$$E\pi = r^{-1} \{ \int_k^{\bar{s}} (s-k-y)f(s)ds - \int_{\underline{s}}^k yf(s)ds \}. \tag{10}$$

Similarly, reservation utility constraint (3) under truthtelling contracts is

$$Ev = r^{-1} \{ \int_k^{\bar{s}} U(y+k-R)f(s)ds + \int_{\underline{s}}^k U(y)f(s)ds \} \geq \bar{V}. \tag{11}$$

The final task is to reconsider reputational constraint (5). Under truthtelling contracts, the constraint consists of the following two kinds of inequalities. If the firm employs the worker at the end of the present period, i.e. if s is greater than or equal to k, then

$$s-k-y + r^{-1}(1-r) \{ \int_k^{\bar{s}} (s-k-y)f(s)ds - \int_{\underline{s}}^k yf(s)ds \} \geq 0,$$

$$\text{for } s \geq k. \tag{12}$$

On the other hand, if the firm lays off the worker at the end of the present period, then[10]

$$-y + r^{-1}(1-r) \left\{ \int_{k}^{\bar{s}} (s-k-y)f(s)ds - \int_{\underline{s}}^{k} yf(s)ds \right\} \geqq 0. \qquad (13)$$

In fact, constraint (12) automatically holds for all s $\geqq$ k if constraint (13) is valid. Thus constraint (12) will be neglected in the subsequent analysis.

As shown in the previous section, reputational constraint (13) differs from the bankruptcy constraint of Farmer (1985) and Kahn and Scheinkman (1985). The main difference is that reputational constraint (13) contains the terms of future expected profits dependent on contract arrangements whereas their bankruptcy constraint does not. Furthermore, in our model, the worker is not indifferent between the employment and the laid off state, so that the possibility of involuntary unemployment can be accounted for.

Now, an optimal contract is obtained by maximizing with respect to k and y the present value of stream of firm's expected profits (10) subject to reservation utility constraint (11) and reputational constraint (13).[11] The first-order conditions for the maximization problem are represented by

$$r^{-1} \left\{ -1 + \lambda \left[U'(y+k-R)(1-F(k)) + U'(y)F(k) \right] - \mu \right\} = 0, \qquad (14)$$

$$-r^{-1}[1-F(k)] + r^{-1}\lambda \left\{ U'(y+k-R)[1-F(k)] + [-U(y+k-R)+U(y)]f(k) \right\}$$
$$- r^{-1}(1-r)\mu [1-F(k)] = 0, \qquad (15)$$

where λ and μ are the nonnegative multipliers associated with (11) and (13), respectively.

On the basis of (14) and (15), we can find out the properties of an optimal contract. The argument is divided into two cases according as the first-best contract summarized by $(k, y) = (R, U^{-1}(r\bar{V}))$ satisfies or violates

reputational constraint (13).

If the first-best contract satisfies reputational constraint (13), we characterize the situation by substituting $k = R$ and $y = U^{-1}(r\bar{V})$ into the right-hand side of (13):

$$r^{-1}(1-r) \int_R^{\bar{s}} sf(s)ds - r^{-1}(1-r)[1-F(R)]R - r^{-1}U^{-1}(r\bar{V}) \geqq 0. \quad (16)$$

In this case, the first-best contract, $(k, y) = (R, U^{-1}(r\bar{V}))$, violates neither (11) nor (13). Furthermore, it also satisfies first-order conditions (14) and (15) because the multiplier μ can equal zero in (14) and (15). Therefore, the first-best contract turns out to be an optimal solution to maximization problem (10).

Alternatively, if the first-best contract violates reputational constraint (13), we see

$$r^{-1}(1-r) \int_R^{\bar{s}} sf(s)ds - r^{-1}(1-r)[1-F(R)]R - r^{-1}U^{-1}(r\bar{V}) < 0. \quad (17)$$

This condition is likely to hold if worker's disutility of effort R or reservation utility $\bar{V}$ is great enough.[12] Under condition (17), an optimal contract has to be a second-best contract because the first-best contract violates reputational constraint (13).

To reveal the properties of the second-best contract, we must transform (14) and (15). Rearranging (14) gives

$$[1 + \mu] = \lambda \{U'(y+k-R)[1-F(k)] + U'(y)F(k)\}. \quad (18)$$

Subtracting (14) from (15) by side by side produces

$$- r^{-1}[1+ \mu - \lambda U'(y)]F(k) - \mu [1- F(k)] = r^{-1}\lambda [U(y)- U(y+ k- R)]f(k).$$

$$(19)$$

Now, using (18) and (19), we can prove that an optimal contract involves $k > R$ and $w - R > y$ if (17) holds. Suppose that $k \leqq R$. Then it follows from $U' > 0$ and $U'' < 0$ that

$$U(y+ k- R) \leqq U(y),$$
$$(20)$$

$$U'(y+ k- R) \geqq U'(y).$$
$$(21)$$

Inspecting (18) with (21) and $\lambda \geqq 0$ yields

$$1 + \mu - \lambda U'(y) \geqq 0, \quad \text{with strict inequality if } k < R. \qquad (22)$$

Given (22), it is found from (19) and $(\lambda , \mu) \geqq 0$ that

$$U(y) - U(y+ k- R) \leqq 0,$$
$$(23)$$

where equality holds if and only if $k = R$. If k is less than R, (23) is satisfied with strict inequality, thus contradicitng (20). If k is equal to R, the definition of k $(\equiv w - y)$ shows that $w - R = y$. This finding implies that the solution to (14) and (15) becomes the first-best contract, $(k, y) = (R, U^{-1}(r\bar{V}))$. Thus (23) again contradicts condition (17) when $k = R$. We therefore verify that $k > R$. It is also found from $k > R$ that the worker is better off on employment than on laid off states: $w = y + k > R + y$.

To sum up, we establish the following proposition.

Proposition 2: Assume that the firm is not committed to any agreed-upon contract.

(i) If the first-best contract satisfies reputational constraint (13) (i.e. if inequality (16) holds), an optimal contract turns out to be the first-best contract: (a) The firm employs the worker if and only if the output of the worker, s, is greater than or equal to worker's disutility of effort, R; and (b) the wage compensated with worker's disutility of effort, $w - R$, is equal to the severance pay, y.

(ii) If the first-best contract violates reputational constraint (13) (i.e. if inequality (17) holds), an optimal contract can involove underemployment and involuntary unemployment: (a) The firm employs the worker if and only if $s \geqq k$ ($> R$); and (b) the wage compensated with worker's disutility of effort is higher than the severance pay, i.e. $w - R > y$.

The idea behind the proof of Proposition 2 can be explained as follows. Proposition 2(i) is based on the fact that the risk-neutral firm can bear all risks of variation of worker's income if the first-best contract satisfies reputational constraint (13). Worker's income then becomes constant irrespective of the level of employment. This fixed wage arrangement permits the risk neutral firm to choose the level of employment efficiently. In fact, with the assumption of Proposition 2(i), the statement of Proposition 2(i) is the counterpart of the result of Grossman and Hart (1981)(1983) because our model reduces to theirs.

To understand the intuition behind Proposition 2(ii), let us suppose that with the assumption of Proposition 2(ii) the firm offers the first-best contract to the worker. Since the first-best contract violates reputational constraint (13), the worker expects that the firm will default the first-best

contract in unfavorable states, where unemployment occurs. Wages and severance pay are then adjusted so as to satisfy reputational constraint (13) in order that the worker might be attracted towards the contract relation. This adjustment causes wages compensated with worker's disutility of effort, $w - R$, to become higher than severance pay, y; that is, $w - R > y$. Given the definition of k ($\equiv w - y$), the obtained inequality relation implies $k > R$ and ensures the existence of the set of states, $\{ s \mid k > s \geq R \}$. Now, for the set of states $\{ s \mid k > s \geq R \}$, the firm strictly prefers layoff to retention because the incentive compatibility constraint induces the firm to lay off the worker if and only if $k > s$. The worker is unemployed for the set of states $\{ s \mid k > s \geq R \}$ although he is employed in these states under the efficient rule of employment.

Proposition 2 shows that the reputational problem under asymmetric information between the firm and the worker is one of the important causes of underemployment if the firm is not committed to any agreed-upon contracts. This result still holds even if the firm has risk-neutral preferences so that underemployment does not arise from asymmetric information alone. Proposition 2 also implies that wages compensated with worker's disutility of effort are higher than severance pay. In other words, under asymmetric information, the firm does not provide perfect income insurance to the worker if the firm cannot commit themselves to any agreed-upon contracts. This conclusion explains why complete severance pay is infrequently observed in the real world (see Oswald(1986)). Furthermore, unemployment realized in this case is involuntary because the worker prefers being employed to being laid off. Our theory therefore generates equilibria in which there are both inefficiently high unemployment (underemployment) and involuntary unemployment.

4-4. Concluding Remarks

This chapter has examined a role of reputation in an implicit contract model where firms cannot commit themselves to the contract arrangements. In contrast to the recent literature on reputation, we have shown that an optimal contract under symmetric information enforces efficient behavior on firms irrespective of the presence of reputational problems. On the other hand, even though firms are risk neutral, we have proved that an optimal contract under asymmetric information can involve inefficiently high unemployment (underemployment) and involuntary unemployment in the presence of reputational problems. We have also shed light the question why laid off workers cannot receive full amount of severance pay.

There are several other promising extensions of our analysis that may pursue. First, we have restricted our attention to the environment where the firm has only one worker. Applying the analysis to a model of many workers enables us to deal with more complicated employment policies of firms. Second, our investigation has been limited to stationary long-term contracts. Relaxation of this assumption seems to be crucial if contracting parties have incomplete information about the attributes of the opponent parties. In the incomplete information case, the contracting parties must hold some expectations about the attributes of the opponents. These expectations depend on the past actions of the opponents and affect current and future equilibrium actions. This kind of dynamic equilibrium situation has recently been developed using the sequential equilibrium method (For example, see Osano (1991)). It seems to be important to discuss the properties of non-stationary long-term implicit contracts within the sequential equilibrium framework.

Notes

1. Several other papers have also examined a role of reputation in the labor contract market. See Grossman (1977) and Carmichael (1984). In particular, the reputational model of Carmichael presumes that workers base their expectations of future wage and employment levels on actual past values; and that firms know this and take it into account when they set current wage and employment levels. Although the reputation formation does not follow a rational principle such as the Bayes rule, his analysis sheds light on many aspects of the modern labor market, including involuntary underemployment and sticky wages.

2. For a discussion of the restrictive assumptions of the Mookherjee's model, see Osano (1991). With the assumption of asymmetric information and no severance payment, Oswald (1986) shows the existence of equilibria characterized by involuntary unemployment and inefficiently high unemployment. However, our model can yield the same results without excluding the presence of severance pay.

3. Relaxation of the assumption of $L(s) = 0$ or 1 does not modify our conclusion, because the production function is linear in our model.

4. A similar assumption is found in the literature on the reputation model of product quality. See Klein and Leffler (1981), Shapiro (1982)(1983) and Allen (1984). For the labor market, see Kuhn (1986).

5. Instead of shutting the operation, the firm may hire workers in the spot market. Even in this case, our subsequent arguments still hold if the present value of stream of firm's expected profits from hiring workers in the spot market is equal to zero.

6. In the subsequent analysis, under an optimal stationary long-term

contract, the present value of stream of expected profits of the firm is assumed to be greater than zero. Then the value of the second term in (4) turns out to be greater than zero because the value of this term equals the present value of stream of expected profits from the next period onward. Thus the firm will have no incentive to stop the contract relation at the beginning in the next period.

7. Proposition 1 does not necessarily suggest that, irrespective of the presence of reputational problems, the contractual market is efficient under symmetric information. This is because noncommitment of the firm to agreed-upon contracts increases the possibility that contract relations are not made.

8. Another way of understanding the result of Proposition 1 can be stated as follows. In the symmetric information case, both the firm and the worker can observe states s, so that the firm can make wages and severance pay contingent on the true state. The firm then finds it profitable to adjust wages and severance pay rather than employment possibility as long as the first-best contract satisfies reputational constraint (5). This is because the determination of wages and severance pay is soly concerned with the distribution of payoffs whereas the determination of employment possibility is mainly involved with the production of payoffs.

9. The "commitment" implies that an agent must always implement the contract arrangements if all agents can observe the variables on which the contract is contingent.

10. The left-hand side of (13) does not depend on s. Thus, when discussing constraint (13), we need not consider which state occurs at the end of the period.

11. In the analysis that follows, we restrict our attention to the case that $\underline{s} < k < \bar{s}$.

12. Let the left-hand side of (17) be Ψ. Partial differentiation of Ψ with respect to k and $\overline{V}$ reveals $\partial\Psi/\partial k < 0$ and $\partial\Psi/\partial\overline{V} < 0$.

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Chapter 5

Dynamic Labor Contracts under Asymmetric Information

5. Dynamic Labor Contracts under Asymmetric Information

5-1. Introduction

The implicit contract model under symmetric information ingeniously attempts to explain the small variations of wages and the large variations of employment in terms of risk sharing arrangements between firms and workers. This explanation, however, might fail to hold if firms have better information about the state of the world than workers, since firms will not have sufficient incentives to reveal their private information truthfully to workers. A natural way of getting around this asymmetric information problem is for firms to write contracts consistent with truthtelling. These truthtelling contracts are characterized by incentive-compatibility constraints, which restrict the choice sets available to firms under symmetric information. Using the asymmetric information contracting model with incentive-compatibility constraints, recent researches (Grossman and Hart [1981][1983], Hart [1983] and Azariadis [1983]) have shown that underemployment can occur if firms are risk averse.

In spite of these developments of implicit contract theory, little attention has been paid to the extension of implicit contract theory into a multi-period, asymmetric information framework in which an exogenous demand shock (the state of nature) is serially correlated and is known only to firms.[1] In the static, symmetric information contracting model with risk averse firms, workers expect higher wages in the good state than in the bad state because firms adjust their wage payments to demand fluctuations.[2] Then, firms can do with lower expected wage payments to ensure a fixed expected utility level to workers if firms can manipulate the expectation of workers so that workers have more prospect of being in the good state. Now, assume a

dynamic contracting model with risk averse firms in which an exogenous demand shock is positively serially correlated and is known only to firms. Claiming that the state is better than it really is, firms with private information may obtain higher future expected revenues because the false report causes workers to hold more optimistic expectation about the state in the next period. Similarly, if an exogenous demand shock is negatively serially correlated, firms with private information may have an incentive to claim that the state is worse than it really is. These arguments show that a serially correlated demand shock may strongly affect the properties of an optimal contract within a multi-period, asymmetric information framework.

This chapter provides an analysis of the inefficiency of firms' employment policies using a multi-period, asymmetric information contracting model in which an exogenous demand shock is serially correlated and is known only to firms. The model in this chapter can predict that serial correlation of the state of nature can cause not only underemployment but also overemployment even when overemployment never occurs in the context of a static, asymmetric information contracting model.

This chapter is organized as follows. The next section introduces a two-period model in which firms make labor contracts with their workers at each period. The section also defines a subgame perfect Bayesian equilibrium of the model. Section 5-3 characterizes the properties of the equilibrium. The final section concludes the article.

5-2. The Model

A. The Basic Framework

We begin by developing a contractual relation between a firm and a

(representative) worker in the context of a two-period model.

Consider a case where the firm's gross revenue at each period $T = t$, $t+1$ is given by

$$Y_T = s_T f(l_T). \tag{1}$$

Here, $f(\cdot)$ represents the production function of the firm, l_T labor supply at period T and s_T an exogenous random product price at period T. It is assumed that $f(0) = 0$ and that $f'(l_T) > 0$ and $f''(l_T) < 0$ for all l_T. To simplify matters, we will assume that the random variables s_T are drawn from a set of discrete states: $S_T = \{s_T \mid s_T = s_1, s_2\}$ with $s_1 < s_2$ according to a probability distribution $Q_T = \{(q_T(s_1), q_T(s_2)); q_T(s_i) > 0 \ (i = 1, 2),$ $q_T(s_1) + q_T(s_2) = 1\}$. Thus the probability that $s_T = s_i$ is $q_T(s_i)$ $(i = 1, 2)$. Since s_T is assumed to have serial correlation, $q_{t+1}(s_j)$ is dependent on s_t and is specified by $q_{t+1}(s_j \mid s_t)$ $(j = 1, 2)$.

The firm has a von Neumann-Morgenstern utility function $V(s_T f(l_T) - w_T)$, where w_T is a wage payment at T. The function V is twice differentiable, increasing, and concave function over the firm's net profit. Each worker also has a von Neumann-Morgenstern utility function $U(w_T - Rl_T)$, where U is twice differentiable, increasing, and strictly concave over consumption gambles. R stands for the opportunity cost or reservation wage of labor at each date, which is taken to be constant.

The firm and the worker enter into a contract at each period before the realization of s_T.[3] The firm must guarantee the worker expected utility $\bar{U}$ at each period to induce him to sign its contract. The expected utility level $\bar{U}$ can be thought of as a utility price determined in a competitive market for contracts. Once the contract has been signed and the state of nature has been realized, the firm and the worker must always adhere to the terms of the

contract signed at each period. Put it otherwise, the firm cannot change the contract terms until the next period begins, and the worker cannot move to another firm until the next period begins. The former assumption about the behavior of the firm can be rationalized by appeal to the force of reputation, whereas the latter assumption about the behavior of the worker can be justified by the costs of moving from one location to another.

It is assumed that, at the end of period t-1, both the firm and the worker know the set of the random variables S_T (T = t, t+1); the probability functions $q_T(s_i)$ (T = t, t+1); the production function f; the utility functions U, V; and the reservation expected utility level $\bar{U}$. On the other hand, the realization of the state of nature at each period is observable only by the firm and not by the worker.[4] To ensure that contract arrangements are implemented ex post, we can simply think of the firm's being asked to report at the end of each period the state s which has really occurred in the period. Then the contracting parties can implement the contract arrangements appropriate for the state reported by the firm at the end of period T, s^*_T (T = t, t+1).

The contract between the firm and the worker at each period is arranged as follows (see Fig. 1). At the end of period t-1, the firm offers a pair of schedules, $C_t(s^*_t) = \{w_t(s^*_t), l_t(s^*_t)\}$ mapping states announced by the firm at period t into total compensation received and hours worked by the worker at period t. Given the prior distribution of s_t, the worker decides whether to participate in the contract $C_t(s^*_t)$ at the beginning of period t. After s_t is realized as s_i, the firm reports a state s^*_{ti} (= $s^*_t(s_i)$);[5] and corresponding wages $w_t(s^*_{ti})$ and employment $l_t(s^*_{ti})$ at period t are determined (i = 1, 2). At the end of period t, the firm also offers a pair of schedules $C_{t+1}(s^*_{t+1}) = \{w_{t+1}(s^*_{t+1}), l_{t+1}(s^*_{t+1})\}$, which specify total compensation received and

hours worked by the worker at period t+1 as functions of states announced by the firm at period t+1. Using the reported state s^*_t as a signal of the state realized at period t,[6] the worker revises his expectation of s_{t+1} and decides whether to participate in the contract $C_{t+1}(s^*_{t+1})$ at the beginning of period t+1. After s_{t+1} is realized as s_j, the firm reports a state $s^*_{t+1,j}$ (= $s^*_{t+1}(s_j)$);[7] and corresponding wages $w_{t+1}(s^*_{t+1,j})$ and employment $l_{t+1}(s^*_{t+1,j})$ at period t+1 are determined (j = 1, 2).

B. Equilibrium of the Model

The contract relation between the firm and the worker presented in the previous subsection is characterized by a subgame perfect Bayesian equilibrium defined as follows. The equilibrium is made up of the firm's and the worker's strategies at each period. The strategies of the firm consist of pairs of wage and employment schedules $C_t(s^*_t) = \{w_t(s^*_t),\ l_t(s^*_t)\}$ and $C_{t+1}(s^*_{t+1}) = \{w_{t+1}(s^*_{t+1}),\ l_{t+1}(s^*_{t+1})\}$, and reporting strategies $\{s^*_t(s_t),\ s^*_{t+1}(s_{t+1})\}$, where s^*_T is restricted to the discrete set S_T (= $\{s_1,\ s_2\}$).[8] The strategy of the worker is the decision of whether to participate in the contract relation. We will consider only pure strategies.

In the subgame perfect Bayesian equilibrium, the strategies of the firm and the worker are *sequentially rational* if the following conditions hold:
(a) At the end of period t+1, the firm must choose the reporting strategy $s^*_{t+1}(s_{t+1})$ in a way that maximizes its ex-post profit at period t+1, given its contract schedules $C_{t+1}(s^*_{t+1})$.
(b) At the beginning of period t+1, the worker must optimally decide whether he accepts the firm's contract offer $C_{t+1}(s^*_{t+1})$, given his own posterior beliefs and the firm's reporting strategy $s^*_{t+1}(s_{t+1})$.

(c) At the end of period t, the firm must offer the period t+1 contract schedules $C_{t+1}(s^*_{t+1})$ so as to maximize its expected profit at period t+1, given its reporting strategies $\{s^*_t(s_t), s^*_{t+1}(s_{t+1})\}$ and the worker's posterior belief formation.

(d) At the end of period t, the firm must also choose the reporting strategy $s^*_t(s_t)$ in a way that maximizes the sum of its ex-post profit at period t and its expected profit at period t+1, given its contract schedules $C_t(s^*_t)$ and $C_{t+1}(s^*_{t+1})$, its future reporting strategy $s^*_{t+1}(s_{t+1})$, and the worker's posterior belief formation.

(e) At the beginning of period t, the worker must optimally decide whether he accepts the firm's contract offer $C_t(s^*_t)$, given his own posterior belief formation, the firm's future contract schedules $C_{t+1}(s^*_{t+1})$, and the firm's reporting strategies $\{s^*_t(s_t), s^*_{t+1}(s_{t+1})\}$.

(f) At the end of period t-1, the firm must offer the period t contract schedules $C_t(s^*_t)$ so as to maximize the sum of its expected profits at period t and at period t+1, given its future contract schedules $C_{t+1}(s^*_{t+1})$, its reporting strategies $\{s^*_t(s_t), s^*_{t+1}(s_{t+1})\}$, and the worker's posterior belief formation.

The strategies are also viewed as *consistent* at equilibrium if the worker's posterior beliefs, $\{q^w_{t+1}(s_1), q^w_{t+1}(s_2)\}$, are formed by Bayes' rule on the basis of his prior beleifs $\{q_t(s_1), q_t(s_2)\}$ and the state announced by the firm at the end of period t, s^*_t. This requirement implies that, given the prior beliefs $\{q_t(s_1), q_t(s_2)\}$, the worker's posterior belief $q^w_{t+1}(s_j)$ (j = 1, 2) is a function of s_j conditional on s^*_t, that is, $q^w_{t+1}(s_j | s^*_t)$.

A brief remark about a signal of the state realized at period t is in order. The worker can use not only the reported state s^*_t but also the offered contract $C_{t+1}(s^*_{t+1})$ as a signal of the realized state s_t to form his

posterior beliefs and to implement the contract arrangements $C_t(s^*_t)$. This is because at the end of period t the contract $C_{t+1}(s^*_{t+1})$ is offered given the realized state s_1. Suppose that $C_{t+1}(s^*_{t+1})$ is not an optimal contract which is offered when both the firm and the worker believe that s^*_{t1} has really occurred. Then, the contract arrangements $C_t(s^*_t)$ are not implementable, because the worker doubts if s^*_{t1} has really been realized. Therefore, the offered contract $C_{t+1}(s^*_{t+1})$ must be consistent with the reported state s^*_{t1}: C^*_{t+1} must be an optimal contract offered when both the firm and the worker believe that s^*_{t1} has really been realized so that $q^w_{t+1}(s_{t+1} \mid s^*_{t1}) = q_{t+1}(s_{t+1} \mid s^*_{t1})$.[9] However, in this case, the worker need not infer the realized state s_t from the offered contract $C_{t+1}(s^*_{t+1})$. Thus, in the subsequent analysis, we will confine our attention to the case in which the worker uses only s^*_t as a signal of the state realized at period t and the firm offers a period t+1 contract $C_{t+1}(s^*_{t+1})$ consistent with this reported state.[10]

When realization of the shock at each period is observable only by the firm and not by the worker, the firm has an incentive to misreport which state has really occurred. However, using the revelation principle at each period, we will focus on incentive-compatibility contracts in examination of the properties of equilibria (see Myerson [1979], Harris and Townsend [1981], and Azariadis [1983]). This implies that we will restrict our attention to separating equilibria at each period.[11]

We now proceed to formalize an equilibrium contract at period t+1. Suppose that s_h (h = 1, 2) is realized at period t. The firm announces a state s^*_{th} ($= s^*_t(s_h)$), and offers a contract $C_{t+1}(s^*_{t+1}) = \{w_{t+1}(s^*_{t+1}), l_{t+1}(s^*_{t+1})\}$ at the end of period t. Since an equilibrium contract must be sequentially rational given the worker's posterior beliefs $\{q^w_{t+1}(s_1 \mid s^*_{th}),$

$q^w_{t+1}(s_2 \mid s^*_{th})\}$, the contract $C_{t+1}(s^*_{t+1})$ must maximize the firm's expected profit at period t+1 subject to the constraints that the worker's expected utility is greater than the reservation expected utility $\bar{U}$ and that the contract offer is incentive-compatible. More specifically, for a realized state s_h and an announced state s^*_{th} at period t, an equilibrium contract at period t+1 must solve, with respect to $C_{t+1}(s^*_{t+1}) = \{w_{t+1}(s^*_{t+1,1}), w_{t+1}(s^*_{t+1,2}), l_{t+1}(s^*_{t+1,1}), l_{t+1}(s^*_{t+1,2})\}$, the problem

$$\text{Max} \sum_{j=1}^{j=2} V(s_j f(l_{t+1}(s^*_{t+1,j})) - w_{t+1}(s^*_{t+1,j})) \cdot q_{t+1}(s_j \mid s_h), \qquad (2)$$

subject to

$$\sum_{j=1}^{j=2} U(w_{t+1}(s^*_{t+1,j}) - Rl_{t+1}(s^*_{t+1,j})) \cdot q^w_{t+1}(s_j \mid s^*_{th}) \geq \bar{U}, \qquad (3)$$

$$s_j = \underset{\substack{s^*_{t+1,j} \\ \in S_{t+1}}}{\text{arg max}} \; [s_j f(l_{t+1}(s^*_{t+1,j})) - w_{t+1}(s^*_{t+1,j})],$$
$$j = 1, 2, \qquad (4)$$

where $s^*_{t+1,j} = s^*_{t+1}(s_j)$.

Some comments about maximization problem (2) should be mentioned. First, constraint (3) represents the worker's expected utility constraint, and constraint (4) expresses the incentive-compatibility constraint for each s_j (j = 1, 2) which induces the firm to report the truthful state at period t+1. Second, the firm's expected utility is calculated using the real conditional probability of $s_{t+1} = s_j$ given $s_t = s_h$, i.e., $q_{t+1}(s_j \mid s_h)$ (j = 1, 2), whereas the worker's subjective expected utility is calculated using the worker's subjective conditional probability of $s_{t+1} = s_j$ given $s^*_t = s^*_{th}$, i.e., $q^w_{t+1}(s_j \mid s^*_{th})$ (j = 1, 2). The latter restriction implies that we must elucidate the worker's posterior belief formation to specify an optimal solution to maximization problem (2).

To this end, we next discuss how the worker forms his subjective conditional probability of $s_{t+1} = s_j$, that is, $q^w_{t+1}(s_j \mid s^*_{th})$ $(j = 1, 2)$. Since the worker's posterior beliefs must be consistent, these beliefs are formed by Bayes' rule:

$$q^w_{t+1}(s_j \mid s^*_{th}) = \sum_{k=1}^{k=2} P[s_t = s_k \mid s^*_{th}] \cdot q_{t+1}(s_j \mid s_k),$$

$$h = 1, 2; \quad j = 1, 2, \quad (5)$$

where $P[s_t = s_k \mid s^*_{th}]$ is the probability of s_k at period t conditional on the state announced by the firm at period t, s^*_{th}. Given the firm's truth-telling strategy at period t, the probability $P[s_t = s_k \mid s^*_{th}]$ is reasonably calculated as follows: $P[s_t = s_k \mid s^*_{th}] = 1$ for $s_k = s^*_{th}$ and $P[s_t = s_k \mid s^*_{th}] = 0$ for $s_k \neq s^*_{th}$.[12] Now, we can determine the worker's posterior beliefs according as the firm announces s_1 or s_2 at period t: If the firm reports s_1 at period t, then $q^w_{t+1}(s_j \mid s_1) = q_{t+1}(s_j \mid s_1)$; and if the firm reports s_2 at period t, then $q^w_{t+1}(s_j \mid s_2) = q_{t+1}(s_j \mid s_2)$.

We next turn to considering an equilibrium contract at period t. We first specify the constraints which must be satisfied by an equilibrium contract at period t. Let us introduce the following functions:

$$\Phi_{t+1}(s_h; s_i) = \sum_{j=1}^{j=2} V(s_j f(l_{t+1}(s^*_{t+1}, j; s_h))) - w_{t+1}(s^*_{t+1}, j; s_h)) \cdot q_{t+1}(s_j \mid s_i),$$

$$(6)$$

$$\Omega_{t+1}(s_h) = \sum_{j=1}^{j=2} U(w_{t+1}(s^*_{t+1}, j; s_h) - Rl_{t+1}(s^*_{t+1}, j; s_h)) \cdot q_{t+1}(s_j \mid s_h).$$

$$(7)$$

Here, $C_{t+1}(s^*_{t+1}; s_h) = \{w_{t+1}(s^*_{t+1}, 1; s_h), w_{t+1}(s^*_{t+1}, 2; s_h), l_{t+1}(s^*_{t+1}, 1; s_h), l_{t+1}(s^*_{t+1}, 2; s_h)\}$ is an optimal solution to maximization problem (2) given $q^w_{t+1}(s_j \mid s^*_{th}) = q_{t+1}(s_j \mid s_h)$;[13] in other words, $C_{t+1}(s^*_{t+1}; s_h)$ is an optimal

period t+1 contract which is offered if both the firm and the worker believes that s_h has really occurred. Now, we can view $\Phi_{t+1}(s_h;s_i)$ as the value of the firm's expected profit at period t+1 and $\Omega_{t+1}(s_h)$ as the value of the worker's expected utility at period t+1 if the firm announces s_h at period t and offers an optimal contract $C_{t+1}(s^*_{t+1};s_h)$ consistent with the announced state s_h. This view holds even if the state reported at period t, s_h, is different from the state realized at period t, s_i.[14]

The incentive-compatibility constraint for each state s_i (i = 1, 2) is then described by

$$s_i = \arg\max_{\substack{s^*_{ti} \\ \in S_t}} [V(s_i f(l_t(s^*_{ti})) - w_t(s^*_{ti})) + \beta \Phi_{t+1}(s^*_{ti};s_i)], \quad i = 1, 2, \qquad (8)$$

where β is the discount factor and $\Phi_{t+1}(s^*_{ti};s_i)$ is derived from substitution of s^*_{ti} for s_h in (6). As has been argued in the previous section, to implement the period t contract, the firm must offer a period t+1 contract $C_{t+1}(s^*_{t+1};s^*_{ti})$ consistent with the state reported by the firm at period t even if s^*_{ti} has not been realized at period t. The definition of $\Phi_{t+1}(s^*_{ti};s_i)$ for $s^*_{ti} \neq s_i$ reflects this restriction.

The worker's expected utility constraint is also represented by

$$\sum_{i=1}^{i=2} [U(w_t(s^*_{ti}) - Rl_t(s^*_{ti})) + \beta \Omega_{t+1}(s^*_{ti})]q_t(s_i) \geq (1+\beta)\overline{U}, \qquad (9)$$

where $\Omega_{t+1}(s^*_{ti})$ is obtained by substitution of s^*_{ti} for s_h in (7).

An equilibrium contract at period t, $C_t(s^*_t)$, now solves the problem

$$\max_{\substack{\{w_t(s^*_{ti})\} \\ \{l_t(s^*_{ti})\}}} \sum_{i=1}^{i=2} [V(s_i f(l_t(s^*_{ti})) - w_t(s^*_{ti})) + \beta \Phi_{t+1}(s^*_{ti};s_i)]q_t(s_i), \qquad (10)$$

subject to (8) and (9).

Note that both the firm's and the worker's expected utility at period t are calculated using the same prior probabilities $q_t(s_i)$ (i = 1, 2).

5-3. Characterization of the Equilibrium

In this section, we will characterize the equilibrium defined in the previous section.

We begin with examining an optimal contract at period t+1. Because of the incentive-compatibility constraints at period t, the worker knows that the actual state of nature at period t, s_t, is equal to the firm's reporting state at period t, s^*_t. Thus, if s_i is realized at period t, then s^*_{ti} is equal to s_i. Then, as argued in the worker's posterior belief formation in section 5-2B, the worker's posterior beliefs $\{q^w_{t+1}(s_1 | s^*_{ti}), q^w_{t+1}(s_2 | s^*_{ti})\}$ reduce to $\{q_{t+1}(s_1 | s_i), q_{t+1}(s_2 | s_i)\}$. Given these relations, we can now rewrite program (2) as the maximization problem, with respect to $\{w_{t+1}(s_1), w_{t+1}(s_2), l_{t+1}(s_1), l_{t+1}(s_2)\}$,

$$\text{Max} \sum_{j=1}^{j=2} V(s_j f(l_{t+1}(s_j)) - w_{t+1}(s_j)) \cdot q_{t+1}(s_j | s_i), \qquad (11)$$

subject to

$$\sum_{j=1}^{j=2} U(w_{t+1}(s_j) - Rl_{t+1}(s_j)) \cdot q_{t+1}(s_j | s_i) \geq \bar{U}, \qquad (12)$$

$$s_1 f(l_{t+1}(s_1)) - w_{t+1}(s_1) \geq s_1 f(l_{t+1}(s_2)) - w_{t+1}(s_2), \qquad (13a)$$

$$s_2 f(l_{t+1}(s_2)) - w_{t+1}(s_2) \geq s_2 f(l_{t+1}(s_1)) - w_{t+1}(s_1). \qquad (13b)$$

Constraint (13) ensures that the firm benefits from reporting that s_j occurs $(s^*_{t+1} = s_j)$ if the true state is s_j $(s_{t+1} = s_j)$; that is, $s^*_{t+1,j} = s_j$.

Thus, we derive (11) and (12) from (2) and (3) by replacing $s^*_{t+1,j}$ with s_j.

The properties of an optimal solution to maximization problem (11) are given by the following proposition:

Proposition 1.

An optimal solution to maximization problem (11) is characterized by

$$s_1 f'(l_{t+1}(s_1)) \geqq R, \tag{14}$$

$$s_2 f'(l_{t+1}(s_2)) = R, \tag{15}$$

$$s_2 f(l_{t+1}(s_2)) - w_{t+1}(s_2) > s_1 f(l_{t+1}(s_1)) - w_{t+1}(s_1), \tag{16}$$

$$w_{t+1}(s_2) - Rl_{t+1}(s_2) \geqq w_{t+1}(s_1) - Rl_{t+1}(s_1), \tag{17}$$

$$\sum_{j=1}^{j=2} U(w_{t+1}(s_j) - Rl_{t+1}(s_j)) \cdot q_{t+1}(s_j \mid s_i) = \bar{U}. \tag{18}$$

Here, (14) and (17) are satisfied with strict inequality unless the solutions to the relaxed version of program (11) with incentive-compatibility constraints (13) omitted are incentive-compatible. If the firm is risk neutral $(V'' = 0)$, (14) and (17) hold with equality.

Proof of Proposition 1. See Hart [1983, Proposition 2] and Azariadis [1983, Section 5]. (Q.E.D.)

A brief comment about this proposition is in order. A contract yields underemployment, efficient employment, or overemployment in s_i according as the firm's marginal revenue product $s_i f'(l_{Ti})$ is greater than, equal to, or less than the worker's reservation wage R. In this light, inequality (14) of Proposition 1 implies that inefficient employment can only occur as

underemployment in the bad state of period t+1. This result can be explained
as follows. In the present model, we assume that the worker's demand for
leisure is independent of income. With this assumption, high risk aversion of
the firm means that, under the optimal symmetric information contract, an
increase in wages with s_{t+1} is substantial relative to an increase in
employment with s_{t+1}. Thus, if the firm with private information about the
state of nature offers the optimal symmetric information contract, the firm
has an incentive to claim that the state is worse than it really is, since the
false report enables the firm to obtain savings in wages more than
compensation for reductions in employment. An optimal contract under
asymmetric information will then cause underemployment in the bad state
because this employment policy decreases the firm's ex-post profit in the bad
state and prevents the firm from reporting the false state. This conclusion
corresponds to the result of a one-period, asymmetric information contract
model such as Azariadis [1983], Grossman and Hart [1981][1983] and Hart
[1983].

We proceed to examine the properties of an optimal contract at period t.
For this purpose, we can rewrite maxmization problem (10) as

$$\text{Max}_{\{l_t(s_i)\} \{w_t(s_i)\}} \quad \sum_{i=1}^{i=2} [V(s_i f(l_t(s_i))) - w_t(s_i)) + \beta \Phi_{t+1}(s_i;s_i)]q_t(s_i), \qquad (19)$$

subject to

$$\sum_{i=1}^{i=2} [U(w_t(s_i) - Rl_t(s_i)) + \beta \Omega_{t+1}(s_i)]q_t(s_i) \geqq (1+\beta)\bar{U}, \qquad (20)$$

$$V(s_1 f(l_t(s_1))) - w_t(s_1)) + \beta \Phi_{t+1}(s_1;s_1)$$

$$\geqq V(s_1 f(l_t(s_2))) - w_t(s_2)) + \beta \Phi_{t+1}(s_2;s_1), \qquad (21a)$$

$$V(s_2 f(l_t(s_2))) - w_t(s_2)) + \beta \Phi_{t+1}(s_2;s_2)$$

$$\geq V(s_2 f(l_t(s_1)) - w_t(s_1)) + \beta \Phi_{t+1}(s_1;s_2). \qquad (21b)$$

Here, $\Phi_{t+1}(s_h;s_1)$ and $\Omega_{t+1}(s_1)$ are defined by (6) and (7) in which $s^*_{t+1,j}$ is replaced with s_j ($j = 1, 2$).[15] Since constraints (21) ensure that the firm tells the true state at period t, we derive (19) and (20) from (9) and (10) by replacing s^*_{t1} with s_1.[16]

We now elucidate the characteristics of an optimal solution to maximization problem (19). The first-order conditions to maximization problem (19) are described by

$$-q_t(s_1)[V'(\pi_{t,11}) - \lambda_t \cdot U'(c_{t,1})]$$
$$- \mu_{t1} \cdot V'(\pi_{t,11}) + \mu_{t2} \cdot V'(\pi_{t,21}) = 0, \qquad (22)$$

$$q_t(s_1)[s_1 f'(l_t(s_1)) \cdot V'(\pi_{t,11}) - \lambda_t \cdot RU'(c_{t,1})]$$
$$+ \mu_{t1} \cdot s_1 f'(l_t(s_1)) \cdot V'(\pi_{t,11}) - \mu_{t2} \cdot s_2 f'(l_t(s_1)) \cdot V'(\pi_{t,21}) = 0,$$
$$(23)$$

$$-q_t(s_2)[V'(\pi_{t,22}) - \lambda_t \cdot U'(c_{t,2})]$$
$$+ \mu_{t1} \cdot V'(\pi_{t,12}) - \mu_{t2} \cdot V'(\pi_{t,22}) = 0, \qquad (24)$$

$$q_t(s_2)[s_2 f'(l_t(s_2)) \cdot V'(\pi_{t,22}) - \lambda_t \cdot RU'(c_{t,2})]$$
$$- \mu_{t1} \cdot s_1 f'(l_t(s_2)) \cdot V'(\pi_{t,12}) + \mu_{t2} \cdot s_2 f'(l_t(s_2)) \cdot V'(\pi_{t,22}) = 0,$$
$$(25)$$

where λ_t, μ_{t1}, and μ_{t2} are the nonnegative multipliers corresponding to (20), (21a) and (21b); and $\pi_{t,ih} = s_i f(l_t(s_h)) - w_t(s_h)$ and $c_{t,h} = w_t(s_h) - Rl_t(s_h)$. Note that the perturbation of wages and employment offered at period t does not have any effects on the value of either $\Phi_{t+1}(s_h;s_i)$ or $\Omega_{t+1}(s_h)$, because this perturbation causes no effects on the worker's posterior beliefs.

Multiplying each side of (22) by $s_1 f'(l_t(s_1))$ and combining it with (23), we obtain the properties of an optimal employment policy,

$$\lambda_t \cdot q_t(s_1)[s_1 f'(l_t(s_1)) - R]U'(c_{t,1})$$

$$= \mu_{t2} \cdot f'(l_t(s_1)) \cdot V'(\pi_{t,21})(s_2 - s_1) \geqq 0, \tag{26}$$

where the final inequality follows from $\mu_{t2} \geqq 0$ and $s_2 > s_1$. Similarly, it is found from (24) and (25) that

$$\lambda_t \cdot q_t(s_2)[s_2 f'(l_t(s_2)) - R]U'(c_{t,2})$$

$$= \mu_{t1} \cdot f'(l_t(s_2)) \cdot V'(\pi_{t,12})(s_1 - s_2) \leqq 0, \tag{27}$$

where the final inequality is derived from $\mu_{t1} \geqq 0$ and $s_2 > s_1$. It is immediate from (26) and (27) that underemployment (overemployment) occurs in the bad (good) state of period t if the multiplier μ_{t2} (μ_{t1}) of incentive compatibility constraint (21b) ((21a)) is positive.

On the basis of (26) and (27), we can discuss inefficiency of employment by investigating whether the multiplier μ_{t2} or μ_{t1} is positive or zero. We begin by examining the two cases (i) that s_T is serially uncorrelated, and (ii) that the firm is risk neutral. We then proceed to the analysis in which the state of nature is serially correlated and the firm is risk averse.

To examine the first two cases, we obtain the following lemma about the properties of the value functions $\Phi_{t+1}(s_h; s_i)$:

Lemma 1.

(1) If s_T is serially uncorrelated, i.e., $q_{t+1}(s_1 | s_2) = q_{t+1}(s_1 | s_1) = q_t(s_1)$ and $q_{t+1}(s_2 | s_2) = q_{t+1}(s_2 | s_1) = q_t(s_2)$, then

$$\Phi_{t+1}(s_2; s_i) = \Phi_{t+1}(s_1; s_i), \qquad\qquad i = 1, 2. \tag{28}$$

(2) If the firm is risk neutral, (28) also holds no matter how s_T is serially correlated.

Proof of Lemma 1. See Appendix. (Q.E.D.)

Using Lemma 1, we prove the following results about the incentive-compatibility constraints at period t:

Lemma 2

(1) If the state of nature is serially uncorrelated, an incentive-compatibility constraint at period t can be binding in the good state, but cannot be binding in the bad state.

(2) If the firm is risk neutral, an incentive-compatibility constraint at period t cannot be binding in any state.

Proof of Lemma 2. See Appendix.   (Q.E.D.)

Now, it is immediate from (26) and (27) that Lemma 2 leads to the following proposition:

Proposition 2.

(1) If the state of nature is serially uncorrelated, an optimal contract at period t will have *underemployment* or *efficient employment* in the *bad* state, and *efficient employment* in the *good* state.

(2) If the firm is risk neutral, an optimal contract at period t will have *efficient employment* in both of the *bad* and the *good* states.

We next turn to discussing the case in which the state of nature is serially correlated and the firm is risk averse. Unfortunately, we cannot apply the proof of Proposition 2 to this case, because each side of the incentive-compatibility constraint for the realized state s_i has $\Phi_{t+1}(s_h; s_i)$ ($h = 1, 2$; $i = 1, 2$), which does not cancel each other out (see (21a) and (21b)). In fact, either $\Phi_{t+1}(s_2; s_i) > \Phi_{t+1}(s_1; s_i)$ or $\Phi_{t+1}(s_2; s_i) < \Phi_{t+1}(s_1; s_i)$ is possible in this case, no matter how the state of nature is

serially correlated. If $\Phi_{t+1}(s_2;s_1)$ is greater than $\Phi_{t+1}(s_1;s_1)$, the incentive-compatibility constraint in the bad state, (21a), can be tighter. If $\Phi_{t+1}(s_2;s_2)$ is greater than $\Phi_{t+1}(s_1;s_2)$, the incentive-compatibility constraint in the good state, (21b), becomes likely to be looser. In contrast, Lemma 2 verifies that only the incentive-compatibility constraint in the good state, (21b), is binding unless s_T is serially correlated. Combining these findings, we see that incentive-compatibility constraints (21) can be tighter in the bad state and looser in the good state for serially correlated s_T than for serially uncorrelated s_T. Thus, it should not be surprising that the incentive-compatibility constraints, both in the bad and the good state, are binding if serial correlation between s_t and s_{t+1} is strong enough. Given (26) and (27), these arguments tell us that underemployment can occur in the bad state, and overemployment in the good state.

Proposition 3.

If the state of nature is serially correlated and if the firm is risk averse, an optimal contract at period t will have *underemployment* or *efficient employment* in the *bad* state, and *overemployment* or *efficient employment* in the *good* state.

Some remarks are in order. First, Dewatripont [1989] has recently derived the possibility of overemployment using a multi-period, asymmetric information contracting model in which the state realized in the initial period lasts all the remaining periods. However, his result rules out overemployment in the good state of each period, whereas our result predicts the possibility of overemployment in the good state of the first period. Second, Propositions 1 and 2 show that inefficient employment can only occur as underemployment in the bad state of each period if the state of nature is

serially uncorrelated. On the other hand, Propositions 1 and 3 reveal that overemployment can also occur in the good state of the first period if the state of nature is serially correlated. These results suggest that the presence of serial correlations in the state of nature can generate greater fluctuations in employment than their absence. This finding does not depend on whether serial correlations in s_T are positive or negative. Indeed, the inefficiency of employment stems from that distortion of incentive-compatibility contracts which is due to the presence of the value functions $\Phi_t(s_h; s_l)$ in the incentive-compatibility constraints.

The intuition behind Proposition 3 can be explained as follows. In the static or one-period framework with risk averse firms, inefficient employment can only occur as underemployment if the worker's utility function has no income effects. However, in the dynamic context, the presence of intertemporal income effects may cause overemployment even though the temporal utility function has zero income effect. To exhibit this mechanism, let us allow the product price s_T to be a continuous random variable taking values in $S_T = [\underline{s}, \bar{s}]$ where $\underline{s} > 0$ ($T = t, t+1$). Since the state space is now a continuum, we replace (21) by the following incentive-compatibility constraint at period t:

$$s = \arg\max_{s^*_t \in S_t} [V(sf(l_t(s^*_t)) - w_t(s^*_t)) + \beta \Phi_{t+1}(s^*_t; s)], \qquad (29)$$

where s^*_t is the state reported by the firm at period t. Incentive-compatibility of $\{l_t(s^*_t), w_t(s^*_t)\}$ then requires

$$V'(sf(l_t(s^*_t)) - w_t(s^*_t)) \cdot \{sf'(l_t(s^*_t)) \cdot [dl_t(s^*_t)/ds^*_t]$$

$$- [dw_t(s^*_t)/ds^*_t]\} \Big|_{s^*_t = s} + \beta [d\Phi_{t+1}(s^*_t; s)/ds^*_t] \Big|_{s^*_t = s} = 0. \qquad (30)$$

Note that all functions in (30) are evaluated at $s^*_t = s$. Now, if the final term in (30) vanishes, i.e., if $d\Phi_{t+1}/ds^*_t$ evaluated at $s^*_t = s$ is equal to zero, applying a discussion similar to that of Cooper [1983][1987] shows that inefficient employment can only occur as underemployment. However, if $d\Phi_{t+1}/ds^*_t$ evaluated at $s^*_t = s$ is not equal to zero, this term can affect the conclusion.

We can clarify this point further by deriving the more specific form of $d\Phi_{t+1}/ds^*_t$ from the continuum state version of maximization problem (2),

$$d\Phi_{t+1}/ds^*_t = \lambda_{t+1} \int_{S_{t+1}} \{U(w_{t+1}(s') - Rl_{t+1}(s')) \cdot [dq^w_{t+1}(s' \mid s^*_t)/ds^*_t]\} \, ds',$$

$$(31)$$

where λ_{t+1} is the nonnegative multiplier associated with the worker's expected utility constraint at period t+1. Since λ_{t+1} implies $d\Phi_{t+1}/d\bar{U}$ ($= d\Phi_{t+1}/d\Omega_{t+1}$) and $\int_{S_{t+1}} U(\cdot)[dq^w_{t+1}/ds^*_t]ds'$ the intertemporal income effect of a change in the firm's report s^*_t on the worker's expected utility level Ω_{t+1}, the right-hand side of (31) represents the intertemporal income effect of a change in the firm's report s^*_t on the firm's expected profit Φ_{t+1}. If no serial correlation exists between s_t and s_{t+1}, then $dq^w_{t+1}/ds^*_t = 0$, which implies $d\Phi_{t+1}/ds^*_t = 0$. If the firm is risk neutral, then $U(\cdot)$ is independent of s', so that (31) reduces to

$$d\Phi_{t+1}/ds^*_t = \lambda_{t+1}U(\cdot) \int_{S_{t+1}} [dq^w_{t+1}/ds^*_t]ds'. \qquad (32)$$

Given that $\int_{S_{t+1}} q^w_{t+1}ds' = 1$, (32) implies $d\Phi_{t+1}/ds^*_t = 0$. Thus, in these two cases, inefficient employment cannot occur or only occurs as underemployment because of the absence of intertemporal income effects. Otherwise, since $d\Phi_{t+1}/ds^*_t$ evaluated at $s^*_t = s$ is not necessarily equal to zero, we cannot

exclude the possibility of overemployment.

5-4. Conclusion

This chapter has considered a two-period, asymmetric information contract

model in which the state of nature is serially correlated and the income

effect on worker's demand for leisure is weak. The main results have been

summarized by the following two statements.

(1) If the state of nature is serially uncorrelated, an optimal contract at

each period has the same characteristic as that of the static, asymmetric

information contract model: inefficient employment can only occur as

underemployment in the bad state of each period.

(2) If the state of nature is serially correlated, an optimal first-period

contract can have not only underemployment in the bad state but also

overemployment in the good state even though an optimal second-period

contract can have inefficient employment only as underemployment in the bad

state.

These results imply that the presence of serial correlations in the state of

nature is likely to cause greater fluctuations in employment than their

absence.

In this chapter, our attention has been focused on the firm's incentive

compatibility problem under the multi-period contract framework. However, we

can also consider the worker's incentive compatibility problem within multi-

period contract models.[17] This problem seems to be particularly interesting

if we incorporate the possibility of the worker's quitting into the model.

Appendix

Proof of Lemma 1:

If the state of nature is serially uncorrelated, the actual conditional probability of $s_{t+1} = s_j$, given $s_t = s_h$, $q_{t+1}(s_j | s_h)$, is equal to the prior belief of $s_t = s_j$, $q_t(s_j)$, for any realized state s_h and reported state s^*_{th}. Since the prior beliefs are independent of the firm's reported state, the contract $C_{t+1}(s^*_{t+1}; s_h)$ introduced to define (6) and (7) is independent of the firm's reported state s_h because of the definition. Given (6), this argument implies that $\Phi_{t+1}(s_h; s_t)$ is independent of s_h, which verifies Lemma 1(1).[18]

If the firm is risk neutral, Proposition 1 shows that

$$s_1 f'(l_{t+1}(s_1)) = R, \tag{A1}$$

$$s_2 f'(l_{t+1}(s_2)) = R, \tag{A2}$$

$$w_{t+1}(s_2) - R l_{t+1}(s_2) = w_{t+1}(s_1) - R l_{t+1}(s_1), \tag{A3}$$

$$\sum_{j=1}^{j=2} U(w_{t+1}(s_j) - R l_{t+1}(s_j)) \cdot q_{t+1}(s_j | s_h) = \bar{U}. \tag{A4}$$

Thus,

$$l_{t+1}(s_1) = F(R/s_1), \tag{A5}$$

$$l_{t+1}(s_2) = F(R/s_2), \tag{A6}$$

$$w_{t+1}(s_1) = R \cdot F(R/s_1) + U^{-1}(\bar{U}), \tag{A7}$$

$$w_{t+1}(s_2) = R \cdot F(R/s_2) + U^{-1}(\bar{U}), \tag{A8}$$

where F is the inverse function of f' and U^{-1} the inverse function of U.

Since (A5)-(A8) show that the contract $\{w_{t+1}(s_1), w_{t+1}(s_2), l_{t+1}(s_1), l_{t+1}(s_2)\}$ is independent of the firm's reported state s_h, it is straightforward from (6) to see that $\Phi_{t+1}(s_h;s_i)$ is independent of s_h, which verifies Lemma 1(2).

Proof of Lemma 2:

If s_T is serially uncorrelated or if the firm is risk neutral, Lemma 1 shows that $\Phi_{t+1}(s_2;s_i) = \Phi_{t+1}(s_1;s_i)$ (i = 1, 2). Then, each side of the incentive-compatibility constraint for the realized state s_i includes $\Phi_{t+1}(s_h;s_i)$ (h = 1, 2; i = 1, 2), which cancels each other out (see (21a) and (21b)). Thus, incentive-compatibility constraints (21) reduce to

$$s_1 f(l_t(s_1)) - w_t(s_1) \geqq s_1 f(l_t(s_2)) - w_t(s_2), \qquad (A9)$$

$$s_2 f(l_t(s_2)) - w_t(s_2) \geqq s_2 f(l_t(s_1)) - w_t(s_1). \qquad (A10)$$

Applying the proof of Azariadis [1983] to an optimal solution to maximization problem consisting of (19), (20), (A9) and (A10), we can verify this lemma.

Notes

1. Hart [1983] has investigated a multi-period, asymmetric information contract model, but he has assumed that workers have access to a perfect bond market and that the state of nature ie serially uncorrelated. Leach [1988] has analyzed a multi-period, asymmetric information contract model with limited liability of firms, but he has also assumed that the state of nature is serially uncorellated.

2. See Proposition 1 of Hart [1983].

3. The firm may make a two-period contract with the worker. In this case, the firm has an incentive to revise its contract at period t+1 by taking advantage of the information about the state realized at period t. The worker also has an incentive to revise his expectation on the basis of the information available to him at the beginning of period t+1. Thus, even though the firm offers a two-period contract, we must analyze the same subgame perfect Baysean equilibrium as that introduced in the next subsection if we permit the contracting parties to renegotiate the terms of the contract.

4. If the firm has considerable latitude in its choice of profit and revenue accounting practices—that is, how to price intermediate goods and inventories, how to evaluate the firm's debt in real terms, how to treat depreciation and obsolescence—, the worker will have great difficulty in monitoring the profit or revenue figures of the firm.

5. $s^*_t(s_t)$ is a schedule which maps states realized at period t into states announced by the firm at period t.

6. As will be argued in the next subsection, we assume that the worker does not use the offered contract $C_{t+1}(s^*_{t+1})$ as a signal of the state realized at period t.

7. $s^*_{t+1}(s_j)$ is a schedule which maps states realized at period t+1 into states announced by the firm at period t+1.

8. To restrict the set of equilibria of the game, we confine the set of the firm's reporting strategy to S_T $(= \{ s_T \mid s_T = s_1, s_2 \})$ $(T = t, t+1)$.

9. If the contract $C_{t+1}(s^*_{t+1})$ is offered at the beginning of period t+1, the contract arrangements $C_t(s^*_t)$ are implementable even though the offered contract $C_{t+1}(s^*_{t+1})$ is inconsistent with the reported state s^*_{t1}. Nevertheless, in this case, the worker knows at period t+1 that the firm misreported which state had really occurred at period t. Thus, given reputation costs or litigation costs, we can also justify in this case the assumption that $C_{t+1}(s^*_{t+1})$ must be consistent with s^*_{t1}.

10. Nevertheless, if the firm is allowed to choose random reporting strategies, the offered contract $C_{t+1}(s^*_{t+1})$ can be viewed as a useful information signal. This kind of double signaling problem has been discussed in Hosios and Peters [1989] using a repeated insurance contract model.

11. In recent papers Laffont and Tirole [1988] and Hosios and Peters [1989] have studied a two-period principal/agent model in which the principal updates his incentive scheme after observing the agent's first-period performance. Laffont and Tirole show that the revelation principle cannot be generally applied to repeated relationships in the continuous state model if the agent with superior information has individual rationality constraints. Hosios and Peters obtain the same result in the two-state model of insurance contracts by assuming that the agent with superior information has a zero discount rate and individual rationality constraints, and that insurance under which benefit payments exceed accident losses are infeasible. However, none of these assumptions are imposed on the model of this chapter, so that as in the signalling models of Spence [1974] and Milgrom and Roberts [1982], separating

equilibria are feasible in each period.

12. In the present framework, there is no possibility that the firm takes out-of-equilibrium actions. Thus, we need not use refinement arguments such as Cho and Kreps [1987].

13. Since the firm offers $C_{t+1}(s^*_{t+1})$ for s_h, we specify the relation using the notation $C(s^*_{t+1}; s_h)$.

14. Note that s_i is not necessarily equal to s_h.

15. Note that $s^*_{t+1,j}$ is always equal to s_j ($j = 1, 2$) because of the incentive-compatibility constraints at period t+1.

16. Note that, even though the firm has offered a period t contract independent of the state reported by the firm, the firm must tell the worker the state realized at period t so that he can revise his expectation of s_{t+1}.

17. Aron [1987] has discussed the problem of motivating workers within a two-period contract model when workers' preferences are unknown to firms and the firm follows the single-period profit maximization policy.

18. In fact, $\Phi_{t+1}(s_h; s_i)$ is independent of not only s_h but also of s_i, because the absence of serial correlation implies $q_{t+1}(s_j \mid s_i) = q_t(s_j)$ in (6).
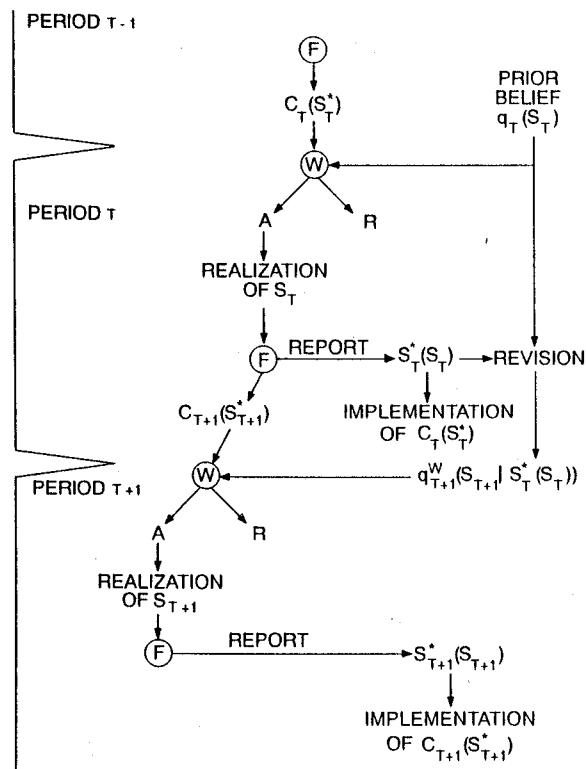
Fig. 1. Contract determination. *F*: firm's decision point; *W*: worker's decision point; *A*: accept; *R*: reject.

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Chapter 6

Long-Term Contracts and Entry Deterrence under Asymmetric Information

6. Long-term Contracts and Entry Deterrence under Asymmetric Information

6-1. Introduction

Although integration of imperfect product-market competition and labor (or sales) contracts may be called by reality, very few researchers consider such interactions simultaneously. Notable exceptions are found in the recent literature of Aghion and Bolton (1987) and Dewatripont (1988a)(1988b). These researches have dealt with the examples of incumbent firms which enter contractual relationships with workers or customers to deter the entry of potential entrants.[1] Aghion and Bolton (1987) construct a sales contract model in which an incumbent seller with private information will sign long-term contracts to prevent the entry of some lower-cost producers. They show that the prices a buyer must pay if he does not trade with the incumbent seller are lower under the optimal asymmetric information contract than under the optimal symmetric information contract. Dewatripont (1988a) discusses how labor contracts can be used for the purpose of strategic commitment. He concludes that an ex-ante efficient contract will involve excessive post-entry production and wage levels if an incumbent firm and its workers possess some private information. Using a numerical example, Dewatripont (1988b) also investigates the effects of union contracts on strategic product market behavior in a dynamic model of entry deterrence through sunk costs, originally developed by Eaton and Lipsey (1980).

In this paper, we consider the effects of a threat of entry on the labor contract arrangements made between an incumbent and its union workers when the labor contract arrangements are observed by a potential entrant who does not have information about the incumbent's cost type. Although the previous papers have examined a simple wage (or price) contract model to stress the aspect of industrial organization, our aim is to develop a more complicated contract model where an incumbent and its risk averse workers may negotiate not only wage compensations but also employment levels. In fact, given that capital equipment is defined in employment units, Dewatripont (1988a) has already analyzed a similar contractual problem. In his model, an incumbent firm and its union

workers bargain both wage compensations and employment levels under the threat of entry of a potential entrant. However, his approach is different from ours in the following three ways: (i) workers' risk averse considerations are neglected; (ii) a work–sharing model is used instead of a layoff model; and (iii) the decision of entry of a potential entrant is exogenous. Relaxing these assumptions, we may elucidate more comprehensively how the threat of entry affects the contract arrangements made between an incumbent firm and its workers.

Specifically, we present a two–period model in which an effective threat of entry forces an incumbent firm and its union workers to modify their actions. The incumbent firm and its union workers are privately informed as to whether the incumbent's intermediate or material input costs are high or low. In the first period, the incumbent and its union workers enter into a contractual relation specifying the levels of wage compensations and employment. A potential entrant observes the agreed contract arrangements and attempts to infer the incumbent's intermediate or material costs. In the second period, the potential entrant decides whether or not to enter the market. Given the entry strategy of the potential entrant, the incumbent decides whether or not to exit; if the incumbent does not exit, the incumbent chooses a price. In this whole process, a low–cost incumbent has an incentive to separate from its high–cost counterpart. It then follows that the low–cost incumbent's contract choice will typically differ from the choice it would make in an environment with complete information.

This chapter is organized as follows. In Section 6–2, we describe the basic model. In Section 6–3, using the perfect Bayesian equilibrium concept and refining the equilibrium set by eliminating dominated strategies, we show that there can exist at most one separating equilibrium. We next consider the possibility of pooling equilibria. Even after dominated strategies are eliminated, many pooling equilibria remain. However, we can restrict the set of pooling equilibrium by requiring the beliefs of the entrant to be intuitive in the sense of Cho and Kreps (1987). In both separating and pooling equilibria, we show

that the equilibrium contracts yield (i) no distortions in wages and severance pays, and (ii) the same kind of distortions in employment and prices if the cost difference between the incumbent types is large enough. Furthermore, if an optimal employment level of the low–cost incumbent in the absence of the threat of entry is large enough, then (a) there exist overemployment and a downward distortion in price; and (b) otherwise, there may exist underemployment and an upward distortion in price. In Section 6–4, we summarize our results as well as directions for future research.

6–2. The Model

We discuss an industry in which an incumbent firm facing potential entry signs a labor contract with its union workers. Specifically, the incumbent monopolizes the market and offers a labor contract to the union workers in the initial stage, whereas a potential entrant may choose to enter the market after observing the offered contract. The entrant makes its choice without having complete knowledge about the incumbent's production costs although the entrant may infer cost information by observing the contract offered by the incumbent. This process of inference might then distort the incumbent's incentive to choose the contract arrangements.

Consider a monopolistic incumbent firm with a linear demand function given by

$$X(p) = a - p, \tag{1}$$

where p denotes price. The incumbent's production costs exclusive of wage costs are described by

$$C_i(n, X(p)) = c_i M(n) X(p), \quad i = L, H. \tag{2}$$

Here, n is the number of employed union workers and c_i is the value of a cost parameter which is drawn from $\{c_L, c_H\}$, with $0 < c_L < c_H$.[2] Although c_i is private information to

the incumbent firm and its union workers,[3] the potential entrant has the prior belief that c_i will be c_H with probability $\rho \in (0, 1)$. The unit variable cost, $c_i M(n)$, is assumed to be decreasing and convex in n, so that $M' < 0$ and $M'' > 0$. Since $C_i(n, X(p))$ represents the purchase of intermediate inputs and materials, the assumption of $M' < 0$ implies that labor can be substituted for intermediate inputs and materials. We also assume that $\lim_{n \to 0} M(n) = \infty$ and $\lim_{n \to \infty} M(n) = 0$. By virtue of having been a supplier in past periods, the incumbent firm is assumed to have the advantage that fixed costs are zero.

Each worker belonging to the incumbent's union is endowed with a unit of labor; and his preference is given by U(Y), where Y is his income. We make the usual assumptions that $U' > 0$ and $U'' < 0$. Each union member derives the utility of U(r) from his alternative job opportunities if he is laid off by the incumbent firm in any stage of the following game.

To introduce a labor contract into the model of entry deterrence, we put the following assumptions about strategies available to the players. Suppose that a contract δ_i is signed between the incumbent of true cost c_i and its union workers before entry takes place. The contract δ_i specifies a wage w_i, a severance pay y_i and an employment level n_i, which must offer each union worker at least U(z), i.e.,

$$n_i U(w_i) + (m - n_i)U(y_i + r) \geq m U(z). \qquad (3)$$

Here, m is the total number of workers belonging to the incumbent's labor union, assumed to be fixed. Since the union may take advantage of its bargaining power, we assume that z > r. The contract δ_i must also satisfy

$$m \geq n_i. \qquad (4)$$

The incumbent does not default any accepted contracts as long as the incumbent remains in the market. However, if the incumbent exits, it is unlikely that the incumbent commits itself on the contract arrangements. For simplicity, we exclude any ability of the

incumbent to be committed to its contracting arrangements if the incumbent leaves the market.[4] We also rule out the possibility of renegotiation after the contracting parties have agreed to their contracting arrangements.[5] Finally, we assume that the contract δ_i is publicly observable because of the presence of collective bargaining.

Given the contract offer δ_i, we can specify the incumbent's profits in nonentry. If entry does not occur, the incumbent remains a monopolist. Using (1) and (2), the profits of the incumbent are

$$\Pi_i(p_i, \delta_i) = p_i(a-p_i) - w_i n_i - y_i(m-n_i) - c_i M(n_i)(a-p_i), \quad i = L, H, \quad (5)$$

where $\delta_i \equiv \{w_i, y_i, n_i\}$.

If entry occurs, the incumbent must make do on duopoly profits. To simplify the analysis, we assume that the post entry game is independent of preentry behavior. This assumption enables us to focus on the effects of the threat of entry on contract arrangements. Let Π_i^I and Π_i^E be the incumbent's and the entrant's duopoly profits in entry when the incumbent's cost type is c_i ($i = L, H$). We assume that $\Pi_L^I > 0 \geq \Pi_H^I$ and $\Pi_H^E > F > \Pi_L^E$, where F is a start-up cost for the entrant. The inequality of $\Pi_H^E > F > \Pi_L^E$ implies that entry does not occur if the entrant knows that the incumbent's cost type is c_L, whereas entry occurs if the entrant knows that the incumbent's cost type is c_H. Furthermore, since we assume that the cost of exit is zero and that the incumbent does not have to be committed to its contract offer in exit, the inequality of $\Pi_H^I < 0$ shows that the high-cost incumbent leaves the market and obtains $\Pi_H^I = 0$ whenever entry occurs. Thus, without loss of generality, we may set $\Pi_H^I = 0$.

All information in the model is common knowledge except for the value of the cost parameter c_i, which is not known to the entrant. Although the entrant cannot observe c_i before making its entry choice, the entrant can observe the contract arrangements signed between the incumbent and its union workers. Let $\rho^*(\delta) \in [0, 1]$ be the entrant's posterior

belief that c_i is c_H when the entrant observes δ.

We now model this situation as an extensive-form game having three stages. In the first stage, the incumbent offers a contract to its union workers, which is a set $\delta_i \equiv (w_i, y_i, n_i)$, where the subscript i corresponds to the incumbent of true cost c_i. In the second stage, the entrant revises its initial belief from ρ_0 to $\rho^*(\delta_i)$ and chooses whether to enter the market. If entry occurs, the entrant must incur a sunk cost F; if entry does not occur, the entrant remains out of the market and incurs no fixed cost. In the third stage, given the entry strategy of the entrant, the incumbent decides whether to leave the market. If the incumbent remains in the market and the entrant does not enter, the incumbent executes the corresponding contract and offers a monopolistic price. If the incumbent remains in the market but the entrant enters, both the incumbent and the entrant would make do on duopolistic profits. In fact, under our assumptions, either the incumbent exits or the entrant does not enter. If the incumbent leaves the market, the incumbent may default the signed contract.

Several remarks about this game are in order. First, we assume that the choice of contract arrangements is less flexible than the choice of an output or price level. These differences in flexibility are captured here by a multistage game framework in which an output or price level is chosen after contract arrangements have been determined. This formulation also reflects the ability of the incumbent to be committed to its strategic variables. Second, as in the entry deterrence models of Dewatripont (1988a)(1988b) and Gertner, Gibbons and Scharfstein (1988), we assume that the entrant cannot infer any information about the incumbent's cost type by observing the incumbent's price. In particular, we assume that the incumbent's price is determined after the entry decision has been made. We hold this assumption to confine our attention to the analysis of the interactions between contract arrangements and entry deterrence.

We now define a perfect Bayesian equilibrium in this game. We shall consider only pure strategy equilibria in the subsequent analysis. In this game, a strategy for the

incumbent consists of a contract $\delta_i \equiv (w_i, y_i, n_i)$ offered in the initial stage and a monopolistic price p_i chosen in the final stage as long as the incumbent remains a monopolist. A strategy for the potential entrant is the decision of whether to enter the market. Let the entrant's strategy be a function from the contract space into an acceptance decision in $\{0, 1\}$, i.e., $A^*(\delta) \in \{0, 1\}$, where $A^* = 1$ indicates nonentry and $A^* = 0$ entry. A perfect Bayesian equilibrium in this game is a collection $\{(\delta_i, p_i)_{i=L,H}, A^*(\delta), \rho^*(\delta)\}$ satisfying the following three conditions:

Condition 1: Given the entrant's strategy, the incumbent maximizes its expected profits by choosing the contract arrangements and the output price; that is, for $i = L, H$,

$$\delta_i^* \in \underset{\delta}{\text{argmax}} \ \{A^*(\delta)\Pi_i(p_i^*, \delta) + [1 - A^*(\delta)]\Pi_i^I\}, \tag{6}$$

subject to (3), (4) and

$$p_i^* \in \underset{p}{\text{argmax}} \ \Pi_i(p, \delta_i^*). \tag{7}$$

Condition 2: Given the incumbent's contract offer and the entrant's belief, the entrant maximizes its profits by choosing whether to enter the market. That is, for all δ, $A^*(\delta) = 1$ if and only if

$$\rho^*(\delta)\Pi_H^E + [1 - \rho^*(\delta)]\Pi_L^E > F. \tag{8}$$

Condition 3: When possible, the entrant's belief $\rho(\delta)$ is derived from Bayes' rule and the incumbent's strategy. Thus, if $\delta_L^* \neq \delta_H^*$, then $\rho^*(\delta_L^*) = 0$ and $\rho^*(\delta_H^*) = 1$. If $\delta_L^* = \delta_H^*$, then $\rho^*(\delta_H^*) = \rho$.

We should mention one caveat on an incentive of union workers to enter into an equilibrium labor contract with the incumbent firm. Let us notice that the ex–ante

expected utility of each union worker contracting with the incumbent of true cost c_i is represented by

$$A^*(\delta_i)[n_i U(w_i) + (m-n_i)U(y_i+r)] + [1-A^*(\delta_i)]U(\omega_i), \qquad (9)$$

where $U(\omega_i)$ is his expected utility after entry has occurred. Since we assume that the high–cost incumbent leaves the market and defaults the signed contract in entry, we may set

$$U(\omega_H) = U(r). \qquad (10)$$

On the other hand, the low–cost incumbent remains the market, so that it is plausible to assume

$$U(\omega_L) \geq U(r). \qquad (11)$$

Combining (3) and (9)–(11), we see that the expression of (9) is greater than $U(r)$. Thus, whether the incumbent's cost type is low or high, each union member has an incentive to enter into an equilibrium labor contract with the incumbent firm.

6–3. Analysis

In this section, we consider the characteristics of the set of perfect Bayesian equilibria. The set of perfect Bayesian equilibria is determined by moving backward from the final to the first stage of the game.

In the final stage, the incumbent remains a monopolist unless entry occurs. Then, the incumbent determines its price by a monopolistic pricing rule for the given contract arrangements; and this rule is summarized by (7). Using the first–order condition for the solution of (7) with (5), the equilibrium monopolistic pricing rule for the incumbent of true

cost c_i in nonentry is represented by

$$p_i^*(n_i) = \frac{1}{2}[a + c_i M(n_i)], \qquad i = L, H. \tag{12}$$

If entry occurs, the incumbent and the entrant act as players of the post entry game. Since we have assumed that the post entry game is independent of preentry behavior, we will neglect the pricing decision of the incumbent firm when entry has occurred.

We next examine the first and the second stages together. It is common for signaling games to have a plethora of perfect Bayesian equilibria. Our model is no exception to this rule; there are many separating and pooling equilibria. Many of these equilibria are supported by unreasonable beliefs off the equilibrium path. However, several recent articles propose stronger definitions of equilibria that restrict these out-of-equilibrium beliefs. We use those refinement methods to eliminate unreasonable equilibria.

We begin with exploring separating equilibria in which $\delta_L^* \neq \delta_H^*$. In separating equilibria, observing the contract arrangements, the entrant becomes fully informed of the incumbent's cost type before making the entry decision. A large class of possible contract arrangements can arise in separating equilibria. However, we can show that a unique separating equilibrium emerges with the elimination of dominated strategies following Milgrom and Roberts (1986).

We now discuss how to eliminate dominated strategies. Let Ψ denote the set of contracts δ which satisfy (3) and (4), and $p_i^*(n)$ denote the equilibrium price for δ which is determined from (12). A contract $\delta \in \Psi$ will be called dominated for c_i if

$$\Pi_i(p_i^*(n), \delta) < \Pi_i^I. \tag{13}$$

In other words, δ is dominated for c_i if δ yields less profits in nonentry than does the duopoly situatuion.[6] An equilibrium is called undominated if the entrant's posterior belief

of being $c_i = c_H$—that is, $\rho^*(\delta)$—is equal to zero whenever δ is dominated for c_H but not for c_L. Hence, the dominance criterion suggests that reasonable beliefs for the entrant entail $\rho^*(\delta) = 0$ for any contract $\delta \in \Psi$ with $\Pi_H(p_H^*(n), \delta) < \Pi_H^I = 0$ and $\Pi_L(p_L^*(n), \delta) \geq \Pi_L^I$. Let us assume (i) that the high–cost incumbent does not mimic the strategies of the low–cost incumbent if the resulting profits of the high–cost incumbent are zero, and (ii) that $\Pi_L(p_L^*(n), \delta) \geq \Pi_L^I$ always holds in separating equilibria. Under this assumption, reasonable beliefs entail $\rho^*(\delta) = 0$ for any contract $\delta \in \Psi$ with $\Pi_H(p_H^*(n), \delta) \leq \Pi_H^I = 0$. Optimality for the low–cost incumbemt (Condition 1) then implies that an equilibrium contract δ_L^* maximizes the low–cost incumbent's profits on the set of Ψ with $\Pi_H(p_H^*(n), \delta_L^*) \leq 0$.[7] Optimality for the high–cost incumbent (Condition 1) also indicates that the high–cost incumbent always exits in separating equilibria because of $\Pi_H^I = 0$ and $\Pi_H^E > F$.[8]

Given (3), (4) and (12), separating equilibria are now summarized by

$$\text{Max} \quad p_L^*(n_L)[a - p_L^*(n_L)] - w_L n_L - y_L(m - n_L) - c_L M(n_L)[a - p_L^*(n_L)], \qquad (14)$$
$$\{w_L, y_L, n_L\}$$

subject to (3), (4) and

$$p_H^*(n_L)[a - p_H^*(n_L)] - w_L n_L - y_L(m - n_L) - c_H M(n_L) [a - p_H^*(n_L)] \leq 0, \qquad (15)$$

where $p_i^*(n_L)$ (i = L, H) is obtained from (12) by substituting n_L into n_i. Inequality (15) represents the incentive–compatibility condition $\Pi_H(p_H^*(n_L^*), \delta_L^*) \leq 0$.

Assuming that (4) always holds with inequality for an optimal solution to (14), we characterize the first–order conditions for the equilibrium contract arrangements as follows:

$$-n_L + \mu n_L U'(w_L) + \lambda n_L = 0, \qquad (16)$$

$$-(m - n_L) + \mu(m - n_L)U'(y_L + r) + \lambda(m - n_L) = 0, \qquad (17)$$

$$-w_L + y_L - c_L M'(n_L)[a - p_L^*(n_L)] + \mu[U(w_L) - U(y_L + r)]$$
$$+ \lambda\{w_L - y_L + c_H M'(n_L)[a - p_H^*(n_L)]\} = 0, \qquad (18)$$

where μ and λ are nonnegative multipliers associated with (3) and (15), respectively. Note that these first–order conditions are rearranged using (12).

As a first step, we examine the features of the equilibrium contracting arrangements in undominated separating equilibria using (16)–(18). Inspecting (3), (16) and (17) yields

$$w_L = y_L + r = z, \qquad (19)$$

which confirms the result of standard implicit contract theory under symmetric information that workers are indifferent between employed and laid off states. In other words, (19) implies that the threat of entry does not affect any incumbent's choice for wages or severance pays if the incumbent shares its information with its union workers. Furthermore, unless (15) is binding with equality for a solution to (14), i.e., $\lambda = 0$, we substitute (19) into (18) and obtain

$$r + c_L M'(n_L)[a - p_L^*(n_L)] = 0, \qquad (20)$$

which is equivalent to the first–order condition with respect to n for the low–cost incumbent in the absence of the threat of entry. However, as long as (15) is binding with equality for a solution to maximization problem (14), the threat of entry affects the choice of the incumbent for its employment and price levels. In the subsequent analysis, we restrict our attention to the case that (15) holds with equality for a solution to maximization problem (14).

We are now in a position to elucidate the effects of the threat of entry on a pair of

optimal employment and price levels of the low–cost incumbent with the aid of Figures 1–3. Let us choose $B_i(n)$ such that

$$r + c_i M'(n)[a - B_i(n)] = 0, \quad i = L, H. \tag{21}$$

It follows from (19) that if $p_i^*(n) = B_i(n)$, (21) represents the optimal condition with respect to n for the monopolistic incumbent of true cost c_i in the absence of the threat of entry. As shown in Appendix, an example of the function $p_i^*(n)$ of (12) and the function $B_i(n)$ of (21) can be depicted as the corresponding schedules $p_i^*(n)$ and $B_i(n)$ in Figures 1–3. Assume that $(\bar{n}_i, \bar{p}_i)$ is a unique maximizer for the monopolistic incumbent of true cost c_i in the absence of the threat of entry under the condition that $n_i \leq m$. Then, we can choose $(\bar{n}_i, \bar{p}_i)$ as a unique intersection of $p_i^*(n)$ and $B_i(n)$ in Figures 1–3 because of the definitions of $p_i^*(n)$ and $B_i(n)$. In Appendix, we can also prove that

$$\bar{n}_L > \bar{n}_H \quad \text{if} \quad M^{-1}(\frac{a}{c_L + c_H}) < \bar{n}_L, \tag{22}$$

$$\bar{n}_L \leq \bar{n}_H \quad \text{if} \quad M^{-1}(\frac{a}{c_L + c_H}) \geq \bar{n}_L, \tag{23}$$

where M^{-1} is the inverse function of $M(n)$.

We begin with discussing the case of Figure 1 in which (22) is satisfied. Let $\phi_i(n, p)$ denote the levels of profits of the incumbent with c_i in nonentry, obtained by the substitution of (19) into $\Pi_i(p, \delta)$. In Figure 1, we draw a possible shape for the isoprofit curve $\phi_H(n, p) = 0$, i.e.,[9]

$$\phi_H(n, p) \equiv p(a-p) - rn - m(z-r) - c_H M(n)(a-p) = 0. \tag{24}$$

Note that points inside a given isoprofit curve correspond to higher levels of profits. The unconstrained maximizer $(\bar{n}_L, \bar{p}_L)$ in the absence of the threat of entry is thus inside the

ellipse formed by $\phi_H(n, p) = 0$ because we assume that constraint (15) holds with equality for a solution to maximization problem (14). We also depict a possible shape for the isoprofit curve $\phi_L(n, p) = \phi_L(n_L^*, p_L^*)$ through (n_L^*, p_L^*);[10] this point is the closest to $(\bar{n}_L, \bar{p}_L)$ of the points where the isoprofit curve $\phi_H(n, p) = 0$ intersects with the $p_L^*(n)$ curve. Since (n_L^*, p_L^*) maximizes $\phi_L(n, p)$ on the set $\phi_H(n, p) \leq 0$, the dominance criterion tells us that (n_L^*, p_L^*) is a unique undominated separating equilibrium. Note that optimality for the pricing decision of the low—cost incumbent requires that (n_L^*, p_L^*) must be on the $p_L^*(n)$ curve.

We next consider the case of Figures 2 and 3 in which (23) holds. In this setting, there may be two possibilities; $n_L^* > \bar{n}_L$ (Figure 2) and $n_L^* \leq \bar{n}_L$ (Figure 3). Applying the similar arguments in Figure 1, we can again show that (n_L^*, p_L^*) is a unique undominated separating equilibrium in Figures 2 and 3.

From Figures 1–3, we obtain the following proposition:

Proposition 1: Suppose that (n_L, p_L) is inside the ellipse formed by $\phi_H(n, p) = 0$ and that $\Pi_L(p_L^*, \delta_L^*) \geq \Pi_L^I$. Then, (i) if $M^{-1}(\frac{a}{c_L + c_H}) < \bar{n}_L$, there exists at most one undominated separating equilibrium (n_L^*, p_L^*) in which $n_L^* > \bar{n}_L$ and $p_L^* < \bar{p}_L$; and (ii) if $M^{-1}(\frac{a}{c_L + c_H}) \geq \bar{n}_L$, there exists at most one undominated separating equilibrium (n_L^*, p_L^*) in which either $n_L^* > \bar{n}_L$ and $p_L^* < \bar{p}_L$ or $n_L^* \leq \bar{n}_L$ and $p_L^* \geq \bar{p}_L$.

Thus, if an optimal employment level of the low—cost incumbent in the absence of the threat of entry is large enough, the distortion associated with efficient signaling in the separating equilibrium causes overemployment and a downward distortion in price. Otherwise, the distortion in the separating equilibrium generates either overemployment and a downward distortion in price or underemployment and an upward distortion in price.

The intuition behind Proposition 1 can be explained as follows. If $M^{-1}(\frac{a}{c_L+c_H}) <$

$\bar{n}_L$, it is seen from (22) that $\bar{n}_L > \bar{n}_H$. Then, the high–cost incumbent finds it less

profitable to employ more workers than $\bar{n}_L$. Hence, to prevent the high–cost incumbent

from pretending that the cost is low, the low–cost incumbent chooses greater employment

than it does in the absence of the threat of entry. However, the analogous explanation

cannot hold if $M^{-1}(\frac{a}{c_L+c_H}) \geq \bar{n}_L$. In this situation, even if $\bar{n}_L < \bar{n}_H$, the low–cost

incumbent may select greater employment than it does in the absence of the threat of entry

because the resulting lower price may deter the high–cost incumbent from pretending to be

the low–cost incumbent. Hence, Proposition 1 indicates that there exist two possibilities if

$M^{-1}(\frac{a}{c_L+c_H}) \geq \bar{n}_L$.

Using a model similar to ours, Dewatripont (1988a) shows that the optimal

asymmetric information contract produces overemployment and higher wage payments

under the threat of entry. The difference between the results of his and our models in

employment mainly depends on his assumption that the decision of entry of the potential

entrant is exogenous. On the other hand, the difference in the results of wage payments

stems from the formulation differences that he uses a work sharing model whereas we use a

layoff model.

Although we have thus far considered separating equilibria, there can also exist

pooling equilibria characterized by $(p_L^*, \delta_L^*) = (p_H^*, \delta_H^*)$ in which the entrant learns nothing

at all from observing an accepted labor contract. However, pooling equilibria cannot exist

if entry would be favorable under the entrant's prior beliefs, that is,

$$\rho\Pi_H^E + (1-\rho)\Pi_L^E \geq F. \qquad (25)$$

In this case, the entrant always enters the market and induces the high–cost incumbent to

exit, so that the high–cost incumbent has no incentive to pretend to be the low–cost

incumbent. In contrast, if (25) fails, many pairs of (p, δ) can arise in pooling equilibria. Even if we refine unreasonable pooling equilibria by the elimination of dominated strategies, any point between $(\hat{n}_L, \hat{p}_L)$ and (n_L^*, p_L^*) on the $p_L^*(n)$ curve in Figures 1–3 may be a pooling equilibrium.

To eliminate equilibria based on unreasonable beliefs, we must further refine our equilibrium concept. Following Cho and Kreps [1987], call a set of equilibrium beliefs unintuitive if there exists $\tilde{\delta} \neq \delta_L^*, \delta_H^*$ such that

$$\Pi_H(\tilde{p}_H, \tilde{\delta}) < \Pi_H(p_H^*, \delta_H^*), \tag{26}$$

$$\Pi_L(\tilde{p}_L, \tilde{\delta}) > \Pi_L(p_L^*, \delta_L^*), \tag{27}$$

where $\tilde{p}_i$ (i = L, H) is determined from the right–hand side of (12) for $\delta = \tilde{\delta}$. If both (26) and (27) hold, the equilibrium (δ_L^*, δ_H^*) could be supported only by an "unintuitive" inference of $\rho^*(\tilde{\delta}) > 0$. Applying this argument to the analysis of pooling equilibria, we see that equilibrium beliefs fail to be intuitive if there exists $\tilde{\delta} \neq \delta^o = \delta_H^* = \delta_L^*$ such that

$$\Pi_H(\tilde{p}_H, \tilde{\delta}) < \Pi_H(p_H^o, \delta^o), \tag{28}$$

$$\Pi_L(\tilde{p}_L, \tilde{\delta}) > \Pi_L(p_L^o, \delta^o), \tag{29}$$

where p_i^o (i = L, H) is determined from the right–hand side of (12) for $\delta = \delta^o$.

To refine the set of pooling equilibria using the intuitive criterion, we put the following assumption. Let $\phi_H(n, p) = \overline{\Pi}_H$ denote the isoprofit curve of the high–cost incumbent which touches the $p_L^*(n)$ curve. Let (n_L^+, p_L^+) denote the point at which $\phi_H(n,p) = \overline{\Pi}_H$ touches the $p_L^*(n)$ curve. We assume that (n_L^+, p_L^+) is outside the region satisfying $\phi_L(n,p) \geq \phi_L(n_L^*, p_L^*)$. This assumption is justified if (c_H-c_L) is large enough to make the value of $|\bar{n}_H-\bar{n}_L|$ large. Because of this assumption, the level of $\phi_H(n,p)$ is

greater as n is closer to $\hat{n}_L$ on the line of the $p_L^*(n)$ curve between n_L^* and $\hat{n}_L$.

We are now in a position to refine the set of pooling equilibria in Figure 1. Suppose a contract $\delta^o = (n^o, z, z-r)$ with $\hat{n}_L \leq n^o < \bar{n}_L$.[11] Using the assumption imposed above, we can choose a contract $\bar{\delta} = (\bar{n}, \bar{z}, \bar{z}-R)$ with $n^o \leq \bar{n} \leq n_L^*$, which satisfies $\Pi_H(\bar{p}_H, \bar{\delta}) = \phi_H(\bar{n}, \bar{p}_H) < \phi_H(n^o, p_H^o) = \Pi_H(p_H^o, \delta^o)$ and $\Pi_L(\bar{p}_L, \bar{\delta}) = \phi_L(\bar{n}, \bar{p}_L) > \phi_L(n^o, p_L^o) = \Pi_L(p_L^o, \delta^o)$. This being the case, none of the contracts δ^o with $\hat{n}_L \leq n^o < \bar{n}_L$ can give intutitive pooling equilibrium strategies. Hence, only the pooling equilibria which can survive the intuitive criterion are made up of pooling contracts δ^o with $\bar{n}_L \leq n^o \leq n_L^*$. Similarly, refining the set of pooling equilibria in Figures 2 and 3, we can choose pooling equilibria with $\bar{n}_L \leq n^o \leq n_L^*$ in Figure 2 and with $\bar{n}_L \geq n^o \geq n_L^*$ in Figure 3, which can survive the intuitive criterion. In fact, since we assume that the high–cost incumbent does not pretend to be a low–cost incumbent for $\Pi_H(n_H^*, p_H^*) = 0$, we rule out the point (n_H^*, p_H^*) from the set of pooling equilibria.

The foregoing arguments lead us to state the following proposition:

Proposition 2: Suppose that the assumptions of Proposition 1 hold and that (25) fails. Also suppose that (n_L^+, p_L^+) defined above is outside the region satisfying $\phi_L(n, p) \geq \phi(n_L^+, p_L^+)$. If pooling equilibria (n^o, p^o) exist, then (i) $\bar{n}_L \leq n^o < n_L^+$ and $\bar{p}_L \geq p^o > p_L^+$ if $M^{-1}(\frac{1}{c_L + c_H}) < \bar{n}$; and (ii) either $\bar{n}_L \leq n^o < n_L^+$ and $p_L \geq p > p_L^+$ or $\bar{n}_L \geq n^o > n_L^+$ and $\bar{p}_L \leq p^o < p_L^+$ if $M^{-1}(\frac{1}{c_L + c_H}) \geq \bar{n}_L$.

Thus, if an optimal employment level of the low–cost incumbent in the absence of the threat of entry is large enough, Proposition 2 implies that overemployment and a downward distortion in price occur in intuitive pooling equilibria. Otherwise, Proposition 2 suggests that either overemployment and a downward distortion in price or underemployment and an upward distortion in price occur in intuitive pooling equilibria. Therefore, whether or not an equilibrium is informative, signaling with labor contracts

entails the same kind of distortions in employment and prices, and no distortions in wages and severance pays.

6—4. Conclusion

We have discussed a model in which an incumbent firm uses its contracting arrangements with its union workers to signal its cost type and to deter the entry of a potential entrant. Our analysis has shown that, whether an equilibrium is separating or pooling, the signaling process causes (i) no distortions in wages and severance pays, and (ii) the same kind of distortions in employment and prices if the cost difference between the incumbent types is large enough. Furthermore, if an optimal employment level of the low—cost incumbent in the absence of the threat of entry is large enough, the signaling causes overemployment and a downward distortion in price; otherwise, the signaling may cause underemployment and an upward distortion in price.

We conclude by mentioning directions for future study. First, in our model, the postentry game is independent of preentry behavior. If this assumption is relaxed, contract arrangements may be allowed to depend on postentry conditions as in the model of Dewatripont (1988a). It would be fairly interesting to check whether our conclusion still holds in this situation. Second, we have assumed that workers have complete information about the cost type of the incumbent. However, if workers have only incomplete information about the incumbent's cost type, we must deal with a "two—audience signaling model" developed in Gertner, Gibbons, and Scharfstein (1988). Third, it is clear that other product market strategies such as exit or predation could affect labor contract issues. Thus, it would be interesting to extend our model into those issues.

Appendix

We first examine the characteristics of the $p_i^*(n)$ schedule. Given $c_L < c_H$, $\lim_{n \to 0} M(n) = \infty$ and $\lim_{n \to \infty} M(n) = 0$, it is found from (12) that for all n,

$$p_L^*(n) \leq p_H^*(n), \tag{A1}$$

where equality holds if and only if $n \to 0$ or $n \to \infty$. Because of $M' < 0$ and $M'' > 0$, we also see

$$dp_i^*(n)/dn < 0 \text{ and } d^2p_i^*(n)/dn^2 > 0, \quad i = L, H. \tag{A2}$$

Furthermore, since we have assumed that $\lim_{n \to 0} M(n) = \infty$ and $\lim_{n \to \infty} M(n) = 0$, we obtain

$$\lim_{n \to 0} p_i^*(n) = \infty \text{ and } \lim_{n \to \infty} p_i^*(n) = (1/2)a, \quad i = L, H. \tag{A3}$$

Conditions (A1)–(A3) characterize an example of the $p_i^*(n)$ schedule in Figures 1–3.

We next consider the features of the $B_i(n)$ schedule. It follows from (21) that

$$B_i(n) = a + r/[c_i M'(n)], \quad i = L, H. \tag{A4}$$

It is found from (A4), $M' < 0$ and $c_L \leq c_H$ that for all n,

$$B_L(n) \leq B_H(n) \leq a. \tag{A5}$$

Differentiating (A4) with respect to n yields

$$dB_i(n)/dn = -[rM''(n)]/\{c_i[M'(n)]^2\} < 0, \quad i = L, H, \tag{A6}$$

where the final inequality in (A6) is derived from $M''(n) > 0$. On the basis of (A5) and (A6), an example of the $B_i(n)$ schedule is shown in Figures 1–3.

Our final task is to compare $\bar{n}_L$ with $\bar{n}_H$ if $(\bar{n}_i, \bar{p}_i)$ is a unique maximizer for the monopolistic incumbent of true cost c_i in the absence of the threat of entry under the condition $n_i \leq m$. Substituting (12) and (19) into (5) and differentiating it with respect to n, we obtain a function $\Gamma_i(n_i)$:

$$\Gamma_i(n_i) \equiv r + (1/2)c_i M'(n)[a - c_i M(n_i)]. \tag{A7}$$

Since we assume that $(\bar{n}_i, \bar{p}_i)$ is a unique maxmizer, the function $\Gamma_i(n)$ has a unique point $\bar{n}_i$ satisfying $\Gamma_i(n_i) = 0$; and is decreasing in n in the neighborhood of $\bar{n}_i$. Furthermore, using (A7), we see

$$\Gamma_L(n) - \Gamma_H(n) = (1/2)M'(n)(c_L - c_H)[a - M(n)(c_L + c_H)]. \qquad \text{(A8)}$$

Because of $M'(n) < 0$ and $c_L < c_H$, it follows from (A8) that

$$\Gamma_L(n) > \Gamma_H(n) \quad \text{if} \quad M^{-1}(\frac{a}{c_L + c_H}) < \bar{n}_L, \qquad \text{(A9)}$$

and

$$\Gamma_L(n) \leq \Gamma_H(n) \quad \text{if} \quad M^{-1}(\frac{a}{c_L + c_H}) \geq \bar{n}_L, \qquad \text{(A10)}$$

where M^{-1} is the inverse function of $M(n)$. Now, it is found from Figure 4 that

$$\bar{n}_L > \bar{n}_H \quad \text{if} \quad M^{-1}(\frac{a}{c_L + c_H}) < \bar{n}_L. \qquad \text{(A11)}$$

Similarly, it is immediate from Figure 5 that

$$\bar{n}_L \leq \bar{n}_H \quad \text{if} \quad M^{-1}(\frac{a}{c_L + c_H}) \geq \bar{n}_L. \qquad \text{(A12)}$$

Notes

1. A few other papers study the effects of financial signaling on product-market competition. See Bhattacharya and Ritter (1983), Brander and Lewis (1986), and Gertner, Gibbons and Scharfstein (1988).

2. We assume that intermediate or material input data are proprietary information and thus are unavailable to the potential entrant. A possible justification for this assumption is that only accounting profits are publicly reported, and that they would be extremely poor indicators of economic profits.

3. If the incumbent's union workers do not know the incumbent's cost type, the incumbent firm must signal to two uninformed audiences; that is, the potential entrant and the incumbent's union workers. For the examples of a two audience signaling model, see Gertner, Gibbons, and Scharfstein (1988), which discuss the effects of financial signaling on product-market competition.

4. If the incumbent is allowed to be committed to its contracting arrangements even in exit, these contract arrangements may be made contingent on the entry or nonentry of the potential entrant.

5. Several recent studies, however, are concerned with renegotiation-proof contracts. See, for example, Dewatripont (1988a) and Hart and Tirole (1988).

6. More precisely, a contract δ will be called dominated for c_i if δ yields less profits to the incumbent of true cost c_i under the best post entry condition than does the duopoly situation under the worst post entry condition.

7. If the entrant knows that the incumbent's cost type is c_L, then the entrant never enters the market because $\Pi_L^E < F$. Thus, the low-cost incumbent maintains the monopoly situation in this case.

8. The high-cost incumbent can obtain $\Pi_H^I = 0$ only if it leaves the market; otherwise, the high-cost incumbent has to make do with $\Pi_H^I < 0$.

9. Note that $\partial \phi_H / \partial p = 0$ on the $p_H^*(n)$ schedule and $\partial \phi_H / \partial n = 0$ on the $B_H(n)$ schedule because of the definitions of these scedules. Then, given that $dn/dp \mid_{\phi_H=0} =$

$-[\partial \phi_H / \partial p]/[\partial \phi_H / \partial n]$, we see that $dn/dp \mid_{\phi_H=0} = 0$ on the $p_H^*(n)$ schedule and $dn/dp \mid_{\phi_H=0} = \infty$ on the $B_H(n)$ schedule.

10. Using the arguments similar to note 9, we draw a possible shape for the isoprofit curve $\phi_L(n, p) = \phi_L(n_L^*, p_L^*)$.

11. The contracts δ^o and $\tilde{\delta}$ must satisfy (19), so that $(w^o, y^o) = (\tilde{w}, \tilde{y}) = (z, z-r)$.
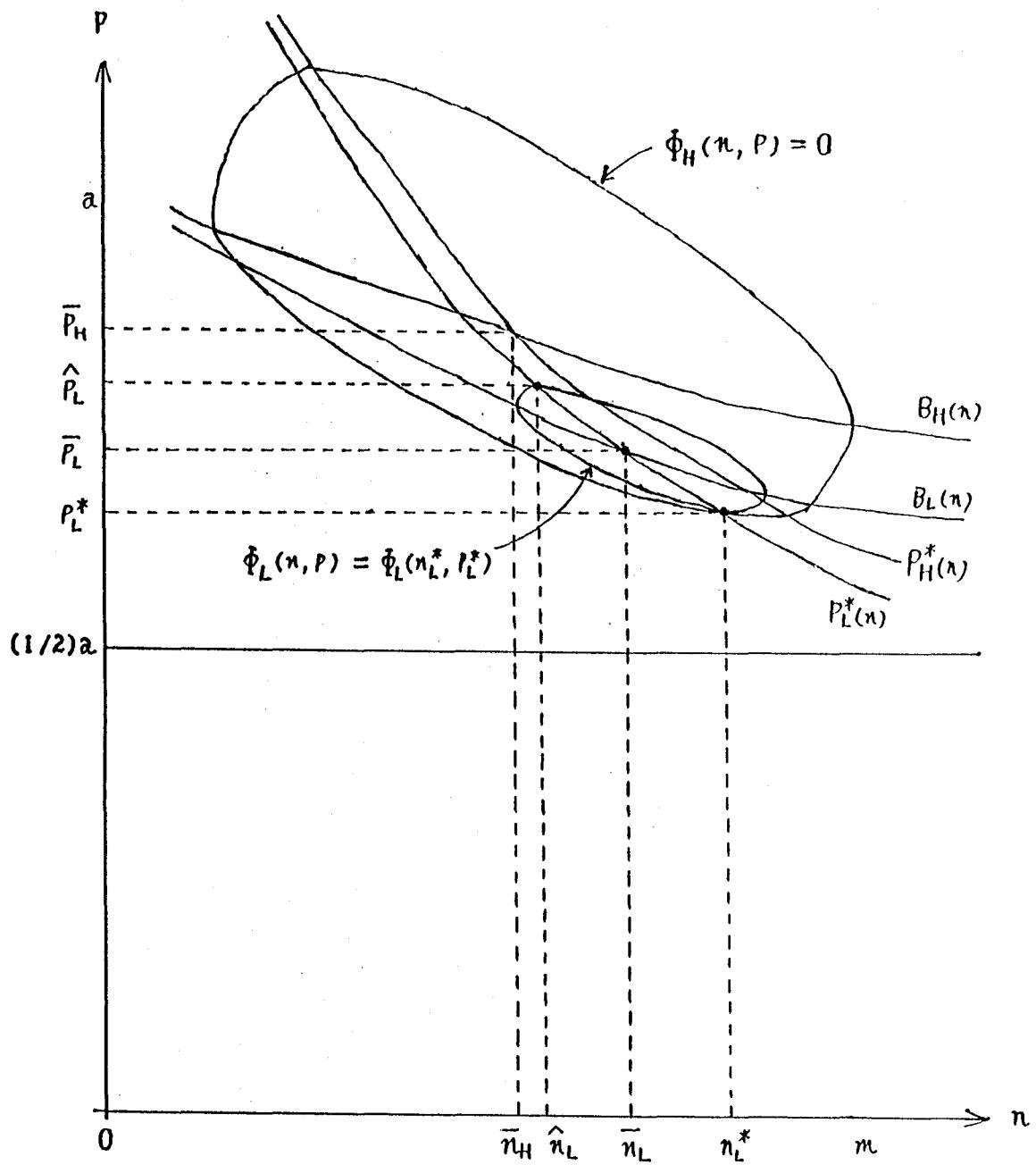
Figure 1.—Condition (22) holds.
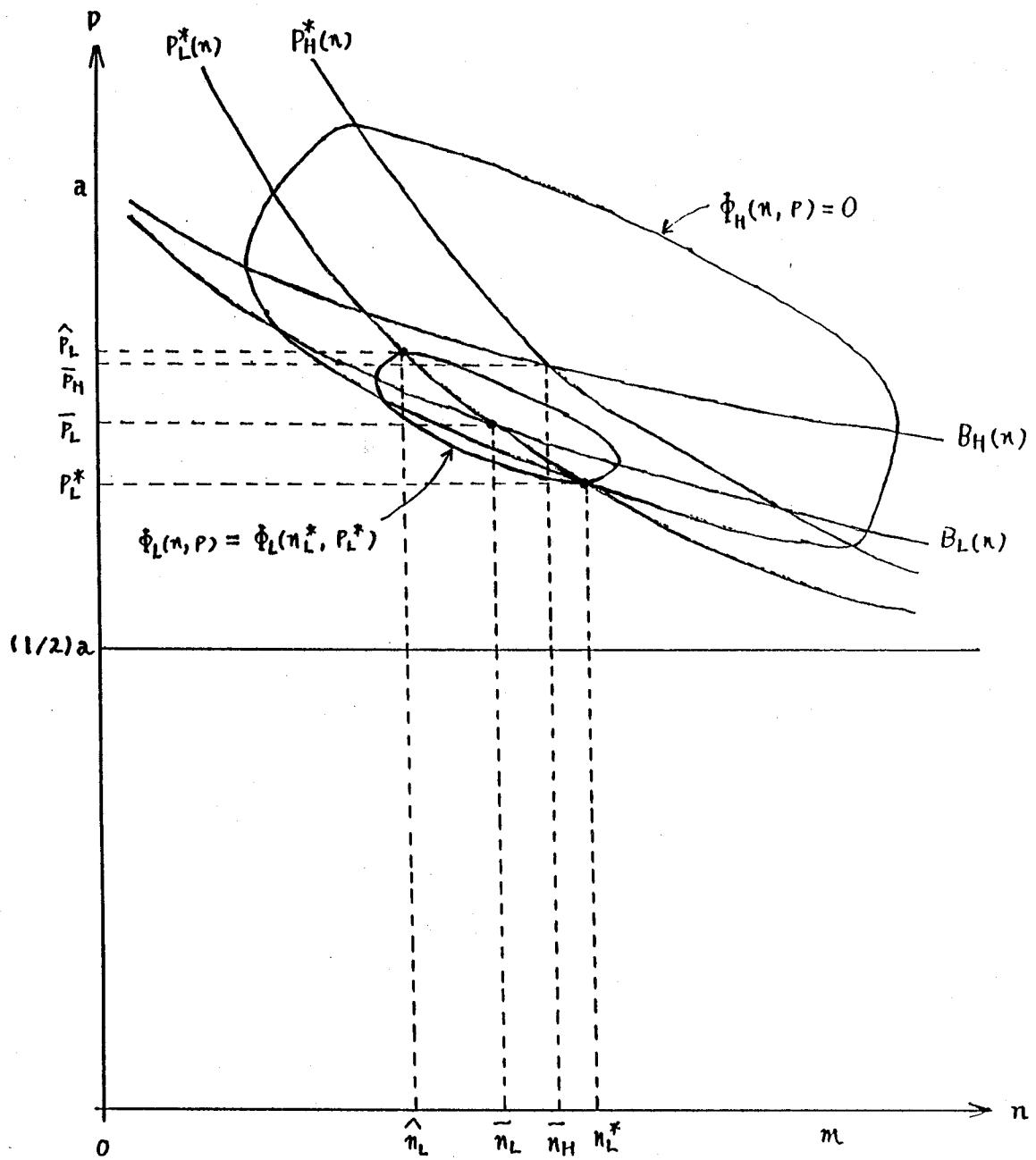
Figure 2.—Condition (23) and $n_L^* > \bar{n}_L$ hold.
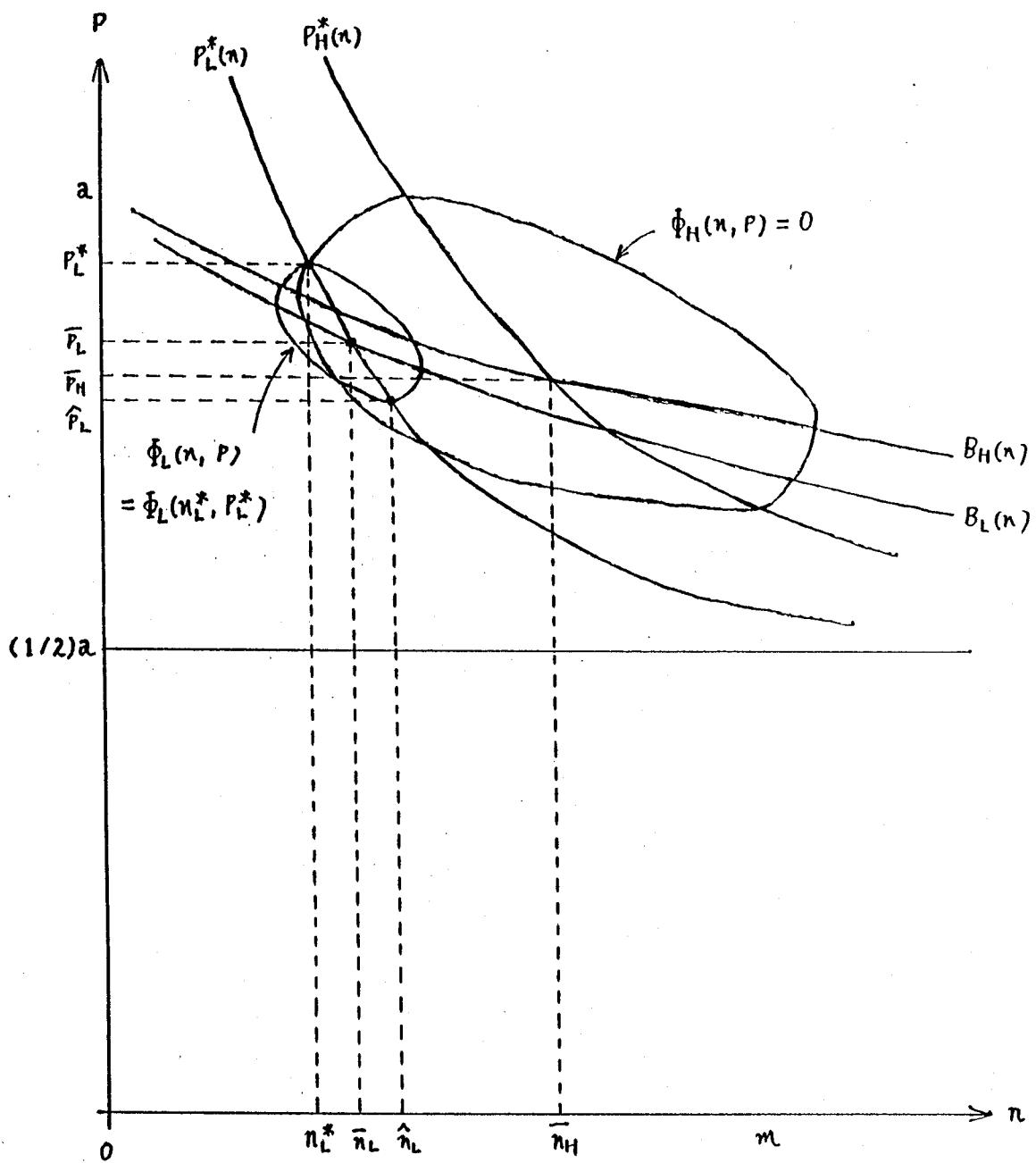
Figure 3.—Condition (23) and $n_L{}^* \leq \bar{n}_L$ hold.
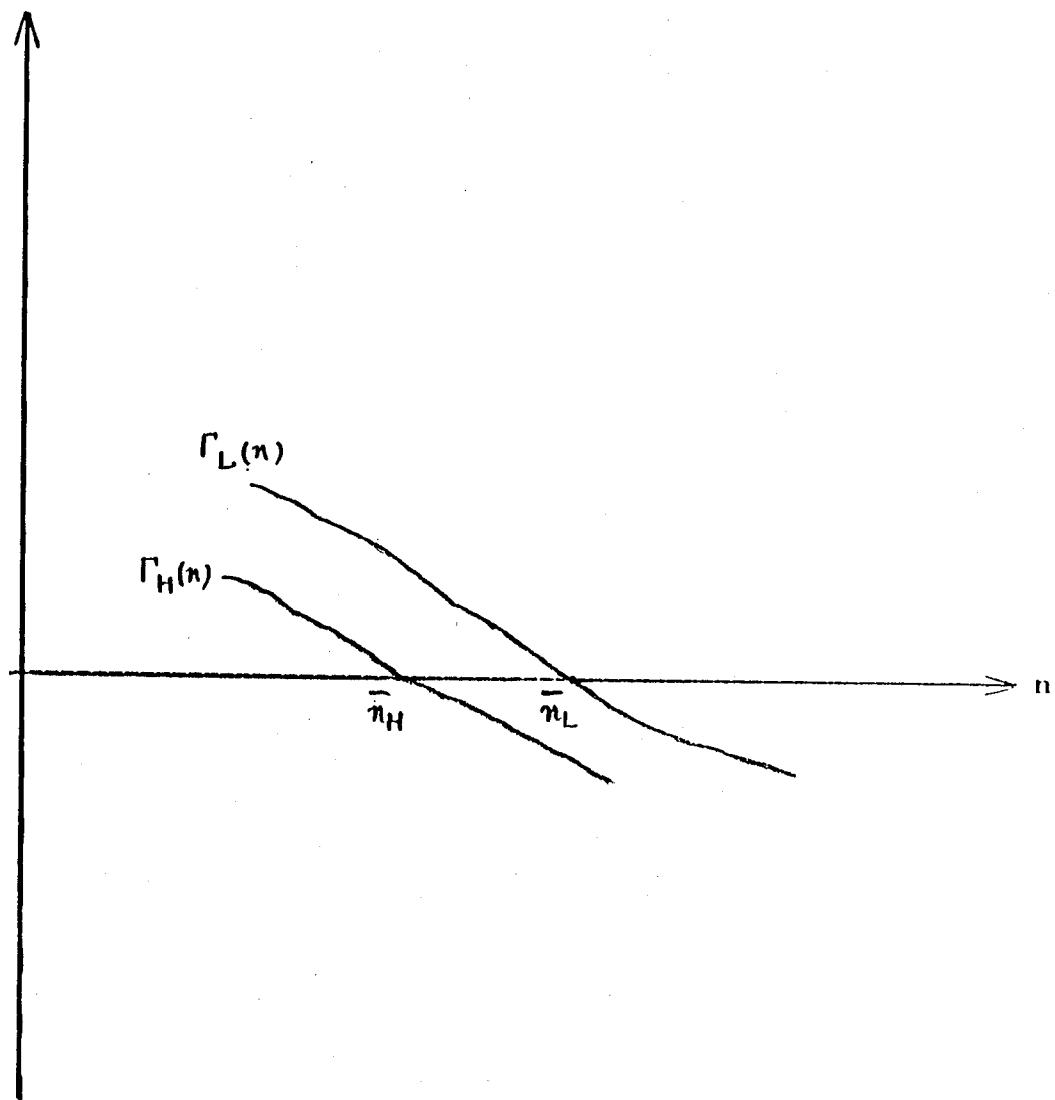
Figure 4.— $M^{-1}(\dfrac{a}{c_L+c_H}) < \bar{n}_L.$
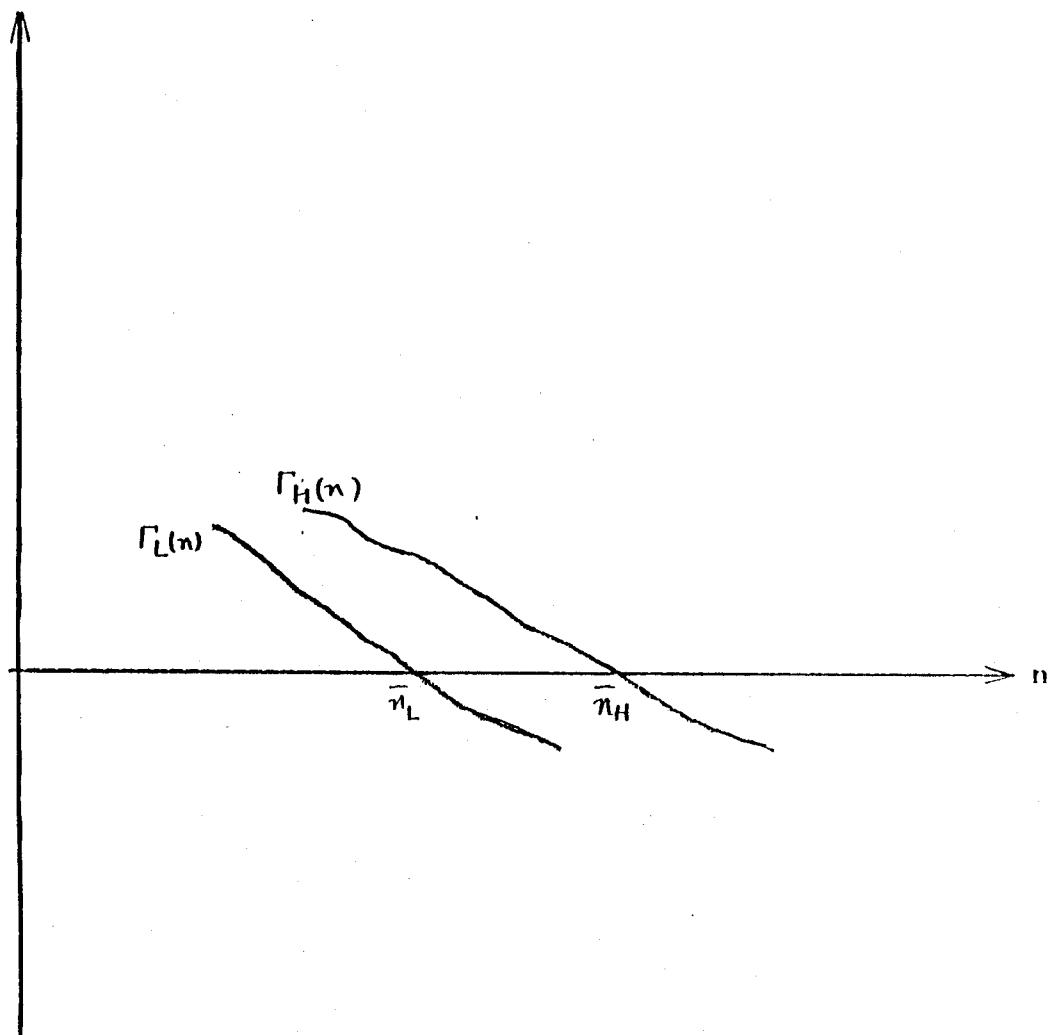
Figure 5.— $M^{-1}(\dfrac{a}{c_L + c_H}) \gtreqless \bar{n}_L.$

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Chapter 7

Implicit Contracts in the Japanese Labor Market

7. Implicit Contracts in the Japanese Labor Market

7-1. Introduction

The implicit contract theory explored by Azariadis (1975) and Baily (1974) shows that wage rigidity and underemployment result from the optimizing behavior of firms and workers. The theory suggests (i) that wage rigidity arises from risk-sharing arrangements between firms and workers, and (ii) that underemployment may occur if workers attach a high utility value to leisure or unemployment insurance benefits.

Although the theoretical implications are important, little attention has been given to empirical testing for the implicit contract theory.[1] Instead, it is frequently stated that the implicit contract theory may empirically be supported by the following stylized fact: Cyclical fluctuations in employment are large relative to the corresponding real wage movements.[2]

However, several alternatives to the implicit contract theory can explain this stylized fact. First, the existence of an adjustment lag in the labor market or the monopoly power of a labor union can generate the stylized relation between employment and wages. If this is the case, the labor market is not cleared in any sense; and observed wage rates cause an inefficient level of employment. Second, the equilibrium business cycle approach, steming from the fundamental contribution of Lucas and Rapping (1968), also predicts such substantial wage elasticity of employment. In this view, the instantaneous adjustment of real wages brings the supply and demand of labor into equality. Nevertheless, if leisure in the current period is highly substitutable with leisure in other periods, movements in the current real wage relative to expected discounted future real wage rates

elicit a large labor supply response. Wage stickiness and unemployment are then interpreted within the competitive equilibrium framework as the outcome of the strong intertemporal substitution in labor supply or erroneous expectations.[3]

The foregoing arguments show that the implications of wage rigidity are crucially different between the three theories mentioned above. In this chapter, we attempt to develop a test for the implicit contract hypothesis to examine the implications of observed wage rigidity.[4] The empirical results indicate that implicit contract relations are not rejected in the Japanese labor market. This finding suggests that some part of observed wage rigidity still remains in the Japanese labor market even if disequilibrium factors are removed or intertemporal substitution in labor supply is not great. This portion of wage rigidity reflects the outcome of efficient risk sharing arrangements between firms and workers.

One of the most important issues concerning implicit contracts is that the effects of monetary or real disturbances on macroeconomic stability depend upon whether implicit contracts are made in real terms or nominal terms. Since implicit contracts in real terms stabilize real wages, they insultate an economy from the effects of monetary shocks by avoiding distortions in real wages and by limiting transitory changes in output and employment. However, this observation implies that implicit contracts in real terms may render monetary policy ineffective for conducting stabilization policies. Furthermore, escalated money wages produced by these contracts may exacerbate unemployment and promote inflation against fluctuations of aggregate supply due to real disturbances (such as adverse changes in the terms of international trade or unexpected reductions in labor productivity). In contrast, implicit contracts in nominal terms

stabilize nominal wages but not real wages. Thus, under implicit contracts

in nominal terms, monetary disturbances have more significant impacts on

output and employment levels than real disturbances do. [5]

The second purpose of this chapter is to test whether implicit contract

relations in the Japanese labor market are made in real terms or nominal

terms. A key result of this test is that the implicit contract hypothesis

in real terms is more fitted to actual data than that in nominal terms.

This finding gives evidence that the Japanese economy is more volatile to

real disturbances than to monetary disturbances.

This chapter is organized as follows. The next section provides a

theoretical model and derives theoretical restrictions for the implicit

contract hypothesis. Section 7-3 develops an empirical method for testing

the implicit contract hypothesis with cross-sections data on firms. Section

7-4 offers empirical results and appraises them. The final section

summarizes our conclusions and remaining problems for future study.

7-2. The Theoretical Framework

We use a risk sharing model based on Shavell (1976). Consider an

economy in which there are two types of agents: firms and workers. Each

firm faces a random variable, P, whose density function g(P) is defined on

(P-, P+). The stochastic property of P reflects the fact that the firm's

revenue is uncertain. If a wage contract is made in the spot auction

market, the wage rate varies with the random variable, P; thus risk averse

workers cannot avoid taking undesirable risk. Implicit contracts are then

viewed as institutional insurance arrangements between firms and workers (represented by labor unions) against this kind of risk.

To simplify the analysis, let us assume a situation in which a firm enters into a wage contract with a labor union. The expected utility of the labor union is then represented by

$$E(U) = \int_{P^-}^{P^+} U(Nw(P))g(P)dP, \tag{1}$$

where U is the utility function of the labor union,[6] N the number of union members, and w(P) the wage income of each union member at state P.[7] The expected utility of the firm is written in the form

$$E(V) = \int_{P^-}^{P^+} V(N \cdot [y(P)-w(P)])g(P)dP. \tag{2}$$

Here, V denotes the utility function of the firm and y(P) stands for the firm's net income per worker prior to the wage payment at state P.[8]

An optimal contract is now obtained from maximization of E(V) subject to E(U) held constant; that is,

$$\max_{w(P)} \int_{P^-}^{P^+} V(N \cdot [y(P)-w(P)])g(P)dP, \tag{3}$$

$$\text{sub. to} \quad \int_{P^-}^{P^+} U(Nw(P))g(P)dP \geq \overline{U}, \tag{4}$$

where $\overline{U}$ is the minimum expected utility of which the firm assures the labor union.

To specify an optimal contract, let us assume that $U(Nw) = -\exp(-aNw)$ and $V(\pi) = -\exp(-b\pi)$. This assumption implies that each agent has a utility function with constant absolute risk aversion. Since it is assumed that $a > b > 0$, labor union's absolute risk aversion, a, is greater than firm's, b.

Now, the first-order condition to maximization problem (3) is given by

$$bN \cdot \exp(-bN \cdot (y(P) - w(P))) = aN\lambda \cdot \exp(-aNw(P)), \qquad (5)$$

where λ is the nonnegative multiplier associated with inequality constraint (4). Taking logs of both sides of (5) leads to

$$w(P) = \frac{b}{a+b} y(P) + \frac{\log a\lambda - \log b}{a+b}. \qquad (6)$$

Equation (6) describes an optimal wage rate in the implicit contract. The optimal wage rate depends on the three parameters which are not directly observable; that is, the degree of labor union's absolute risk aversion, a, the degree of firm's absolute risk aversion, b, and the multiplier, λ.

If we view $(\log a\lambda - \log b)/(a+b)$ as a fixed effect and $b/(a+b)$ as a coefficient of $y(P)$, we can regress $w(P)$ on $y(P)$. However, this estimation approach is equivalent to measuring the extent of wage rigidity relative to firm's net income per worker prior to the wage payment, $y(P)$. Since we wish to test the implicit contract hypothesis rather than measure the extent of wage rigidity, we must use another estimation method.

Fortunately, as will be discussed in the next section, we can find a proxy for approximating the degrees of risk aversion of the labor union and

the firm, 'a' and 'b'. Thus we can estimate equation (6) by considering
'log λ' a parameter or by taking variances of both sides of (6) so as to
eliminate λ from (6). (Note that λ and N are state invariant.)

In the analysis that follows, we will adopt the latter procedure
because the implications of the estimation equation are more
straightforward. The implicit contract hypothesis is now characterized by

$$VAR(w) = (\frac{b}{a + b})^2 \cdot VAR(y). \tag{7}$$

Here, VAR(w) is the variance of wage income and VAR(y) the variance of
firm's net income per worker prior to the wage payment.

Some remarks are in order. First, (7) tells us that the variance of
wage income, VAR(w), is negatively associated with labor union's absolute
risk aversion, a; but that it is positively associated with firm's absolute
risk aversion, b, or the variance of firm's net income per worker prior to
the wage payment, VAR(y). Second, given the assumed inequality relation a >
b > 0, (7) shows that VAR(w) < (1/4)VAR(y). In other words, variations of
wage income are much smaller than those of *firm's net income per worker
prior to the wage payment* if the firm is less risk averse than its labor
union. This finding is reminiscent of the well-known proposition that wage
income is more rigid in the implicit contract than in the competitive
auction contract.

Representation (7) does not depend on whether the variables are defined
in real terms or nominal terms. If the variables are defined in real terms,
wage rigidity is realized in real terms because wage contracts are made in
real terms. In contrast, if the variables are defined in nominal terms,

implicit contracts cause nominal wage rigidity. Thus, in the subsequent
sections, we will test the implicit contract hypothesis in real terms
against that in nominal terms by estimating (7) with data in both real terms
and nominal terms.

7-3. The Empirical Model

Before proceeding to the empirical test, we must fill some gaps between
the theory and the reality.

First, we must measure the degree of risk aversion of each agent.
Friend and Blume (1975) state that the degree of investor's relative risk
aversion is inversely related to the ratio of his holdings of *marketable
risky assets* to *marketable total assets* if assets are made up of riskless
assets and marketable risky assets. In accordance with their specification,
we adopt as a measure of RRA the inverse of the holding ratio of *marketable
risky assets* to *marketable total assets*. However, equation (7) shows that
VAR(w) is directly related to the degree of absolute risk aversion but not
to the degree of relative risk aversion. Thus we must modify equation (7)
using the following relations of absolute to relative risk aversion:

$$a = WRA/(Nw) \text{ and } b = FRA/(N \cdot FPR).$$ (8)

Here, WRA, FRA, and FPR denote the degree of labor union's relative risk
aversion, the degree of firm's relative risk aversion, and the firm's profit
per worker, respectively. Substituting (8) into (7), we have

$$VAR(w) = [\frac{FRA/FPR}{(WRA/w) + (FRA/FPR)}]^2 \; VAR(y). \qquad (9)$$

From now on, we will confine our attention to (9) instead of (7).

Second, if workers are homogeneous across sampling firms, the degree of union's absolute risk aversion, a, is viewed as a fixed effect in (7) because our empirical model is estimated with cross-sectional data on firms. Then we can drop the degree of union's relative risk aversion, WRA, and wage income, w, from the estimating equations, for these two variables are also interpreted in (9) as a fixed effect across sampling firms. Since longitudinal data of worker's households are not acceptable, we assume that workers are homogeneous across sampling firms.

Third, measurement of VAR(w) and VAR(y) poses some problems. Since we estimate our empirical model with cross-sectional data on firms, we compute these variances using annual time series data on each firm. However, computation of these two variances is not straightforward, because both wage income per worker and firm's net income per worker prior to the wage payment grow with an apparant time trend. To concentrate on cyclical fluctuations, we measure VAR(w) or VAR(y) as the variance of deviation from a linear trend of w or y.[9]

Finally, to discuss whether wage contracts are arranged in real terms or nominal terms, we must compare the results estimated with data in real terms to those estimated with data in nominal terms. To this end, we choose a deflator which transforms a nominal variable into a real one. In the analysis that follows, we will use as the deflator the consumer price index (CPI) or the wholesale price index (WPI).

We are now ready to present specifications for testing the implicit

contract hypothesis in real terms or nominal terms. Linearizing the right-hand side of (9) with respect to the explanatory variables and taking logarithms of both its sides, we obtain the following estimating equations:

$$\log \mathrm{VAR}(W^*) = a_0 + a_1 \log \mathrm{FRA} + a_2 \log \mathrm{FPR}$$
$$\phantom{\log \mathrm{VAR}(W^*) = a_0 +} (+) \phantom{a_1 \log \mathrm{FRA} + a_2} (-)$$
$$+ a_3 \log \mathrm{VAR}(Y^*) + \sum_j a_{3+j} \mathrm{DUM}_j + \xi_0, \qquad (10)$$
$$ (+)$$

$$\log \mathrm{VAR}(W^*/P^c) = b_0 + b_1 \log \mathrm{FRA} + b_2 \log \mathrm{FPR}/P^c$$
$$(+) \qquad\qquad (-)$$
$$+ b_3 \log \mathrm{VAR}(Y^*/P^c) + \sum_j b_{3+j} \mathrm{DUM}_j + \xi_1, \qquad (11)$$
$$(+)$$

$$\log \mathrm{VAR}(W^*/P^w) = c_0 + c_1 \log \mathrm{FRA} + c_2 \log \mathrm{FPR}/P^w$$
$$(+) \qquad\qquad (-)$$
$$+ c_3 \log \mathrm{VAR}(Y^*/P^w) + \sum_j c_{3+j} \mathrm{DUM}_j + \xi_2. \qquad (12)$$
$$(+)$$

Here,

W = firm's nominal wage payment per worker,

W^* = W adjusted with a time trend factor,[10]

Y = firm's nominal net income per worker prior to the wage payment,

Y^* = Y adjusted with a time trend factor,[11]

P^c = consumer price index,

P^w = wholesale price index,

DUM_j = dummy variable of the j-th industry.[12]

The error terms, $[\xi_0, \xi_1, \xi_2]$, are assumed to be distributed normally. The predicted signs of the explanatory variables, which are derived from partial differentiation of the right-hand side of (9), are shown in the

parentheses below them.

Some comments are in order. First, firm's relative risk aversion FRA is not deflated by any price index, because FRA is a ratio between the two nominal variables. Second, direct calculation reveals that the coefficient of log VAR(y) is equal to unity. This theoretical restriction of the coefficient of log VAR(y) can be used to verify the implicit contract hypothesis. However, it should not be surprising if the coefficient value of log VAR(y) is less than unity. The reasons behind this intuition are as follows: (i) Some disequilibrium factors such as high separation costs (including human capital grounds) or the monopoly power of labor union are not precluded; (ii) measurement errors across sampling firms in wages, the index of risk aversion, or firm's net income per worker prior to the wage payment are not avoided, because these variables are calculated from the mean or the variance of their annual observations over estimation periods.

Equations (10)-(12) are estimated with financial data on firms in manufacturing, mining, and construction industries in Japan. The financial data are presented in the Data Appendix. We calculate VAR(w) (resp. VAR(y)) from the variance of annual observations of w (resp. y) of each firm over estimation periods. We compute the other variables from the mean of their annual observations over the same estimation periods.

7-4. Results

We begin with estimating equations (10)-(12) over the period from 1965 Fiscal year to 1983 Fiscal year. We also estimate these equations over two

estimation periods: from 1965 Fiscal year to 1974 Fiscal year and from 1975

Fiscal year to 1983 Fiscal year. The estimation in the two subperiods

enables us to consider whether or not the first oil crisis brought out a

structural change in the Japanese labor market. Although many of the same

sampling firms are used in the tests mentioned above, the number of sampling

firms being actually available in the period from 1975 Fiscal year to 1983

Fiscal year is about five times that of sampling firms in the other two

periods. The difference in the number of sampling firms stems from the

restrictions of Needs-Financial Data File.[13] To verify the implicit

contract hypothesis in the larger set of sampling firms, we reestimate (10)-

(12) over the period from 1975 Fiscal year to 1983 Fiscal year using all of

the available sampling firms.

These estimation results are summarized in Tables 1-3. Three columns

in each table correspond to the estimates of equations (10)-(12). From now

on, equations (10), (11), and (12) are referred to as the VAR(W), the

VAR(W/P^c), and the VAR(W/P^w) equation, respectively.

Table 1 reports the results for the entire period. The estimates

suggest that the implicit contract hypothesis is not rejected throughout

1965-1983. All of the estimates except the coefficient of the profit of the

firm (FPR) have the plausible sign and are significant. The sign of the

coefficient of the profit of the firm is also in accordance with the

theoretical requirement although the standard errors are large.

Furthermore, the coefficient of the profit of the firm is more significant

in the VAR(W/P^c) equation than in the other two equations.

We next discuss the results estimated with many of the same sampling

firms over the two estimation periods: the period 1965-1974 and the period

1975-1983. In the period *before* the first oil crisis, the implicit contract

hypothesis does not completely fit the data. In contrast, in the period *after* the first oil crisis, the empirical results of the VAR(W) and the VAR(W/P^c) equation are broadly consistent with the implicit contract hypothesis (see Table 2). In particular, this finding is verified in the VAR(W/P^c) equation. The estimated coefficient of relative risk aversion of the firm—the key variable of our analysis—is more significant in the VAR(W/P^c) equation than in the VAR(W) equation.

It might be surprising that, despite our finding that the estimates are not satisfactory in the period *before* the first oil crisis, the estimation results are much better in the *entire* period than in the period *after* the first oil crisis. However, these observations are not necessarily inconsistent, because detrended wage variations are more stable across sampling firms in the *entire* period than in the period *after* the first oil crisis.

In fact, in the period *after* the first oil crisis, we can improve the explanatory power of the implicit contract hypothesis by increasing the number of sampling firms.[14] Table 3 lists the results estimated in the period *after* the first oil crisis using all of the available sampling firms. These estimates support the implicit contract hypothesis more strongly than the estimates in Table 2. On the other hand, since the coefficient of relative risk aversion of the VAR(W/P^c) equation is as significant at the 1% level as that of the VAR(W) equation, the results in Table 3 do not serve to determine whether the VAR(W/P^c) equation fits the data better than the VAR(W) equation.

Nevertheless, we can state that increasing the number of sampling firms suffers the loss of the test power for distinguishing between the real and the nominal implicit contract hypothesis. This is because cross-section

variances (such as the differences between firms in wage adjustments) become

large as the number of sampling firms becomes greater.

Tables 4 and 5 give the estimated results using standard deviations as

a measure of cyclical variations in our estimating equations. The columns

$\sigma (W)$, $\sigma (W/P^c)$, and $\sigma (W/P^w)$ correspond to the VAR(W), the VAR(W/P^c), and

the VAR(W/P^w) equation, respectively. Table 4 presents the results

throughout 1965-1983 whereas Table 5 lists the results in the period *after*

the first oil crisis. We confine the estimations of Table 5 to the smaller

set of sampling firms because the larger set of sampling firms yielded great

cross-section variances. The estimates in these two tables broadly verify

the tendencies observed in Tables 1-3. In particular, it is found that the

VAR(W/P^c) equation is more fitted to data than the other equations.

In all of these estimations, the parametric restriction test of the

coefficient of VAR(y) provides evidence against the implicit contract

hypothesis.[15] However, as argued in the previous section, some

disequilibrium factors or measurement errors in each variable permit the

coefficient of VAR(y) to be much less than unity. This consideration

suggests that the result of the parametric restriction test does not

constitute a resounding rejection of the implicit contract hypothesis. In

addition, the insignificant levels of the VAR(W/P^c) equation are broadly

smaller than those of the other two equations in this parametric restriction

test.

To sum up, our empirical evidence suggests that, in the Japanese labor

market, the implicit contract hypothesis is not rejected by real wage

movements deflated by the consumer price index. It also indicates that the

first oil crisis changed the structure of the Japanese labor market:

Implicit contract relations arranged in real terms are verified in the

period *after* the first oil crisis, whereas this finding is not observed in the period *before* the first oil crisis.

The structural change of the Japanese labor market due to the first oil crisis can be interpreted as follows. During the period 1965-1973, a high rate of growth characterizes the Japanese economy. Throughout the period, the Japanese labor market faced excessive excess demand, and so observed wages reflected the favorable conditions alone.[16] Thus cyclical fluctuation in observed wages is much smaller in the period 1965-1973 than in the other periods. However, variances of wages observed among sampling firms are considerably alike if cyclical wage fluctuation for each firm is rather small. Thus, *before* the first oil crisis, it is difficult to estimate our empirical equations with cross-sectional data on firms. In contrast, after the first oil crisis, there is a structural decline in the growth rate; and so the era of over-full employment ends. Cyclical fluctuation in wages for each firm then becomes greater because incessant excess demand of the labor market does not exist. The difference between the estimated results of the two subperiods can be explained as a result of this change in the pattern of cyclical wage fluctuation.

7-5. Concluding Remarks

This chapter has tested the implicit contract hypothesis using microeconomic data in the Japanese labor market. The empirical observations show (i) that the implicit contract hypothesis in real terms is not rejected by data and (ii) that the tendency is more strongly verified *after* than

before the first oil crisis. This finding suggests that a certain degree of

wage rigidity is viewed as an efficient response of the market to

undesirable risks. It also gives evidence that, in the Japanese economy,

real disturbances have more impacts on output and employment levels than

nominal disturbances.

We conclude this chapter by suggesting a number of limitations and

possible extensions of the present analysis. First, our estimating

equations may be derived from a collective bargaining hypothesis if

management's bargaining power improves when financial condition of the firm

deteriorates and risky assets increase in its total portfolio. Then the

estimating results in the present chapter can be explained by both the

implicit contract hypothesis and the collective bargaining hypothesis.[17]

Thus it is fairly interesting to develop an empirical method which can

distinguish between these two hypotheses. Second, in this chapter, we

assume that the contracting approach is applied to wage determination but

not to employment determination. Thus, some readers would wonder if the

neglect of employment may bring out our results. Unfortunately, it is

difficult to check this problem because employment data for each firm—in

particular, work hours data—are not acceptable in the Japanese labor

market. Indeed, using both the wage and the work hours equations with

aggregate macroeconomic data, Osano and Inoue (1991) has tested a dynamic

implicit contract model, and have obtained the results which support the

dynamic implicit contract model. Third, the prominant features of the labor

market can be explained by several theories other than the implicit contract

theory. In fact, Weiss (1980) and Shapiro and Stiglitz (1984) succeed in

establishing the possibility of an unemployment equilibrium by viewing wage

rates to be a kind of incentive inducing mechanism. This asymmetric

information problem will have to be incorporated into future extensions.[18]

Data Appendix

In this appendix, we define the variables referred to in the text. All these variables are used as the mean or variance of their annual observations over the estimation periods.

(1) W: Firm's nominal wage payment per worker.

   W = (Firm's labor expense including pension and retirement expense at

       the end of the firm's fiscal year)/(Number of firm's ordinary

       workers at the end of the firm's fiscal year).

   W* = W adjusted with a time trend factor.

(2) P^c: Consumer price index at the end of the firm's fiscal year (P^c = 100

       at 1980).

(3) P^w: Wholesale price index at the end of the firm's fiscal year (P^w = 100

       at 1980).

(4) FRA: Degree of relative risk aversion of the firm.

   FRA = (Firm's liquid assets at the end of the firm's fiscal year)

       /[(Firm's liquid assets at the end of the firm's fiscal year) –

       (Firm's cash and deposits at the end of the firm's fiscal

       year)][19].

(5) FPR: Firm's earnings per worker prior to the interest and the tax

       payment.

   FPR = (Firm's earnings prior to the interest and the tax payment at the

end of the firm's fiscal year)/(Number of firm's ordinary workers at the end of the firm's fiscal year).

(6) Y: Firm's net income per worker prior to the wage payment.

Y = [(Firm's earnings prior to the interest and the tax payment at the end of the firm's fiscal year) + (Firm's labor expense including pension and retirement expense at the end of the firm's fiscal year)]/(Number of firm's ordinary workers at the end of the firm's fiscal year).

Y^* = Y adjusted with a time trend factor.

Data source: Nihon Keizai Shinbun Inc., Needs-Financial Data File.

Notes

1.   In the past few years, Bellante and Link (1982) and Brown (1982) have
developed empirical tests for the implicit contract theory. Bellante and
Link suggest that risk averse workers choose jobs which offer lower wages
and lower financial risk. Although their estimation equation is not
necessarily derived from the optimal behavior of firms and workers, their
estimates in the US labor market seem to support the implicit contract
hypothesis. On the other hand, Brown carries out a more rigorous test based
on the firm's maximization behavior. He finds evidence that, other things
being equal, variations of wage rates are smaller than those of the marginal
product of labor. Besides these two studies, the literature of the wage
indexation and the efficient contracting model provides other examples of
empirical tests for the contract hypothesis. See Cousineau, Lacroix, and
Bilodeau (1983), Card (1983)(1986), Brown and Ashenfelter (1986),
MaCurdy and Pencavel (1986), and Svejnar (1986).

2.   The extent of wage rigidity in the Japanese labor market can be
calculated from the ratio of the *standard deviation of the firm's value
added* to the *standard deviation of the firm's wage payment* if the annual
time series data of these two figures are adjusted with time trend. The
ratios calculated among sampling firms for the period from 1965 to 1983
average out at 5.04 for nominal values, 5.69 for real values deflated with
the consumer price index, and 5.36 for real values deflated with the
wholesale price index. The data for calculating these ratios are taken from
the Needs-Financial Data File (see note 13).

3.   We can also discuss the differences between the macroeconomic
implications of the equilibrium business cycle and the implicit contract

model using the timing and the persistence effect advocated in Clark and Summers (1982). The timing effect is identical with the effect attributed to the intertemporal substitution in labor supply. The persistence effect is due to frictions and specificity of employment relationship, thus generating persistence of employment. Since the same presumptions as the persistence effect underlie the implicit contract model, the presence of implicit contracts involves the persistence effect. Clark and Summers suppose an economy in which the government undertakes unexpected expansionary policies. The initial impact of the change is an increase in employment irrespective of whether the timing or the persistence effect predominates. However, these two effects have the exact opposite implications for the long-run effects of unexpected expansionary policies. If the timing effect is predominant, employment after the shock will be less than it would have been had the shock never occurred. This is because individuals wish that a large proportion of their lives in the labor force is scheduled to coincide with periods of maximum opportunity. In contrast, if the persistence effect prevails, short-run increases in employment will tend to persist because of factors such as habit information, adjustment costs, or human capital accumulation. For detailed arguments, see Clark and Summers (1982).

4. Our estimation approach is mainly based on Osano and Tsutsui (1985)(1986), who test the implicit contract hypothesis in the bank loan market. For the empirical literature of employment and wage adjustments in the Japanese labor market, see Shimada, Hosokawa, and Seike (1982), Muramatsu (1983), Ono (1985), Ohashi (1985), Ohtake (1985), and Hanai (1986). In particular, Ohtake supports the disequilibrium hypothesis whereas Hanai rejects the equilibrium business cycle hypothesis.

5. See Gray (1976) and Fischer (1977). This issue is also concerned with the recent macroeconomic investigation on whether rigidity is realized in terms of real or nominal wages. See Sachs (1979), Branson and Rotemberg (1980), Gordon (1982) and Grubb, Jackman and Layard (1983). These researches state that, in countries with nominal-wage rigidity, expansionary policy can reduce the real wage and thus increase the aggregate supply; on the other hand, in real-wage countries, it cannot. Furthermore, using the results estimated with aggregate time series data, these studies determine which countries are in which category of wage rigidity. For a criticism on such approaches, see Ueda and Yoshikawa (1983).

6. The utility function for the labor union can be of the form

$$E(U) = \int_{P-}^{P+} NU(w(P))g(P)dP. \tag{N1}$$

As long as N is state independent, both specifications lead to the same empirical specification if the definition of relative risk aversion of the labor union is slightly modified.

7. In the rest of this chapter, we will use expression "at state P" to denote "When a random variable equals P".

8. $y(P)$ = (sales) — (cost of materials) — (interest payments)

$\qquad\qquad$ + (profits of inventories) — (tax on profits).

9. Specifically, we remove a linear time trend from the wage movement as follows:

$$w_t = \alpha_0 + \alpha_1 \cdot t + \varepsilon_t, \tag{N2}$$

where t is the time and ε_t the disturbance term. VAR(w) is then computed

from the variance of ε_t. A similar procedure is also applied to the computation of VAR(y).

10. See note 9.

11. See note 9.

12. The industries are as follows: mining; construction; food; textiles; paper; chemicals; medicines; petroleum; rubber; glass, stone and clay; iron and steel; non-ferrous metals; machinery and equipment; electrical machinery; ships; automobiles; transportation equipment; and precision machinery and equipment.

13. The Needs-Financial Data File is constructed from financial data on all nonfinancial corporations listed on the Tokyo Securities Exchange, compiled annually at the end of fiscal years 1965-1983 as *Nikkei Electronic Data Bank System, Nikkei Financial Data*. For most of the listed corporations, this data file does not include data on labor expense *before* 1970. Thus the number of available sampling firms is greater *after* 1975 than *before* 1974.

14. The difference between the results of Tables 2 and 3 may stem from the fact that the average scale of sampling firms is larger in Table 2 than in Table 3. Large scale firms are less likely to stabilize their profits through wage contracts because they have easy access to the capital market. If this is the case, in large-scale sampling firms, the variances of wages may not greatly be related with our explanatory variables. The estimates in Tables 2 and 3 may verify these tendencies.

15. We employ the F-test to test the parametric restriction of the coefficient of log VAR(y). An F-statistic is defined by

$$F = \frac{(A - B)/k}{B/N}, \qquad (N3)$$

where A is the sum of squares of the residuals in the regression with the restriction imposed, B the sum of squares of the residuals in the regression without the restriction imposed, k the number of restrictions, and N the degree of freedom of B. Under the null hypothesis, the F-statistic is distributed as an $F(k, N)$ distribution.

16. See Kosai (1981) and Hamada and Kurosaka (1984).

17. We thank one of the anonymous referees of Journal of the Japanese International Economies for suggesting this point.

18. The recent work of Krueger and Summers (1988) has carried out this line of research.

19. Although firms have real assets, most of these assets are not easily marketable. Thus, when calculating FRA, we restrict our attention to liquid assets.

Table 1

Estimates of the Variance Equations

in the Years 1965–1983

(t-values in parentheses)

Independent Variable (Variance)	VAR(W)	VAR(W/P^c)	VAR(W/P^w)
Constant Term (a_0)	-2.489 (-5.447**)	-2.861 (-5.512**)	-2.487 (-5.073**)
Relative Risk Aversion of the Firm (FRA)	2.478 (1.719*)	3.330 (2.058**)	3.213 (2.097**)
Firm's Profit per Worker (FPR)	-0.072 (-0.418)	-0.270 (-1.445)	-0.145 (-0.834)
Variance of Firm's Net Income per Worker prior to the Wage Payment (VAR(Y))	0.481 (5.980**)	0.550 (6.391**)	0.486 (6.021**)
R^2	0.509	0.437	0.450
r^2	0.449	0.366	0.381
F	8.468	6.141	6.475

Notes: Number of observations = 179
** Significant at the 5% level.
* Significant at the 10% level.

Table 2

Estimates of the Variance Equations

in the Years 1975-1983 (1)

(t-values in parentheses)

Independent Variable (Variance)	VAR(W)	VAR(W/P^c)	VAR(W/P^w)
Constant Term (a_0)	-3.268 (-5.825**)	-3.242 (-5.947**)	-2.467 (-5.101**)
Relative Risk Aversion of the Firm (FRA)	2.106 (1.298)	2.873 (1.816*)	2.759 (1.963*)
Firm's Profit per Worker (FPR)	-0.207 (-1.229)	-0.134 (-0.809)	0.112 (0.740)
Variance of Firm's Net Income per Worker prior to the Wage Payment (VAR(Y))	0.488 (6.671**)	0.473 (6.734**)	0.384 (5.580**)
R^2	0.387	0.397	0.465
r^2	0.308	0.318	0.394
F	4.891	5.032	6.584

Notes: Number of observations = 165
** Significant at the 5% level.
* Significant at the 10% level.

Table 3

Estimates of the Variance Equations

in the Years 1975-1983 (2)

(t-values in parentheses)

Independent Variable (Variance)	VAR(W)	VAR(W/P^c)	VAR(W/P^w)
Constant Term (a_0)	-3.588 (-15.838**)	-3.310 (-15.069**)	-2.550 (-12.982**)
Relative Risk Aversion of the Firm (FRA)	1.464 (2.355**)	1.269 (2.104**)	1.058 (1.970*)
Firm's Profit per Worker (FPR)	-0.046 (-0.678)	-0.056 (-0.810)	0.051 (0.810)
Variance of Firm's Net Income per Worker prior to the Wage Payment (VAR(Y))	0.405 (12.145**)	0.398 (12.270**)	0.324 (10.486**)
R^2	0.310	0.330	0.385
r^2	0.294	0.315	0.371
F	19.653	21.471	27.146

Notes: Number of observations = 936
** Significant at the 5% level.
* Significant at the 10% level.

Table 4

Estimates of the Standard Deviation Equations

in the years 1965-1983

(t-values in parentheses)

Independent Variable (Standard Deviation)	σ (W)	σ (W/P^c)	σ (W/P^w)
Constant Term (a_0)	-1.004 (-4.244**)	-1.292 (-4.910**)	-1.104 (-4.443**)
Relative Risk Aversion of the Firm (FRA)	1.277 (1.649*)	1.650 (1.971*)	1.600 (2.014**)
Firm's Profit per Worker (FPR)	0.110 (1.276)	-0.049 (-0.535)	0.006 (0.070)
Standard Deviation of Firm's Net Income per Worker prior to the Wage Wage Payment (σ (Y))	0.302 (3.654**)	0.495 (5.456**)	0.424 (4.997**)
R^2	0.444	0.404	0.417
r^2	0.376	0.329	0.343
F	6.515	5.358	5.641

Notes: Number of observations = 179
    ** Significant at the 5% level.
    * Significant at the 10% level.

Table 5

Estimates of the Standard Deviation Equations

in the Years 1975-1983

(t-values in parentheses)

Independent Variable (Standard Deviation)	$\sigma(W)$	$\sigma(W/P^c)$	$\sigma(W/P^w)$
Constant Term (a_0)	-1.507 (-5.121**)	-1.523 (-5.420**)	-1.087 (-4.331**)
Relative Risk Aversion of the Firm (FRA)	0.904 (1.072)	1.270 (1.565)	1.285 (1.768*)
Firm's Profits per Worker (FPR)	-0.080 (-0.904)	-0.061 (-0.713)	0.087 (1.115)
Standard Deviation of Firm's Net Income per Worker prior to the Wage Payment ($\sigma(Y)$)	0.423 (5.587**)	0.444 (6.055**)	0.328 (4.515**)
R^2	0.341	0.369	0.430
r^2	0.257	0.286	0.355
F	4.015	4.455	5.715

Notes: Number of observations = 165
   ** Significant at the 5% level.
   * Significant at the 10% level.

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Chapter 8

Testing between Competing Models of Real Business Cycles

8. Testing Between Competing Models of Real Business Cycles

8-1. Introduction

A business cycle phenomenon is typically found in time-series data on employment and real wages. According to the data of almost all developed countries, employment fluctuations are considerably greater than wage fluctuations. Many recent economic studies have attempted to explain this phenomenon. Most of these studies fall into the equilibrium business cycle theory in which business cycles are the result of individual agents optimizing in a competitive environment. Among the most famous early examples of such a theory are the rational expectations-general equilibrium models of Lucas (1972) and Barro (1976) which stress the role of nominal shocks in the presence of imperfect information. More recently, the predominant equilibrium business cycle theory has been the real business cycle model of Kydland and Prescott (1982), Long and Plosser (1983) and King and Plosser (1984) which emphasizes the importance of real shocks to production technology.

Real business cycle theory considers a model economy populated by a single infinitely-lived individual with given initial resources, production possibilities and tastes. The representative individual chooses a preferred consumption-production plan and the resulting allocation is Pareto optimal. The implications of real business cycle theory are thus derived from the Pareto optimal equilibrium allocation as calculated from the planning problem of a "social planner" or representative agent. A policy implication of this theory is that monetary policy has no significant effect on output. In this view, observed money-output relations are the consequences of responses of the monetary shock to output fluctuations brought about by random real shocks to technology.

Since real business cycle models characterize equilibrium prices and
quantities by solving the social planning problem, the resulting Pareto optimal
equilibria must be decentralized. The usual way of decentralizing Pareto
optimal equilibria is to use spot competitive markets. Thus, real business
cycle models are typically based on the intertemporal substitution of leisure
to account for large fluctuations in employment with small fluctuations in real
wages. This idea, often called the intertemporal substitution theory, stems
from the fundamental contribution of Lucas and Rapping (1968). Their basic
hypothesis is that leisure is easily substitutable across periods so that
individuals are willing to supply a large amount of labor effort in periods
with high wages. If this is true, then small transitory movements in perceived
real wages can have large effects on the path of labor supply.

The ability of the intertemporal substitution theory to explain observed
fluctuations in employment and real wages thus heavily depends upon the
presence of strong substitutability in labor supply across periods. Thus the
empirical literature on the intertemporal substitution theory has focused on
the estimation of the elasticity of intertemporal substitution in labor supply.
However, almost all of these studies find that the elasticity of intertemporal
substitution in labor supply is very low.[1] This finding implies that the
intertemporal substitution theory has difficulty in explaining the observed
fluctuations in employment and real wages.

The foregoing arguments suggest the necessity to develop other lines of
research for decentralizing Pareto optimal equilibria generated by the real
business cycle model.[2] Recent work by Sargent (1979, Chapter 16, p.376), Rosen
(1985) and Wright (1988) shows that long-term contracts can support precisely
the same dynamic quantity allocation as can be supported by spot markets in

labor. Their long-term contract model—which we will call the efficient long-term contract model from now on—differs from the long-term contract model of Fischer (1977) and Taylor (1979) in that contracting parties consider not only wage but also employment determination in the contract negotiation.[3,4]

The basic idea of the efficient long-term contract theory is that employment is long-term and current wages are nothing more than installment payments on a long-term obligation. This idea is concerned with the following two aspects of the contractual relation between firms and workers. First, as argued by Baily (1974) and Azariadis (1975), firms are usually less risk averse than workers and thus have an incentive to insure workers against wage fluctuations by means of intertemporal risk-sharing arrangements. Second, as pointed out by McDonald and Solow (1981), firms and workers bargain over wages and employment under the presence of high separation costs, search costs, and training costs. Wages then have a role as an internal distribution parameter according to which organizational rents are distributed. This finding suggests that within bilateral bargaining situations, wages do not necessarily vary with employment. These two aspects imply that wage stickiness can arise from intertemporal risk-sharing or intertemporal bilateral bargaining arrangements between firms and workers under the efficient long-term contract theory.

This chapter will explore the empirical properties of the efficient long-term contract model as an alternative to the intertemporal substitution model in accounting for large fluctuations in employment with small fluctuations in real wages.[5] The theoretical implications of the efficient long-term contract model suggest that real business cycle theory can be consistent with the observed cyclical fluctuations in employment and real wages even if the intertemporal substitution elasticity of labor supply is low.

We will use aggregate Japanese data to test the efficient long-term contract model against the intertemporal substitution model. In Japan, most labor agreements are characterized by permanent employment and are negotiated in a synchronized manner during the spring wage offensive (Shunto). As long as management and workers evaluate their agreements over a long-run horizon, we predict that the efficient long-term contract hypothesis provides a solid basis for understanding the movements of employment and real wages in the Japanese economy.[6]

This chapter is organized as follows. The next section first reviews the intertemporal substitution theory based on a standard model of life-cycle labor supply and then displays the efficient long-term contract theory built on a dynamic efficient contracting model. However, unlike the standard real business cycle model, we focus on the labor market and do not specify the complete general equilibrium models. The theoretical argument reveals that the intertemporal substitution model is nested within the efficient long-term contract model if labor input is adjusted by means of work-sharing alone. Section 8-3 develops a testing method for distinguishing between these two models. Section 8-4 tests the efficient long-term contract model against the intertemporal substitution model using aggregate Japanese data. The results support the efficient long-term contract model, whereas the intertemporal substitution model is rejected. The final section offers some concluding remarks.

8-2. Theory

In this section, we discuss the formal relation between the intertemporal substitution model and the efficient long-term contract model. We begin by

presenting the basic structure of the two models.

The per capita production function of a representative firm at period t is:

(1) $\qquad Y_t = F_t(L_t, K_t, u_t)$,

where L_t is per capita labor supply to the firm at t, K_t is the per capita real stock of capital at the beginning of t, and u_t is a random variable at t. It is assumed that F_t is increasing and concave in L_t and K_t. The per capita profits of the firm after payments to capital owners and workers in period t are

(2) $\qquad \pi_{ft} = [P_tF_t(L_t, K_t, u_t) - W_tL_t - (1 + R_t + \eta_t)P_tK_t]$,

where P_t is the price of the firm's output at t, W_t is the nominal wage rate at t, η_t is the rate of depreciation of capital at t, and R_t is the price of capital which is equal to the nominal return from holding a security between t-1 and t.

There is a representative infinitely-lived consumer-worker, who derives pleasure from consumption and leisure, and whose utility function is stationary and additively separable over time.[7] His expected discounted lifetime utility, V_0, is then

(3) $\qquad V_0 = E_0[\sum_{t=0}^{t=\infty} \rho^t \cdot U(C_t, L_t)]$.

Here, E_0 is an expectation operator conditional on information available at the initial period; ρ is a constant discount factor; C_t is real consumption at t; L_t is labor effort at t; and U is increasing in C_t, decreasing in L_t, and concave in C_t and L_t.

Taking a series of labor supply $[L_t; 0 \leq t \leq \infty]$ as given, we can characterize the optimal consumption-saving decision of the consumer-worker. To this end, we must introduce the budget constraint faced by the consumer-worker. Let us suppose that the consumer-worker has access to some financial assets which can be both bought and sold, and that he receives a dividend π_{dt} out of the firm's profits π_{ft}. We also assume that the consumer-worker does not face any quantity constraints in the labor and product markets. With these assumptions, the budget constraint of the consumer-worker in period t is

(4) $P_t C_t + A_t \leq W_t L_t + \pi_{dt} + (1 + R_t) A_{t-1}.$

Here, A_t is the nominal value of assets possessed by the consumer-worker at the end of period t. Given a value of initial assets A_{-1} and a series of $[P_t, W_t, R_t, L_t, \pi_{dt}; 0 \leq t \leq \infty]$, the consumer-worker chooses a contingency plan for $[C_t, A_t: 0 \leq t \leq \infty]$ to solve the following maximization problem:

(5) $\underset{C_t, A_t}{\text{Max}} \quad E_0[\sum_{t=0}^{t=\infty} \rho^t \cdot U(C_t, L_t)],$

        subject to (4).

We now present the intertemporal substitution and the efficient long-term contract models by concentrating upon the labor market.[8] From now on, we designate the former as the ITS model and the latter as the ELC model.

To formulate the ITS model, we need to determine the demand for labor by the firm and the supply of labor of the consumer-worker. We begin by examining the demand for labor by the firm. Within the framework of the intertemporal substitution theory, the labor market is competitive, and the firm continuously maximizes its single-period profits. Thus the demand for labor by the firm is

determined by the marginal productivity condition:

(6) $W_t = P_t \cdot \partial F_t / \partial L_t.$

Dividing equation (6) by its counterpart in period t+1, taking expectations (as

of t), and rearranging, we have the following dynamic marginal productivity

condition:[9]

(7) $E_t [\dfrac{W_{t+1}/P_{t+1}}{W_t/P_t} - \dfrac{\partial F_{t+1}/\partial L_{t+1}}{\partial F_t/\partial L_t}] = 0,$

where E_t is an expectation operator conditional on information available at

period t.

We next determine the supply of labor of the consumer-worker in the ITS

model. In the ITS model, the supply of labor of the consumer-worker is

simultaneously determined along with his consumption-saving plan. More

specifically, taking a value of initial assets A_{-1} and a series of $[P_t, W_t, R_t,$

$\pi_{dt}; 0 \leqq t \leqq \infty]$ as given, the consumer-worker chooses a contingency plan for

$[C_t, L_t, A_t: 0 \leqq t \leqq \infty]$ to solve the following maximization problem:

(8) $\underset{C_t, L_t, A_t}{Max} \quad E_0 [\overset{t=\infty}{\underset{t=0}{\Sigma}} \rho^t \cdot U(C_t, L_t)],$

       subject to (4).

The first-order conditions of the solution for maximization problem (8) can be

written in the following form:[10]

(9) $\dfrac{W_t}{P_t} \dfrac{\partial U/\partial C_t}{\partial U/\partial L_t} = -1,$

$$(10) \quad E_t[\rho \, \frac{\partial U/\partial C_{t+1}}{\partial U/\partial C_t} \, \frac{P_t(1 + R_{t+1})}{P_{t+1}}] - 1 = 0,$$

$$(11) \quad E_t[\rho \, \frac{\partial U/\partial L_{t+1}}{\partial U/\partial L_t} \, \frac{W_t(1 + R_{t+1})}{W_{t+1}}] - 1 = 0.$$

Equation (9) is the static substitutable relation of consumption to labor supply at period t. The Euler equation for consumption, (10), states the substitutable relation of consumption between period t and period t+1. The Euler equation for labor supply, (11), expresses the substitutable relation of labor supply between period t and period t+1. Note that either Euler equation (10) or (11) is redundant if (9) holds exactly in all periods.

For our empirical analysis, we need to transform equation (9). Dividing equation (9) at t+1 by its counterpart at t and taking expectations as of t, we can replace (9) with the following Euler equation:[11]

$$(12) \quad E_t[\frac{W_{t+1}}{W_t} \, \frac{P_t}{P_{t+1}} \, \frac{\partial U/\partial C_{t+1}}{\partial U/\partial C_t} \, \frac{\partial U/\partial L_t}{\partial U/\partial L_{t+1}}] - 1 = 0.$$

The ITS model is then described by the dynamic marginal productivity condition, (7), and the Euler equations derived from the dynamic optimization of the consumer-worker, (10), (11) and (12).

We next turn to characterizing the ELC model. Let us consider a model in which the firm offers a long-term contract to the consumer-worker. The long-term contract the firm offers is drawn up in the initial period when the states of nature in the present and future periods are unknown, and specifies wage-employment policies conditional on the set of available information at t, I_t. Thus, the contract can be represented by the vector, $[W_t(I_t), L_t(I_t); 0 \leq t \leq$

∞], where $W_t(I_t)$ is the nominal wage rate at t conditional on I_t and $L_t(I_t)$ the per worker labor input at t conditional on I_t. To simplify notation, we simply will write W_t and L_t rather than $W_t(I_t)$ and $L_t(I_t)$.

Before proceeding to the specification of the ELC model, we need to derive the optimal consumption-saving decision of the consumer-worker in the ELC model given a contract. This decision will be a solution to maximization problem (5). Solving (5) and substituting the resulting optimal contingency plan for consumption back into $E_0[\sum_{t=0}^{t=\infty} \rho^t \cdot U(C_t, L_t)]$, we obtain the following indirect lifetime utility function:

(13) $V_0 = V(\{W_t\}_{t=0}^{t=\infty}, \{L_t\}_{t=0}^{t=\infty}; A_{-1}, \{R_t\}_{t=0}^{t=\infty}, \{P_t\}_{t=0}^{t=\infty}, \{\pi_{dt}\}_{t=0}^{t=\infty})$.

The function V_0 is increasing in W_t, decreasing in L_t, and concave in W_t and L_t because the direct utility function U is increasing in C_t, decreasing in L_t, and concave in C_t and L_t. Given the first-order conditions for maximization of (5), the partial derivatives of the indirect lifetime utility function are:

(14) $\partial V_0/\partial W_t = \lambda_t L_t = [P_t]^{-1} \rho^t \cdot [\partial U/\partial C_t]L_t,$

(15) $\partial V_0/\partial L_t = \rho^t \cdot \partial U/\partial L_t,$

where λ_t is the nonnegative multiplier associated with constraint (4) at period t. The first equality in (14) follows from Roy's identity and the second equality in (14) comes from the efficiency conditions for maximization of (5).

We next proceed to specify the contract offer of the firm by exploiting the indirect lifetime utility function V_0. Given (2), the expected value of the discounted sum of the per capita profits accruing from the contract offer

$[W_t, L_t; 0 \leq t \leq \infty]$ is[12]

$$(16) \qquad \Gamma_0 = \pi_{f0} + E_0 \{ \sum_{t=1}^{t=\infty} [\prod_{i=1}^{i=t} (1 + R_i)^{-1}] \pi_{ft} \}.$$

The firm desires to maximize (16) with respect to its contract offer subject to the constraint that the indirect utility function V_0 of the worker at least matches a reservation utility, V^*. In general, V^* is determined by dynamic bilateral bargaining between the firm and the consumer-worker or from alternative wages available to the consumer-worker. However, it is rather complicated to discuss the determination process of V^*, so that we will regard V^* as exogenously given. Taking $[A_{-1}, V^*, P_t, R_t, K_t, \pi_{dt}; 0 \leq t \leq \infty]$ as given, the problem the firm faces is to choose a sequence of $[W_t, L_t; 0 \leq t \leq \infty]$ to solve

$$(17) \quad \underset{W_t, L_t}{\text{Max }} \Gamma_0 = P_0 F_0(L_0, K_0, u_0) - W_0 L_0 - (1 + R_0 + \eta_0) P_0 K_0$$
$$+ \sum_{t=1}^{t=\infty} \{ [\prod_{i=1}^{i=t} (1+R_i)^{-1}][P_t F_t(L_t, K_t, u_t) - W_t L_t - (1+R_t+\eta_t) P_t K_t] \},$$

subject to

$$(18) \qquad V_0 = V(\{W_t\}_{t=0}^{t=\infty}, \{L_t\}_{t=0}^{t=\infty} ; A_{-1}, \{R_t\}_{t=0}^{t=\infty}, \{P_t\}_{t=0}^{t=\infty}, \{\pi_{dt}\}_{t=0}^{t=\infty}) \geq V^*.$$

Solving maximization problem (17) and using (14) and (15), the first-order conditions are

$$(19) \qquad \gamma_t = \zeta [P_t]^{-1} \rho^t \cdot \partial U / \partial C_t,$$

$$(20) \qquad \gamma_t P_t \cdot \partial F / \partial L_t = - \zeta \rho^t \cdot \partial U / \partial L_t,$$

where $\gamma_t = \prod_{i=1}^{i=t} (1 + R_i)^{-1}$; and ζ is the nonnegative multiplier associated

with constraint (18). Combining (19) and (20) yields

$$(21) \quad \frac{\partial U/\partial C_t}{\partial U/\partial L_t} \partial F_t/\partial L_t + 1 = 0.$$

Rewriting (19) and (20) in intertemporal form leads to

$$(22) \quad E_t[\rho \frac{\partial U/\partial C_{t+1}}{\partial U/\partial C_t} \frac{P_t(1 + R_{t+1})}{P_{t+1}}] - 1 = 0,$$

$$(23) \quad E_t[\rho \frac{\partial U/\partial L_{t+1}}{\partial U/\partial L_t} \frac{\partial F_t/\partial L_t}{\partial F_{t+1}/\partial L_{t+1}} \frac{P_t(1 + R_{t+1})}{P_{t+1}}] - 1 = 0.$$

Note that either (22) or (23) is redundant if condition (21) holds exactly. As has been shown in the ITS model, the static equation, (21), expresses the substitutable relation of consumption to labor input at period t. The Euler equation for consumption, (22), is the substitutable relation of consumption between period t and t+1. The Euler equation for labor input, (23), states the substitutable relation of labor input between period t and t+1.

For later empirical analysis, we transform (21)—as we have transformed (9) into (12)—to arrive at the following Euler equation:[13]

$$(24) \quad E_t[\frac{\partial U/\partial C_{t+1}}{\partial U/\partial C_t} \frac{\partial U/\partial L_t}{\partial U/\partial L_{t+1}} \frac{\partial F_{t+1}/\partial L_{t+1}}{\partial F_t/\partial L_t}] - 1 = 0.$$

The ELC model now consists of the system of equations (22), (23), and (24). Note that wages do not necessarily equal the marginal product of labor in the ELC model because the dynamic marginal productivity condition (7) need not be satisfied.

We now explore the formal relation between the ELC model and the ITS

model. For this purpose, we rearrange the ITS model by substituting dynamic marginal productivity condition (7) into (11) and (12):

$$(11') \quad E_t[\rho \, \frac{\partial U/\partial L_{t+1}}{\partial U/\partial L_t} \, \frac{\partial F_t/\partial L_t}{\partial F_{t+1}/\partial L_{t+1}} \, \frac{P_t(1 + R_{t+1})}{P_{t+1}}] - 1 = 0,$$

$$(12') \quad E_t[\frac{\partial U/\partial C_{t+1}}{\partial U/\partial C_t} \, \frac{\partial U/\partial L_t}{\partial U/\partial L_{t+1}} \, \frac{\partial F_{t+1}/\partial L_{t+1}}{\partial F_t/\partial L_t}] - 1 = 0.$$

Note that (11') and (12') are identical with (23) and (24), respectively. Furthermore, equation (10) is identical with equation (22). These findings show that the system of equations (7), (22), (23), and (24) also describes the ITS model. Thus we can nest the ITS model within the ELC model when the ITS model is characterized by (7), (22), (23) and (24).

8-3. Estimation Framework

In this section, we first present the nonlinear regression equations of the ELC and the ITS models by specifying preferences of the consumer-worker and production technology of the firm. We then develop a testing method to compare how these two models fit the data.

The utility function we use is an additively separable one in consumption and labor supply:

$$(25) \quad U(C_t, L_t) = \alpha^{-1} \cdot (C_t)^{\alpha} - \beta^{-1} \cdot (L_t)^{\beta}.$$

The functional form provides for the possibility of different degrees of intertemporal substitution in consumption and labor supply: $(1 - \alpha)^{-1}$ and $(\beta - 1)^{-1}$ represent the elasticity of intertemporal substitution in consumption

and in labor supply respectively. These two indexes reflect how the consumer-worker adjusts consumption and labor supply in response to anticipated changes in wages over his life-cycle. It is assumed that $0 \neq \alpha < 1$ and $1 < \beta$ because U is increasing in C, decreasing in L, and concave in C and L.

The production technology of the firm is Cobb-Douglas:

$$(26) \qquad F_t(L_t, K_t, u_t) = \theta_0 \cdot \exp(\delta t + u_t)(L_t)^{\sigma} \cdot (K_t)^{1-\sigma} .$$

Here, θ_0 is a positive constant term, δ is the rate of technical progress, σ is the substitution rate between capital and labor, and u_t is the period t real shock to the firm's production technology.[14] Since F_t is increasing and concave in L_t and K_t, it is assumed that $0 < \sigma < 1$.

We now rearrange the ELC and the ITS models using the specific functional forms (25) and (26). We first reformulate the ELC model by substituting (25) and (26) into (22), (23), and (24). Then, taking natural logarithms of both sides of these equations yields

$$(27) \qquad \Delta \ln C_{t+1} + \frac{1}{\alpha - 1} \ln(1 + R_{t+1}) - \frac{1}{\alpha - 1} \Delta \ln P_{t+1} + \frac{\ln \rho}{\alpha - 1} = \xi_{1,t+1},$$

$$(28) \qquad \Delta \ln L_{t+1} + \frac{1 - \sigma}{\sigma - \beta} \Delta \ln K_{t+1} - \frac{1}{\sigma - \beta} \ln(1 + R_{t+1})$$

$$+ \frac{1}{\sigma - \beta} \Delta \ln P_{t+1} - \frac{- \delta + \ln \rho}{\sigma - \beta} = \xi_{2,t+1},$$

$$(29) \qquad \Delta \ln L_{t+1} + \frac{\alpha - 1}{\sigma - \beta} \Delta \ln C_{t+1} + \frac{1 - \sigma}{\sigma - \beta} \Delta \ln K_{t+1} + \frac{\delta}{\sigma - \beta} = \xi_{3,t+1}.$$

Here, Δ denotes the difference operator, that is, $\Delta \ln C_{t+1} = \ln C_{t+1} - \ln C_t$; $\xi_{1,t+1} = \varepsilon_{1,t+1}$; $\xi_{i,t+1} = \varepsilon_{i,t+1} - [1/(\sigma - \beta)] \cdot \Delta u_{t+1}$ ($i = 2, 3$); and $\varepsilon_{i,t+1}$ is a random variable ($i = 1, 2, 3$).

We next rewrite the ITS model by substituting (25) and (26) into (7), (22), (23), and (24), and then taking natural logarithms of both sides of these equations. Then the ITS model is represented by (27), (28) and (29) plus the following equation:

$$(30) \quad \Delta \ln \frac{W_{t+1}}{P_{t+1}} + (1 - \sigma) \, \Delta \ln L_{t+1} - (1 - \sigma) \Delta \ln K_{t+1} - \delta = \xi_{4,t+1},$$

where $\xi_{4,t+1} = \varepsilon_{4,t+1} + \Delta u_{t+1}$ and $\varepsilon_{4,t+1}$ is a random variable.

Some comments on these two equation systems are in order. First, there are nonlinear parametric restrictions across the equations in both systems. In other words, α, β, ρ, δ, and σ appear several times across the equations of each system. Second, the "error terms" ($\xi_{1,t+1}, \ldots, \xi_{4,t+1}$) are made up of (i) prediction errors ($\varepsilon_{i,t+1}$) due to the fact that only a limited subset of information is available,[15] and (ii) real shocks in production technology of the firm (Δu_{t+1}). The latter factor arises from production uncertainty, u_{t+1}, which is assumed to follow a martingale: $\Delta u_{t+1} = v_{t+1}$, where v_{t+1} is independently and identically distributed. Since these two errors are assumed to be serially uncorrelated and uncorrelated with the included instrumental variables, the total error terms ($\xi_{1,t+1}, \ldots, \xi_{4,t+1}$) are also serially uncorrelated and uncorrelated with the included instrumental variables.

We can now discuss a method for testing the ELC and the ITS models. To estimate and test the parameters of these two models, we estimate the parameters of the models using the nonlinear instrumental variables (NIV)

estimators developed by Hansen (1982) and Hansen and Singleton (1982).

Our estimated results then will be evaluated in the following two ways.
First, we check whether the estimates have plausible standard errors and obey
the well-behaved properties of the utility and the production functions; that
is, $0 \neq \alpha < 1$, $1 < \beta$, $0 < \rho < 1$ $(\ln \rho < 0)$, $\delta > 0$ and $0 < \sigma < 1$.
Second, we test the nonlinear parametric restrictions across the equations of
both the ELC and the ITS models using the J-statistic of the overidentifying
restrictions implied by these models. The J-statistic is defined as T times
the minimized value of some criterion function using orthogonality conditions,
where T is the sample size. As shown in Hansen (1982), the J-statistic under
the null hypothesis is distributed asymptotically as chi-square with the
degrees of freedom equal to the difference between the total number of
orthogonality conditions and the number of estimated parameters.

8-4. Empirical Results

In this section, we use quarterly Japanese data from 1965:Q3 to 1985:Q3 to
estimate both the ELC and ITS models. The definitions of the variables are
summarized in the Data Appendix. We use the following set of the instruments
in our estimation:

(31) $Z_{t+1} = [1, \ln (1+R_{t+1}), \Delta \ln P_{t+1}, \Delta K_{t+1},$

$$\Delta \ln (W_t/P_t), \Delta \ln C_t, \Delta \ln L_t].$$

To justify the econometric procedures described in the previous section, we
assume that all the variables entering the estimating equations, including the
instruments, are stationary.[16]

Some data choices deserve comments. First, the yields of Telephone and Telegram Bonds or the yields of *Gensaki* (bond trading with repurchase agreement) are used as a proxy of the nominal interest rate R_{t+1}. Second, bonus payments are excluded from the series of wage payments although our empirical conclusions hold when bonus payments are included. Third, two series of labor hours are used: the total working and the overtime working hours of regular workers in all manufacturing industries. Fourth, the general consumer price index is used as a proxy of the price P_t because our empirical results are not modified by using the wholesale price index. Fifth, durable expenditures as well as nondurable and service expenditures are included in our consumption series because the *quarterly* Japanese data series of aggregate consumption of *workers' households* is not broken down further.[17] However, this does not affect our results when estimating equation (28) alone or estimating the combined subsystem of (28) and (30).

Our empirical analysis proceeds as follows. We first discuss the results of the single-equation test for the ELC model. However, as has already been shown, the ITS and the ELC models share equation (28) if the dynamic marginal productivity condition (30) holds. To determine which model better explains the actual data, we estimate and test the combined subsystem of (28) and (30). Finally, we estimate and test the whole equation systems of both the ELC and the ITS models.

The results of the single-equation test for the ELC model are summarized in Table 1. The term, $-\delta + \ln \rho$, is listed in Table 1 because neither $\ln \rho$ nor δ can be identified separately from (28) alone. The first column reports the estimated values of the parameters of the ELC model when we use total working hours as labor hours and the yields of Telephone and Telegram Bonds

(TTB rate) as the interest rate. The second column presents the estimates when the yields of Telephone and Telegram Bonds are replaced with the yields of *Gensaki*. The coefficient estimates in these two columns are very similar. The parameter estimates of β (the taste parameter of workers in labor supply) and σ (the substitution rate between capital and labor) are plausible and highly significant. However, the parameter value of $-\delta + \ln \rho$, estimated from the constant term of (28), is inconsistent with the theoretical restrictions on the signs of ρ and δ although the standard errors are large.

The implausible estimates of $-\delta + \ln \rho$ can be explained in the following two ways. The first explanation is that the constant term of (28) would reflect the effect of the negative drift in the series of the logarithms of total working hours which is not explained by the model under investigation.[18] To verify this, we estimate the Euler equation in labor supply using overtime working hours in place of total working hours since the series of overtime working hours has no secular trend. The results are in the third column of Table 1. All of the parameter estimates are plausible although the standard error of $-\delta + \ln \rho$ remains large. The second explanation is that the parameters included in the constant term are not identified from aggregate data unless the age structure of the population is changing in a known way and this change is taken into account in the analysis (see Altonji and Ham (1990)). Since our representative agent model does not satisfy this requirement of identification, this could be causing the implausible estimates of $-\delta + \ln \rho$.

The bottom row of Table 1 gives a test statistic for the overidentifying restrictions implied by the Euler equation in labor supply. In all three cases, the overidentifying restrictions of the Euler equation in labor supply cannot be rejected.

We next turn to testing the ITS model represented by the subsystem of (28) and (30). As a preliminary test, we first estimate the dynamic marginal productivity condition (30) separately. The results are reported in the top half of Table 2. The first column contains the estimated values when total working hours are used for the labor hours variable whereas the second column lists the estimates when overtime working hours are used instead. In both cases, the production-substitutability parameter σ is significantly greater than unity, which contradicts the theoretical restriction on the production function.

The results when the dynamic marginal productivity condition (30) is estimated separately lead us to expect that the ITS model consisting of the subsystem (28) and (30) will have trouble explaining the cyclical movements of employment and real wages. This conjecture is verified in the bottom half of Table 2. For any combination of working hours variable and the interest rate variable, the production-substitutability parameter σ is highly significant and greater than unity, which contradicts the theoretical restriction on the production function. Furthermore, the overidentifying restrictions of the ITS model are rejected at the 0.5 % level in all cases.

We now consider the results for the whole equation systems of both the ELC and the ITS models. We first estimate the equation systems exclusive of (27) because (27) can be derived from (28) and (29). However, even though the other two equations fit the actual data well, it seems unlikely that (27) holds exactly in every period. Thus we next estimate the whole equation systems of both the ELC and the ITS models inclusive of (27). In the following estimation, we restrict our attention to the case in which total working hours are used as labor hours and the yields of Telephone and Telegram Bonds as the

interest rate.

Table 3 displays the results for the whole equation systems exclusive of (27). The first column presents the estimates of the ELC model, and the second column reports the estimates of the ITS model.

For the ELC model, all of the parameter estimates except δ are plausible. The estimates of the taste parameters of consumer-workers, α and β, ensure that the utility function (25) is well-behaved. Furthermore, the estimated value of α is significant at the 1 % level. The estimated discount rate per quarter, ρ, and the estimated substitution rate between capital and labor, σ, also satisfy their theoretical restrictions although the standard errors are large. Furthermore, the implausible (negative) estimate of δ can again be explained by the fact that it is estimated from the constant terms and thus its estimate is affected by both the negative drift in the series of the logarithms of total working hours and the change in the age structure of the population. The J-statistic for the test of the overidentifying restrictions of the ELC model, J(9), does not provide strong evidence against the ELC model: The overidentifying restrictions of the ELC model are not rejected at the 2.5% level.

For the ITS model, the results in the second column in Table 3 again contradict the theoretical restriction on the production function because the parameter estimate of σ is significant and greater than unity. The estimated value of the discount rate, ρ, is also inconsistent with its theoretical restriction. Furthermore, the overidentifying restrictions of the ITS model are strongly rejected at the 0.5% level.

Table 4 presents the results for both the ELC and the ITS models inclusive of the Euler equation in consumption. The parameter estimates of the ELC model

except ln ρ in Table 4 are plausible. This again indicates that the parameters derived from the estimated constant terms are unstable because of both the negative drift found in the series of the logarithms of total working hours and the change in the age structure of the population.

The second column of Table 4 shows that in the ITS model the estimate of the production-substitution parameter, σ, does not violate the theoretical restriction on the production function. Thus the parameter estimates in Table 4 with the exception of ln ρ provide little evidence against the ITS model. However, the overidentifying restrictions of the ITS model are strongly rejected at the 0.5% level; on the other hand, the overidentifying restrictions of the ELC model are not rejected at the 2.5% level. This constitutes a resounding rejection of the ITS model in favor of the ELC model.

The averaging involved in seasonal adjustment might disturb our results. To check this, we estimate both the ELC and the ITS models with fiscal half year data because Japanese fiscal half year data are free from some of the main causes of seasonal adjustment. The estimates can verify the basic tendency found in the results estimated with quarterly data.[19]

The large J-statistics and subsequent rejection of the ITS model reported in Tables 2-4 may be the result of the misspecification of the dynamic marginal productivity condition (30) in the ITS model. It may be misspecified because there exist scale economies in production or because product markets are monopolistically competitive. To check this possibility, we take this as the alternative hypothesis and test it against the null hypothesis that (30) is valid. These hypotheses are tested using the test statistic developed by Eichenbaum, Hansen and Singleton (1988, Appendix C). In Tables 2-4, the value of this statistic is denoted by C(n). The values of C(n) suggest that the

large J-statistics of the ITS model in Tables 2-4 are due to the inconsistency between the parameter values generated by the ITS model and by the dynamic marginal productivity condition.

However, this does not necessarily imply that the ITS model exclusive of (30) is consistent with the data, since the ITS model is nested within the ELC model only in the presence of (30). To explore this further, we estimate the "structural" ITS model using (10)-(12) with (25) and (26).[20,21] The results of the estimation of this model are presented in Table 5. The first column of Table 5 reports the estimates of the single equation test using the Euler equation in labor supply, (11). The second column lists the estimates of the subsystem made up of (10) and (11). The third column contains the results using the whole equation system of the structural ITS model.

The estimates in the second column of Table 5 show that neither the estimated taste parameter of consumer-workers in consumption, α , nor the estimated production-substitution parameter, σ , are economically plausible. Furthermore, the overidentifying restrictions are rejected at the 0.5% level in the second and the third columns of Table 5. Only the estimates of the single equation test in the first column of Table 5 are consistent with the restrictions of the ITS model although (i) the elasticity of intertemporal substitution in labor supply, $1/(\beta - 1)$, is very low, and (ii) both the negative drift in the series of the logarithms of total working hours and the change in the age structure of the population distort the sign of the discount factor, ρ . However, the single equation test of the ITS model is not very meaningful since wage determination cannot be accounted for by (11) alone.

To summarize, our estimations and tests provide evidence that observed fluctuations in aggregate employment and real wages in the Japanese economy are

characterized by the efficient long-term contract model, but not by the
intertemporal substitution model.

8-5. Conclusion

This chapter has tested the efficient long-term contract model against the
intertemporal substitution model using aggregate Japanese data. The tests
indicate that the efficient long-term contract model is consistent with the
data, but the intertemporal substitution model is not. This suggests that
cyclical movements of aggregate employment and real wages in the Japanese
economy arise from intertemporal risk sharing or intertemporal bilateral
bargaining arrangements between firms and workers. Our results also provide
some evidence in favor of the real business cycle model with long-term
contracts. This observation may improve our ability to explain the good
performance of macroeconomic adjustment of the Japanese economy in spite of the
absence of competitive spot labor markets.

This chapter has only begun to touch on the implications of dynamic
efficient contracting models for macroeconomic questions and could be extended
in several directions. For example, the efficient long-term contract model of
this chapter does not allow the firm to lay off its workers. However, there
are a number of reasons why layoff decisions are worth investigating (see
Alogoskoufis (1988)). Thus it would be promising to develop a dynamic
efficient contracting model in which the firm can layoff its workers.

Data Appendix

(1) R_{t+1}: Series (i) Yields of Telephone and Telegram Bonds between t and t+1 taken from the *Monthly Statistics Report*. Series (ii) Yields of *Gensaki* between t and t+1 taken from the *Monthly Statistics Report*.

(2) P_t: General consumer price index taken from the *Monthly Report of Retail Prices*.

(3) K_t: Real capital stock per worker $= K_t^N/(N_t P_t^I)$.

   N_t: Number of workers employed in all manufacturing industries taken from the *Quarterly Reports of Incorporated Enterprises Statistics*.

   K_t^N: Depreciable asset in all manufacturing industries taken from the *Quarterly Reports of Incorporated Enterprises Statistics*. K_t^N is calculated as a book value.[22]

   P_t^I: Wholesale price index for investment goods taken from the *Price Indexes Monthly*.

(4) W_t: Cash earnings of regular workers in all manufacturing industries taken from the *Monthly Labor Survey*. Bonus payments are excluded from W_t.

(5) C_t: Real Consumption per worker $= C_t^N/P_t$.

   C_t^N: Living expenditures of worker's households taken from the *Monthly Report on the Family Income and Expenditure Survey*. Transfers are excluded from C_t.

(6) L_t: Series (i) Total working hours of regular workers in all manufacturing industries taken from the *Monthly Labor Survey*. Series (ii) Overtime working hours of regular workers in all manufacturing industries taken from the *Monthly Labor Survey*.

All data are seasonally adjusted and available from the authors upon request.

the intertemporal labor supply model. Their empirical evidence casts doubt on the usefulness of either the intertemporal contracting model or the intertemporal labor supply model. However, their analysis differs in several respects from the analysis of this chapter: (1) Their Euler equation system is approximated by the linearized reduced form, so that nonlinear estimation is avoided; (2) Their attention is focused on the movements of working hours and wage earnings, and not on the movements of working hours and consumption; (3) Longitudinal data are used instead of aggregate data; (4) The productivity of worker is regarded as exogenous because their production function is linear in labor input.

6.   The bilateral bargaining model does not necessarily exclude highly flexible wages although the wage implied by the bilateral bargaining model does not follow the marginal productivity condition. Thus, we still can use the bilateral bargaining model to model the movements in employment and real wages in the Japanese economy even though wage fluctuations are relatively great in Japan.

7.   Some recent studies have estimated a model of life-cycle labor supply and consumption with nontime-separable preferences. See Eichenbaum, Hansen and Singleton (1988) and Hotz, Kydland and Sedlacek (1988).

8.   It is straightforward to extend these two models into a general equilibrium framework. However, to keep matters simple, we do not pursue the strategy here. Since we focus on the labor market, we will not use the Euler equation for capital stock in our empirical analysis.

9.   In the subsequent sections, our equation systems are estimated using the Euler equation method developed by Hansen (1982) and Hansen and Singleton (1982). The estimator of this method to be asymptotically consistent requires

the variables to be stationary. Transforming (6) into (7) satisfies this

requirement.

10.   The optimum path is assumed to be attained at an interior solution.

11.   See note 9. The necessity for rewriting (9) also arises from the

stochastic singularity between real wages, hours worked and consumption. The

nontime-separable preferences approach of Eichenbaum, Hansen and Singleton

(1988) and Hotz, Kydland and Sedlacek (1988) does not suffer from this problem.

12. $\prod_{i=1}^{i=t} (1+R_i)^{-1} = [(1+R_1)\cdots(1+R_t)]^{-1}$. The optimum path is assumed to be

attained at an interior solution.

13.   See note 11.

14.   If $x_t = \exp(\delta t + u_t)$, then x_t has the time series representation

$x_t = x_{t-1}\exp(\lambda_t)$, where $\lambda_t = \delta + u_t - u_{t-1}$. Since $\triangle u_t = u_t - u_{t-1}$ is

assumed to be independently and identically distributed with mean zero, λ_t is

a serially uncorrelated iid process with mean δ.

15.   The estimated equations possibly include only a limited subset of

information, so that there may be some predicted lagged variables which are not

incorporated in the regression, but are observed by the individual. The

effects of these predicted lagged variables are reflected in the error terms.

By definition, the factors of the error terms are uncorrelated with the

included instrumental variables.

16.   Using the regression equation $\ln R_t = a_0 + a_1 \ln R_{t-1} + a_2 t + u_t$, we test

the presence of a stochastic trend ($a_1 = 1$) and a deterministic linear trend

($a_2 \neq 0$) of the logarithms of the nominal interest rate series. For the

yields of Telephone and Telegram Bonds, $a_1 = 1$ is rejected at the 1 % level

whereas $a_2 = 0$ is not rejected at the 5 % level. For the yields of *Gensaki*, a_1

= 1 is rejected at the 1 % level whereas $a_2 = 0$ is not rejected. Thus, the

logarithms of the nominal interest rate series can be viewed as stationary.

17. Horie (1985) constructs a *yearly* consumption data series of *workers'*
households consisting of consumption expenditures on services and nondurables
plus the value of service flows from consumer durables. Ogawa, Takenaka and
Kuwata (1986) also make a similar *quarterly* consumption data series of *all*
households. These two data series, however, are inadequate for our purpose
because we must use a *quarterly* consumption data series of *workers' households*.

18. The negative trend in the series of total working hours originates from a
change in individual preferences to leisure or of employment practice. If this
negative trend has a substantial effect on the constant term of (28), the
parameter value estimated from the constant term is imprecise.

19. In Japan, bonus payments are almost always made twice a year, once in the
summer (in June or July) and once at the end of year (in December). Seasonal
extra expenditures— *Ochugen* in July and *Oseibo* in December— are also made in a
similar way. Since the Japanese fiscal year is from April 1 to March 31 in the
next year, the use of fiscal half year data eliminates some of the main causes
of seasonal adjustment. The estimated results are available from the authors
upon request.

20. Using aggregate US data, the ITS model made up of (10)-(12) is estimated
in Mankiw, Rotemberg and Summers (1985) with time-separable preferences, and in
Eichenbaum, Hansen and Singleton (1988) with nontime-separable preferences. In
both papers, their conclusion is similar to ours.

21. We also find substantial evidence against both the subsystem of (10) and
(12) and the subsystem of (11) and (12).

22. Using market replacement values for K_t does not make substantial
differences in the estimated results.

Table 1

Estimates of the Euler Equation in Labor Supply, (28)

	Total Working Hours and TTB Rate	Total Working Hours and Gensaki Rate	Overtime Working Hours and TTB Rate
$-\delta + \ln \rho$	0.0037 (0.0066)	0.0052 (0.0064)	-0.0017 (0.0131)
β	5.2535 (0.6820)	5.1617 (0.6488)	2.5247 (0.5700)
σ	0.5153 (0.1778)	0.5246 (0.1723)	0.5751 (0.3575)
$J(4)$ [*]	2.287 [$J(4, 50) = 3.357$]	1.563 [$J(4, 75) = 1.923$]	7.346 [$J(4, 10) = 7.779$]

Notes: Standard errors of the parameter estimates are given in parentheses. The well-behavedness of the utility function implies $0 < \rho < 1$ ($\ln \rho < 0$) and $1 < \beta$. The well-behavedness of the production function requires $0 < \delta$ and $0 < \sigma < 1$.

[*] $J(4)$ is a test of the overidentifying restrictions embodied in the model, asymptotically distributed as $\chi^2(4)$ under the null hypothesis. $J(4, x)$ shows that $J(4)$ is critical at the x% level; in other words, if $J(4)$ is smaller than $J(4, x)$, overidentifying restrictions cannot be rejected at the x% level.

Table 2

(a) Estimates of the Dynamic Marginal Productivity Condition, (30) [*]

	Total Working Hours	Overtime Working Hours
δ	0.0123 (0.0032)	0.0109 (0.0031)
σ	1.2338 (0.0812)	1.0966 (0.0561)
J(5) [**]	1.336 [J(5, 90) = 1.610]	1.517 [J(5, 90) = 1.610]

(b) Estimates of the ITS Model Represented by the Subsystem of (28) and (30)

	Total Working Hours and TTB Rate	Total Working Hours and Gensaki Rate	Overtime Working Hours and TTB Rate
ln ρ	0.0100 (0.0692)	0.0115 (0.0684)	0.0049 (0.1172)
β	5.5843 (5.6516)	5.4263 (5.3031)	2.9538 (5.6003)
δ	0.0107 (0.0281)	0.0106 (0.0283)	0.0108 (0.0276)
σ	1.0607 (0.5972)	1.0543 (0.5906)	1.0797 (0.4889)
J(10) [**]	61.48 [J(10, 0.5) = 25.19]	57.08 [J(10, 0.5) = 25.19]	67.43 [J(10, 0.5) = 25.19]
C(5) [***]	59.19 [C(5, 0.5) = 16.75]	55.52 [C(5, 0.5) = 16.75]	60.08 [C(5, 0.5) = 16.75]

Notes: See the footnote in Table 1.
* TTB rate is used as R_{t+1} in the instrumental variables.
** J(n) is a test of the overidentifying restrictions embodied in the model, asymptotically distributed as $\chi^2(n)$ under the null hypothesis. J(n, x) shows that J(n) is critical at the x% level; in other words, if J(n) is smaller than J(n, x), the overidentifying restrictions cannot be rejected at the x% level.
*** C(5) is a misspecification test of dynamic marginal productivity condition (30), asymptotically distributed as $\chi^2(5)$. C(5, x) shows that C(5) is critical at the x% level; in other words, if C(5) is smaller than C(5, x), the null hypothesis cannot be rejected against the alternative hypothesis at the x% level.

Table 3

Estimates of the ELC and the ITS Models
(Based upon the System Exclusive of (27))

	ELC Model	ITS Model
$\ln \rho$	-0.0005 (0.0985)	0.0073 (0.0462)
α	0.9731 (0.1612)	0.8913 (0.1440)
β	18.7028 (27.9943)	9.9457 (6.4343)
δ	-0.0215 (0.2840)	0.0097 (0.0271)
σ	0.1277 (5.2227)	1.0055 (0.4737)
$J(n)$ [*]	17.23 [J(9, 2.5) = 19.02]	114.0 [J(16, 0.5) = 34.27]
$C(7)$ [**]		96.77 [C(7, 0.5) = 20.28]

Notes: See the footnote in Table 1. The well-behavedness of the utility function implies $0 \neq \alpha < 1$. Total working hours are used as labor hours and TTB rate as the interest rate.

[*] J(n) is a test of the overidentifying restrictions embodied in the model, asymptotically distributed as $\chi^2(9)$ under the ELC model and $\chi^2(16)$ under the ITS model. J(n, x) shows that J(n) is critical at the x% level; in other words, if J(n) is smaller than J(n, x), the overidentifying restrictions cannot be rejected at the x% level.

[**] C(7) is a misspecification test of dynamic marginal productivity condition (30), asymptotically distributed as $\chi^2(7)$. C(7, x) shows that C(7) is critical at the x% level; in other words, if C(7) is smaller than C(7, x), the null hypothesis cannot be rejected against the alternative hypothesis at the x% level.

Table 4

Estimates of the ELC and the ITS Models
(Based upon the System Inclusive of (27))

	ELC Model	ITS Model
ln ρ	0.0103 (0.0742)	0.0087 (0.0453)
α	0.8364 (0.0590)	0.8444 (0.0527)
β	10.0683 (9.4334)	8.4619 (4.5133)
δ	0.0005 (0.1561)	0.0098 (0.0269)
σ	0.3827 (2.7471)	0.9873 (0.4229)
J(n) *	27.71 [J(16, 2.5) = 28.85]	127.38 [J(23, 0.5) = 44.18]
C(7) **		99.67 [C(7, 0.5) = 20.28]

Notes: See the footnote in Table 3.
* J(n) is a test of the overidentifying restrictions embodied in the model, asymptotically distributed as $\chi^2(16)$ under the ELC model and $\chi^2(23)$ under the ITS model. J(n, x) shows that J(n) is critical at the x% level; in other words, if J(n) is smaller than J(n, x), the overidentifying restrictions cannot be rejected at the x% level.
** C(7) is a misspecification test of dynamic marginal productivity condition (30), asymptotically distributed as $\chi^2(7)$. C(7, x) shows that C(7) is critical at the x% level; in other words, if C(7) is smaller than C(7, x), the null hypothesis cannot be rejected against the alternative hypothesis at the x% level.

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Table 5

Estimates of the ITS Model
(Based upon the System of Equations (10)-(12))

	(11)	(10) and (11)	(10)-(12)
ln ρ	0.01229 (0.01026)	0.01979 (0.1436)	0.01569 (0.07353)
α	-------	1.426 (9.702)	-2.0542 (4.392)
β	8.292 (1.187)	32.77 (59.85)	27.49 (41.87)
J(n) [*]	1.983 [J(5, 75) = 2.675]	66.18 [J(11, 0.5) = 26.76]	102.88 [J(18, 0.5) = 37.16]

Notes: See the footnote in Table 3.
[*] J(n) is a test of the overidentifying restrictions embodied in the model, asymptotically distributed as $\chi^2(n)$ under the null hypothesis. J(n, x) shows that J(n) is critical at the x% level; in other words, if J(n) is smaller than J(n, x), the overidentifying restrictions cannot be rejected at the x% level.

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