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# Monitoring Cost, Agency Relationship, and Equilibrium Modes of Labor Contract[#/]

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## 1. Introduction

In this paper, we investigate why and how different modes of economic relations arise in a labor market when work incetive is a crucial factor in the labor management. Among various economic relations of potential theoretical interests, we shall focus upon the length of the labor contracts (short-term versus long-term labor contracts) and the existence of involuntray unemployment. To our knowledge, no attempt has been made to analyze these two aspects of labor market explicitly, yet simultaneously. By doing so, we will obtain several interesting implications; particularly multiplicity of Nash equilibria.

Several papers have studied the micro-economic foundations of persistent unemployment. When one attempts to explain persistent involuntary unemployment, it is crucial to show that firms do not lower wage level (or utility level) even if the wage (utility) they offer is higher than the market wage (utility). Salop [1979] argues that, when training costs are borne by firms, firms may find it profitable to offer above the market wage level in order to dicscourage turnover of workers who find their job attributes less satisfactory. Weiss [1980] offers another explanation: if firms must offer the same wage to heterogeneous workers, a reduction of the offered wage may turn away more able workers who have higher reservation wages even when the market wage drops down. In this paper, we shall utilize the notion developed by Calvo [1979] (also used for a different context in Calvo and Wellisz [1978], [1979]) and later elaborated by Shapiro and Stiglitz [1984], Bowles [1985] and Bulow and Summers[1986].)

Suppose firms monitor randomly chosen workers to check whether their job performances satisfy the job requirement. Suppose further that a worker will be dismissed when he is found working unsatisfactorily.[1/] Then, because workers can obtain the market utility even when he is dismissed, firms must offer a utility level higher than what market guarantees in order to create a proper work incentive. Different from Calvo, Shapiro-Stiglitz and others, we shall use this incentive mechanism as a vehicle to explain not only the existence of involuntary unemployment but also the desirability of long-term labor contracts by explicitly introducing contracts as firms' strategy choice. We shall also diverge from them by explicitly introducing an additional penalty to shirked workers; a worker who is discovered shirking will be dismissed without the payment of wage in that period.

An implicit assumption behind this is that a firm can withhold wage payment and terminate employment contract of its worker only if it can verify to a third party (judge) that the worker has shirked. Because of this assumption, a firm cannot terminate employment of its entire labor force without wage payment by falsely claiming that all workers have shirked. Verifiability assumption thus eliminates the possibility of both employee's and employer's manipulation. The assumption of verifiability can be replaced by reputation of firms.

There have been many papers which dealt with the problem of long-term labor contract, explicitly or implicitly. The line of research originated by Azariadis [1975] and Baily [1974] is a promiment example which explains the superiority of long-term contracts using the difference in risk attitudes between employers and employees. The existence of training costs, that of learning by doing, and the problem of incentive which gives rise to seniority wage schedule (e.g., Lazear [1979a]) also make long-term contracts desirable. However, the reason that the long-term labor contract is advantageous in our set-up is quite different from those cited above.

When it is profitable for firms to create utility differnce between their employees and outside workers, it is also profitable to guarantee long-term labor contracts to their employees. This is so because, in order to create the same utility difference, firms can save wage cost per period by offering long-term contacts.

In the following, however, we shall show that it is not always optimal for firms to offer long-term labor contracts. If, by competition, firms are paying sufficiently high wage, workers will work according to the instruction even if monitoring is less frequent[2/] and no utility difference exists, because losing the wage payment of that period when dismissed is a large enough threat to workers.

We shall formulate a model of labor market which will cope with both involuntary unemployment and the length of labor contracts. It will be shown that a different type of equilibrium may emerge depending upon the parameters of the economy; one Nash equilibrium of this market takes the form of a full-employment equilibrium with short-term labor contracts, while another equilibrium is characterized by long-term labor contracts accompanied by involuntary unemployment. We shall also identify factors which will affect the mode of euilibrium labor contracts. In particular, we shall show that when (i) unemployment compensation is smaller, (ii) worker's productivity is higher, or (iii) monitoring is less costly, then the full-employment equilibrium (with short-term contracts) becomes more likely to prevail.

Finally, by introducing the age (or work-experience) as a part of firm's recruitment strategy, we shall show that this economy always has another type of Nash equilibrium: that is, this economy has multiple Nash equilibria. When firms hire only new workers (new college graduates), workers will work conscientiously because they fear that they may not be able to obtain new jobs once they are dismissed. All the workers will find jobs when they enter the labor market and will spend their lives in the firm they first enterend. Therefore, there is no older workers who will solicit for new jobs, which in turn will confirm firm's belief that offering jobs only to new workers is the most profitable strategy. This equilibrium is consistent with the observation that, in Japan, both the natural rate of unemployment and the rate of labor turnover are substantially lower than the corresponding rates in other countries, and the normal employment practice is that of lifetime employment.

In section 2, the model is formulated. Section 3 analyzes properties of the optimal labor contracts. In section 4, the first type of Nash equibrium is proved to exist and its properies analyzed. In section 5, the second type of Nash equilibrium with the different recruitment strategy is analyzed and compared to the equilibrium in section 4. Section 5 concludes the paper.

## 2. Economy

We consider an extremely simplified economy where all firms (the number of which may vary over time) are identical, producing a homogeneous output and labor being the only resource necessary for production. This output is the only commodity in the economy used for consumption and as monitoring input.

We assume that each individual firm employs, by technological reasons, either N (presumably a large integer) workers or none. This assumption of indivisibility of labor input is made for the simplicity of exposition.

When a firm employs N workers, output per worker, y, is a function of work-effort intensity ($e \varepsilon R_+$) at which an average worker chooses to work, i.e., $y=f(e)$. We assume:

<u>A.1</u> (a) f is continuous and strictly increasing in e,

(b) $f(0)=0$.

Individual work-effort intensity, e, is not observable by firms (output is observed only in aggregate terms and work-effort intensity of a single worker cannot be inferred from this observation) unless firms invest in monitoring activity. By spending $c(\pi)$ (units of the output) per worker in monitoring activity in one period, a firm can identify the effort intensity of $\pi$ fraction of its employees in the period, i.e., it can identify the effort of $\pi N$ workers.[3/] From a worker's viewpoint, he may be monitored in the period with probability $\pi$. We assume:

<u>A.2</u> (a) $c(0) \geq 0$.

(b) c is continuous and strictly increasing in $\pi$ on [0,1].

By <u>A.2</u>, monitoring is impossible without positive input and monitoring is costly.

For the sake of simplicity, workers are assumed to live an infinite number of periods. Moreover, a flow of new workers is added to the existing labor pool in every period so that the total labor pupulation increases at the rate of $\gamma>0$. In each period, there are an infinite number of workers of various generations living in this economy. Workers have the identical von Neumann-Morgenstern lifetime utility function $\Sigma_{t=1}^{\infty} \beta^{t-1} u(q_t, e_t)$ where $\beta \varepsilon (0,1)$

is the discount factor, u is the instantaneous (one-period) N-M utility function, $q_t$ is the amount of consumption in period t, and $e_t$ is the effrot intensity in period t. We assume:

<u>A.3</u> (a) u(q,e) is continuous and concave.

(b) u(q,e) is increasing in q and decreasing in e, and u(0,0)=0.

Since individual work-effort intensity, e, can be neither costlessly observed nor freely inferred, an efficient mode of labor contract must be designed to provide a proper incentive for a worker to work conscientiously.[4/] [5/] Such labor contracts, in general, fall into two different categories, i.e., a short-term labor contract and a long-term labor contract.[6/]

A short-term labor contract (STLC, for short) is a pair, $(\hat{w},\hat{e})$, secifying conditional wage payment (in units of output), $\hat{w}\varepsilon R_+$, and effort requirement, $\hat{e}\varepsilon R_+$, in a certain period. At the end of this period, firm that offered this contract is obliged to pay $\hat{w}$ to the worker who has accepted it unless the firm uncovers that the worker did not work at the effort level of at least $\hat{e}$ (i.e., that the worker <u>shirked</u>). If, by monitoring, firm uncovers the worker's shirking, it dismisses him without paying any wage at all.[7/] If either the worker worked satisfactorily or the firm does not uncover the worker's shirking, it must conclude that the worker's work performance was satisfactory and pay $\hat{w}$ to him. Regardless of the worker's performance, STLC ceases to be in effect at the end of the period.

A long-term labor contract (LTLC) is a pair, $(\hat{w},\hat{e})\varepsilon R_+^2$, such that the firm is obliged to renew the contract, $(\hat{w},\hat{e})$, in each succesive period unless the firm uncovers the worker's shirking. If his shirking is uncovered in a certain period, he will be dismissed from the firm without receiving his wage, $\hat{w}$, in that period and the contract will be terminated. From the worker's viewpoint, a LTLC guarantees a secure employment and steady wage payments of $\hat{w}$ provided that he works at the level of at least $\hat{e}$ in every period. If he works at the level of less than $\hat{e}$, he must chance losing his contract and thereby losing the steady income.

A firm's strategy, then, is a quadruple $(\hat{w},\hat{e},I,\pi)$ in $R_+^2\times\{L,S\}\times[0,1]$ where L indicates that the contract to be a LTLC while S indicates it to be a STLC. The level of $\pi$ will be assumed to be common knowledge and the firm is assumed to maintain this level because of its reputation. Henceforth, we sometimes refer a triplet, $(\hat{w},\hat{e},I)$, as a contract.

Throughout the paper we assume that the employed workers have no source of income other than wage. Unemployed workers, however, are eligible for unemployment compensation, $C\geq0$. We also assume, for the sake of simplicity, that the capital market is incomplete and workers can neither borrow nor lend.[8/] Hence employed worker's consumption must coincide with his wage received in each period and unemployed worker's consumption is C. Unemployed workers, therefore, will receive utility of $u(C,0)=u_C\geq0$ in each period.

Holding a (long-term) contract, a worker's behavior (namely choosing the desired effort level) depends upon the type of contracts available outside the firm and the probability of obtaining such an outside contract upon losing his current contract. More precisely, a worker's choice of effort level depends upon the level of expected life-time utility, $u_M/(1-\beta)$, available for a worker who has lost the contract. We call this level the expected market utility.

## 3. Optimal Contract

Consider a worker who has accepted a STLC of $(\hat{w},\hat{e})$ in period t=1. The only relevant choice for him is either to work at the effort level of $\hat{e}$ or to work at the level of zero. For if he decided to work at the level of at least $\hat{e}$, he would not gain any extra income by working at levels exceeding $\hat{e}$. On the other hand, if he decided to shirk (i.e., to choose $e<\hat{e}$), the probability of losing the wage payment would be the same regardless of the choice of his effort level. Noting that his expected instantaneous utility is $(1-\pi)u(\hat{w},0)$ when he chooses the effort level of zero, his optimal choice of e, $e^*(\hat{w},\hat{e},S,\pi;u_M)$, must be;

$$(1)\quad e^*(\hat{w},\hat{e},S,\pi;u_M) = \begin{cases} \hat{e} & \text{if } u(\hat{w},\hat{e})\geq(1-\pi)u(\hat{w},0) \\ 0 & \text{otherwise.} \end{cases}$$

When $u(\hat{w},\hat{e})=(1-\pi)u(w,0)$, he is actually indifferent between choosing $\hat{e}$ and 0. It is our assumption, however, that he always chooses $\hat{e}$ in this case. Although $e^*$ is independent of $u_M$ for STLC, we shall include $u_M$ as an argument of $e^*$ for the conveniece of notation.

Next, consider a worker who has accepted a LTLC of $(\hat{w},\hat{e})$. If he works at $e=\hat{e}$ throughout his life, his expected life-time utility will be $u(\hat{w},\hat{e})/(1-\beta)$. On the other hand, if he works at e=0 and the firm chooses $\pi$ as its monitoring ratio in each period while he is employed, his expected life-time utility will be $\rho(\pi)[(1-\pi)u(\hat{w},0)+\frac{\beta\pi}{1-\beta}u_M]$ where $\rho(\pi)=1/[1-\beta(1-\pi)]$. In this expression, $\rho(\pi)$ is the present discounted value operator for receipts of one util for each period contingent upon the contract being held at the beginning of the period. In each period that he holds the contract at the beginning of the period, he receives the utility of $u(\hat{w},0)$ if he escapes monitoring (with probability $1-\pi$), and he loses the contract and obtains the lifetime utility of $\frac{\beta}{1-\beta}u_M$ (0 utility in the period and $u_M$ next period on, with probability $\pi$). Thus, the optimal choice of e, $e^*(\hat{w},\hat{e},L,\pi;u_M)$, must be:

$$(2)\quad e^*(\hat{w},\hat{e},L,\pi;u_M) = \begin{cases} \hat{e} & \text{if } \frac{1}{1-\beta}u(\hat{w},\hat{e}) \geq \rho(\pi)[(1-\pi)u(\hat{w},0)+\frac{\pi\beta}{1-\beta}u_M] \\ 0 & \text{otherwise.} \end{cases}$$

We now consider how firms design the optimal labor contract and choose the optimal monitoring ratio for the purpose of maximizing their profit. If the contract is $(\hat{w},\hat{e},I)$, the monitoring ratio is $\pi$, and the market utility level is $u_M$, then any firm finds its profit per worker per period to be:

$$(3)\quad \begin{cases} f(\hat{e})-\hat{w}-c(\pi) & \text{if } e^*(\hat{w},\hat{e},I,\pi;u_M)=\hat{e} \\ f(0)-(1-\pi)\hat{w}-c(\pi) & \text{if } e^*(\hat{w},\hat{e},I,\pi;u_M)=0. \end{cases}$$

Since f(0)=0, firms can maximize profit only by inducing workers to work at $\hat{e}$. Moreover under our assumption, any worker expects to obtain at least $u_M/(1-\beta)$ life-time expected utility even if he does not hold a contract at the beginning of the current period. Thus, in order to attract any (outside) worker, firms must devise a contract which will yield at least $u_M/(1-\beta)$ expected life-time utility. Hence the problem that firms must solve takes the form of:

$$(4)\quad \underset{(\hat{w},\hat{e},I,\pi)}{\text{maximize}} \quad f(\hat{e})-\hat{w}-c(\pi)$$

$$\text{subject to} \quad \text{(a)}\ e^*(\hat{w},\hat{e},I,\pi;u_M)=\hat{e}$$

$$\text{(b)}\ u(\hat{w},\hat{e},)\geq u_M.$$

We first consider the choice of I; i.e., STLC vs LTLC. The work incentive of these contracts are created by two factors; probability of being sampled and penalty when caught shirking. In the case of LTLC, penalty consists of two factors; the loss of wage payment and the loss of contract itself.

In the case of STLC, penalty is the loss of wage $\hat{w}$ only, and probability of being sampled is $\pi$. The worker who has shirked and caught will receive zero utility. On the other hand when a LTLC is chosen instead, even if firms choose the same sampling ratio ($\pi$) and hence the penalty imposed in the period is the same as the STLC, a worker must risk the possibility of losing the contract itself. Thus if the level of utility he can obtain from outside the firm ($u_M$) is smaller than the level of utility the contract guarantees, the work incentive will be larger for LTLC than for STLC. This can be seen explicitly by rearranging the condition for $e^*(\hat{w},\hat{e},L,\pi;u_M) = \hat{e}$ in (2) as:

$$(2)' \quad e^*(\hat{w},\hat{e},L,\pi;u_M) = \begin{cases} \hat{e} & \text{if } u(\hat{w},\hat{e}) \geq (1-\pi)u(\hat{w},0)-\frac{\pi\beta}{1-\beta}[u(\hat{w},\hat{e})-u_M] \\ 0 & \text{otherwise.} \end{cases}$$

Thus as long as $u(\hat{w},\hat{e})>u_M$, firms can save monitoring cost by offering a LTLC instead of STLC. If $u(\hat{w},\hat{e})=u_M$, however, there is no merit (for firms) of choosing a LTLC. To sum up;

<u>Lemma 1</u>: <u>Let</u> $(\hat{w}^*,\hat{e}^*,I^*,\pi^*)$ <u>solve the problem (4) and</u> $f(\hat{e}^*)-\hat{w}^*-c(\pi^*)\geq 0$. <u>If, at the soultion, (4b) is not binding (i.e., if</u> $u(\hat{w}^*,\hat{e}^*)>u_M$) <u>then the optimal contract</u> $(\hat{w}^*,\hat{e}^*,I^*)$ <u>is a LTLC</u> (<u>i.e,</u> $I^*=L$). <u>If</u>, <u>on the other hand,</u> $u(\hat{w}^*,\hat{e}^*)=u_M$ <u>then the optimal contract can be either L or S.</u>

<u>Proof</u>: Suppose $u(\hat{w}^*,\hat{e}^*)>u_M$, but contrary to the assertion, the optimal contract is a STLC. By supposition (4b) is not binding, and hence (4a) must be binding. Since $I^*=S$ and $I^*\neq L$, (in view of (1) and (2)') both

$$(5) \quad u(\hat{w}^*,\hat{e}^*)=(1-\pi^*)u(\hat{w}^*,0)$$

and

$$(6) \quad u(\hat{w}^*,\hat{e}^*) \leq (1-\pi^*)u(\hat{w}^*,0) - \frac{\beta\pi^*}{1-\beta}[u(\hat{w}^*,\hat{e}^*)-u_M]$$

must hold. By the supposition these two conditions can hold simultaneously only when $\pi^*=0$. From (5), $\hat{e}^*=0$ and hence $\hat{w}^*=0$ by the non-negativity of the profit. Therefore, $u(\hat{w}^*,\hat{e}^*)=u(0,0)=0$ but this contradicts to our supposition that $u(\hat{w}^*,\hat{e}^*)>u_M\geq 0$. Hence $I^*=L$.

To show the second part of the lemma, simply observe that $e^*(\hat{w},\hat{e},S,\pi;u_M) = e^*(\hat{w},\hat{e},L,\pi;u_M)$ when (4b) holds with equality.

By Lemma 1 and its proof, it is evident that a STLC is chosen only when firms are indifferent between a STLC and a LTLC. Therefore, the optimal strategy of firms can be described by the optimal solution of:

$$\text{(7)}\quad \underset{(\hat{w},\hat{e},\pi)}{\text{Maximize}}\quad f(\hat{e})-\hat{w}-c(\pi)$$
$$\text{subject to (a) } e^*(\hat{w},\hat{e},L,\pi;u_M)=\hat{e}$$
$$\text{(b) } u(\hat{w},\hat{e})\geq u_M$$

as long as its solution $(\hat{w}^*,\hat{e}^*,\pi^*)$ provides non-negative profit.

By Lemma 1, the optimal contract is necessarily a LTLC $(\hat{w}^*,\hat{e}^*)$ if (7b) holds with strict inequality. On the other hand, when (7b) holds with equality the optimal contract can take the form of either a LTLC $(\hat{w}^*,\hat{e}^*)$ or a STLC $(\hat{w}^*,\hat{e}^*)$, and firms are indifferent because either contract provides the same profit. For the sake of the simplicity of exposition, we sometimes refer the latter case as when a STLC is optimal.

## 4. Equilibrium

In this section we shall describe an equilibrium situation of the labor market. The notion of equilibrium we are concerned here is that of a long-run steady-state equilibrium with Nash behavior. Namely, we shall consider situations where the following conditions hold; (a) firms are maximizing their profits given other firms' contractual choices, (b) profits obtained are zero so that there is neither entry nor exit, and (c) aggregate employment grows at the rate of $\gamma$, the rate at which the entire population grows.

We first show that the maximum level of profit that a firm can obtain per worker is a decreasing function of the expected utility level prevailing in the (external) market, $u_M$. For this purpose, denote the solution of (7) as $(\hat{w}(u_M),\hat{e}(u_M),\pi(u_M))$[10/] and define $P(u_M)=f(\hat{e}(u_M))-\hat{w}(u_M)-c(\pi(u_M))$ and $u(u_M)=u(\hat{w}(u_M),e(\hat{u}(u_M))$. Let $\alpha = \sup\{u(w,e)|f(e)-w\geq 0\}$ and note $u(C,0)=u_C$. We shall assume that $u_C<\alpha$.

<u>Lemma 2:</u> P <u>is a continuous and non-increasing function on</u> $[u_C,\alpha]$. <u>Moreover,</u> $P(\alpha)<0$.

<u>Proof</u>: Define a set-valued mapping $F:[u_C,\alpha]\rightarrow R^3_+$ as:

$$F(u_M)=\{(\hat{w},\hat{e},\pi)\varepsilon R^3_+|\text{(7a) and (7b) are satisfied}\}.$$

Clearly, $F(u_M)$ has a relative interior for any $u_M\varepsilon[u_C,\alpha)$. Moreover, u, c and $\rho$ are all continuous functions. Hence F is lower hemi-continuous on $[u_C,\alpha]$. F is easily checked to be upper hemi-continuous, and it follows that F is continuous. Since f is continuous, P is continuous in $u_M$ on $[u_C,\alpha]$.

Take any $u_M$, $u_M'\varepsilon[u_C,\alpha]$ such that $u_M'<u_M$. From (2) and (7), if $\pi(u_M)>0$ then $(\hat{w}(u_M),\hat{e}(u_M),\pi(u_M))$ is in $F(u_M')$ and $P(u_M')\geq P(u_M)$ follows immediately. So assume that $\pi(u_M)=0$. Then by (2), $u(u_M)=u(\hat{w}(u_M),\hat{e}(u_M))=u(\hat{w}(u_M),0)$. It follows that $\hat{e}(u_M)=0$ and using the same argument we used in the proof of the first half of Lemma 1, it must contradict to the fact that $u(u_M)\geq u_M>u_C\geq 0$. Hence P is non-increasing for any $u_M$.

Finally, by the definition of $\alpha$, $P(\alpha)<0$.

We now show the existence of a long-run steady-state equilibrium in this econmy. First, consider the case $P(u_C)<0$. By Lemma 2, there is no plan (i.e., contract and monitoring input) which will bring non-negative profit to firms. Hence demand for labor is always zero. Therefore, we assume (excluding the trivial case, $P(u_C) = 0$):

<u>A.4</u> $P(u_C)>0$.

Under <u>A.4</u> if workers expect $u_M=u_C$ to be the level of expected utility when they are out of contracts, firms can obtain positive profit by designing an appropriate contract and choosing a suitable level of monitoring input. Competition in labor market, then, will push up the level of utility for workers, $u(\hat{w},\hat{e})$, above $u_C$.

By Lemma 2, there exists $u_M^*(>u_C)$ such that $P(u_M^*)=0$. Namely, if workers anticipate that they can obtain $u_M^*/(1-\beta)$ level of expected life-time utility when out of contract, firms can obtain only zero profit by choosing the optimal plan $(\hat{w}(u_M^*),\hat{e}(u_M^*),\pi(u_M^*))$. This situation certainly satisfies (a) and (b) of the definition of a long-run steady-state equilibrium. There are two possibilities in view of Lemma 1; when $u(u_M^*)=u_M^*$ and when $u(u_M^*)>u_M^*$.

When $u(u_M^*)>u_M^*>u_C$, by Lemma 1 the equilibrium contract is necessarily a LTLC. However, although workers who hold the equilibrium contract expect to obtain $u(u_M^*)/(1-\beta)$ level of life-time utility, workers who do not hold contracts at the beginning of the period can expect to attatin only $u_M^*/(1-\beta)$ level of life-time utility. This difference must be created by the existence of involuntary unemployment. More specifically, let $\nu\varepsilon[0,1]$ be the ratio of unemployed workers obtaining a new contract in each period. Then:

(8) $u_M^*= \hat{\nu}u(u_M^*)+(1-\hat{\nu})u_C$.

where $\hat{\nu}=\nu/[1-(1-\nu)\beta]$. Clearly $0<\nu<1$. Let the total labor force in period t be $N_t$, and the rate of unemployment be $(1-n)$. Then in period t, $\nu(1-n)N_t$ workers will find a job while there will be an addition of new workers to the unemployment pool, $\gamma N_t$. Hence in period t+1, the number of unemployed workers are:

$$(1-\nu)(1-n)N_t+\gamma N_t=(1-n)N_{t+1}=(1-n)(1+\gamma)N_t, \text{ or}$$

(9) $1-n=\gamma/(\gamma+\nu)>0$.

Therefore, involuntary unemployment must exist even in the long-run.

On the othe hand, when $u(u_M^*)=u_M^*$, the equilibrium contract is either a STLC or a LTLC between which firms are indifferent (i,e., firms have no incentive to choose a LTLC). Moreover, since the level of utility which contracted workers can obtain coincides with the level expected by those workers who hold no contract, full employment must prevail.

To summarize,

Proposition 1: Under A.1-A.4 there exists a long-run steady-state eqilibrium in this economy. This equilibrium is characterized either by the renewal of STLCs with full-employment or by the existence of involuntary unemployment where, in each period, only a fraction of unemployed workers obtain new employment under LTLC.

## 5. Comparative Statics

Whether the equilibrium is of full-employment with the renewal of STLCs or of persistent unemployment with LTLCs depends upon parameters of the economy such as; 1) amount of unemployment compensation; 2) properties of production function, f; 3) properties of monitoring cost function, c. The rate of growth of the population, $\gamma$, does not affect propeties of the long-run equilibrium, as is easily seen from equations (8) and (9). As a matter of fact, if $\gamma$ increases, the rate of growth of the number of firms changes accordingly, leaving unemployment rate and equilibrium mode of labor contract unaffected.

From (8), the level of unemployment compensation must affect only through the change of $u_M$. However, the equilibrium level of expected utility for workers who are out of contract, $u_m^*$, is determined by the technological and utility considerations only (Proposition 1 and arguments behind it). That is, when the level of unemployment compensation C (and hence the associated utility level $u_C$) increases, unemployment rate must increase, in order to create the same level of threat to workers even if the loss of utility $u(u_M^*)-u_C$ is smaller than before.

In order to analyze the effects of a change in other parameters, consider the optimal solution of yet another problem;

(10) Maximize $\underset{(\hat{w},\hat{e},\pi)}{} f(\hat{e})-\hat{w}-c(\pi)$

$$\text{subject to } e^*(\hat{w},\hat{e},L,\pi;u_M)=\hat{e}.$$

The solution for (10) coincides with that of (7), the true problem for firms, only when firms are not constrained by (7b) at the optimal solution of (10). That is, the solution of (7) and (10) are the same only when firms choose a LTLC (over STLC) as the true profit maximizing contract.

To further simplify the problem, assume that:

<u>A.6</u> Utility function for workers, u(w,e) takes the form of w-G(e), where G is increasing and concave in e.

In view of (2') and A.4, the constraint for (10) is equivalent to;

$\hat{w}-G(\hat{e}) \geq (1-\pi)\hat{w}-\frac{\beta\pi}{1-\beta}[w-G(\hat{e})-u_M]$, or equivalently,

$(1-\pi)(1-\beta)G(\hat{e}) \leq \pi[u-\beta u_M]$.

Denoting $\hat{w}-G(\hat{e})=\hat{u}$, then, the problem (10) can be rewritten as;

(10') Maximize $f(\hat{e})-\hat{u}-G(\hat{e})-c(\pi)$

$(\hat{u},\hat{e},\pi)$

subject to $(1-\pi)(1-\beta)G(\hat{e})\leq\pi(\hat{u}-\beta u_M)$.

Assuming (10') has a unique interior solution and functions f, G and c are all differentiable, the optimal solution for (10') must satisfy the following three conditions:

(11a) $\hat{e} = H(\alpha)$,

(11b) $[f'(\hat{e})-G'(\hat{e})]H'(\alpha)\frac{\hat{\pi}}{(1-\beta)(1-\hat{\pi})} = 1$,,

(11c) $\hat{u}-u_M=\hat{\pi}(1-\hat{\pi})c'(\hat{\pi})$.

where H is the inverse of G, and $\alpha = \frac{\hat{\pi}}{(1-\beta)(1-\hat{\pi})}(\hat{u}-\beta u_M)$. It follows that $\hat{u}-\beta u_M$ itself is independent of $u_M$. This gives rise to the next lemma, but to state it we need some more notation.

Denote the optimal solution of (10) as $(u^{\#}(u_M),e^{\#}(u_M),\pi^{\#}(u_M))$, the value of $u^{\#}(u_M)+G(e^{\#}(u_M))$ by $w^{\#}(u_M)$, and that of $f(e^{\#}(u_M))-w^{\#}(u_M)-c(\pi^{\#}(u_M))$ by $P^{\#}(u_M)$. On the other hand, recall that $P(u_M)$ is the level of maximized (per capita per period) profit, and $u(u_M)$ is the level of utility workers can obtain by accepting the optimal contract.

<u>Lemma 3</u>: <u>Under A.1 - A.6,</u> $u^{\#}(u_M) = k+\beta u_M$ <u>for some constant</u> k>0.

The result of Theorem 1 in the previous section is depicted in Figure 1 in view of Lemma 3. The graph of $u^{\#}(u_M)$, having the slope $\beta$, is depicted as

EFG. The graph of $u(u_M)$ must consist of the portion EF of the graph of $u^{\#}(u_M)$ when (7b) is not binding, and of the portion FK of the $45^0$ line when (7b) is binding. The utillity level corresponding to F is the critical level $u_0$.

If $u_M < u_0$, $u^{\#}(u_M) > u_M$ and hence the solution of (7) coincides with that of (10). The optimal contract is necessarily a LTLC. If $u_M \geq u_0$ instead, then the solution for (10) differs from that of (7), $u(u_M) = u_M$ and the optimal contract is a STLC (or, more strictly, it can take the form of either a LTLC or a STLC.) The graph of $P^{\#}(u_M)$ and $P(u_M)$ must look like ABD and ABD'. For $u_M \leq u_0$, $P^{\#}(u_M)=P(u_M)$ and hence the two graghs coincide. By definition $u^*$, where $P(u^*)=0$, is the market utility level correspoding to the equilibrium of the economy. In the case depicted in the Figure, since $u^* > u_0$, the equilibrium contract can take the form of a STLC or a LTLC. If, on the other hand, the graph of $u^{\#}(u_M)$ is E'F'G' and that of $P(u_M)$ is ABCD", then the equilibrium market utility, $u^{**}$, is smaller than the critical utility, $u_0'$ and the equilibrium contract is necessarily a LTLC.

With the help of the Figure, we now proceed to the rest of comparative statics. Suppose there is a technological progress that improves average productivity leaving marginal productivity invariant, i.e., for any e, new production function, $\tilde{f}$, takes the form of $\tilde{f}(e)=f(e)+a$ for some constant $a>0$. This shift will not change the optimal contract for any $u_M$ and hence leave the shape of both $u^{\#}(u_M)$ and $u(u_M)$ intact. The functions $P^{\#}(u_M)$ and $P(u_M)$, however, will shift up and the equilibrium market utility level, $u^*$ will increase. From the Figure, it follows that the equilibrium contract becomes more likely to be a STLC (or it is more likely that firms find the optimal contract to be not necessarily a LTLC).

Intuitively, the increase in average productivity induces higher profit which leads to entry of new firms. Labor demand is larger, pushing up the expected market utility for workers, $u_M$. To provide the optimal work incentive to workers by a LTLC, firms must provide even higher utility by offering larger wage, smaller required effort, or smaller sampling ratio. But such a revision of contract may eradicate the advantage of LTLC over STLC. The same effect will take place if the monitoring becomes less costly, i.e., the function, $c(\pi)$, shifts down.

## 6. Observable Age

Up to this point, we assumed that worker's characteristics such as his age or years of job experience are unobservable and all the workers (regardless of age and experience) must be treated in the same manner. If we assume, however, that these characteristics are observable and, therefore, market for labor is segregated according to age or job experience, a different kind of equilibrium may emerge as its consequence. This is so even if, as we have assumed, workers live for an infinite number of periods and young workers and old workers are identical from firm's viewpoint. We will consider the case when labor market is segregated according to age, though the case when it is segregated according to job experience can be analyzed in essentially the same manner.

Suppose that firm's strategy consists not only of wage, effort and monitoring ratio but also of age of workers they will hire. Suppose further that firms strategies are so that only the youngest workers (age zero workers) can be hired. Then, older workers cannot expect to find a new job in this economy. They must expect to live without any income other than unemployment compensation for the rest of life, once they lose their jobs. Resulting large difference between utility levels when they can stay on the firm and when they lose their jobs may ease the burden of monitoring cost for firms.

If firms decided to offer a contract only to the youngest workers, the optimal contract and the optimal monitoring input would be described by the optimal solution of:

$$\text{(12)}\quad \underset{(\hat{w},\hat{e},\pi)}{\text{maximize}} \quad f(\hat{e})-\hat{w}-c(\pi)$$

$$\text{subject to (a)}\quad e^{*}(\hat{w},\hat{e},I,\pi;u_C)=\hat{e}$$

$$\text{(b)}\quad u(\hat{w},\hat{e})\geq v_M$$

as long as its solution $(\hat{w}^{*},\hat{e}^{*},\pi^{*})$ satisfies $f(\hat{e}^{*})-\hat{w}^{*}-c(\pi^{*})\geq 0$. In (12), $v_M$ is the level of market utility the youngest workers can expect when they first enter the market.

Any firm can offer a (different) contract to older workers as well. If, however, there is no older workers currently unemployed, in order to recruit workers currently employed elsewhere, firms must offer workers a utility higher than the level they are currently receiving. In view of the structure of the problem (11), such a strategy is bound to give less profit than that obtainable by hiring the youngest workers. Hence, firms will offer contract only to the youngest workers.

Therefore, if there is a utility level $v_M$ such that (a) the optimal contract for (11) is a LTLC, (b) the optimal solution for (11) gives zero profit, (c) the youngest workers are fully employed, and (d) employed workers' optimal solution is non-shirking and hence there is no old unemployed workers, there will be yet another Nash equilibrium.

<u>Lemma 4</u>: <u>If</u> $v_M>u_C$ <u>then the optimal contract</u>, $(\hat{w}^{*},\hat{e}^{*})$ <u>is a LTLC</u>.

Proof: Obvious from Lemma 1.

Denote the optimal solution of (11) as $(\hat{w}_S(v_M), \hat{e}_S(v_M), \pi_S(v_M))$. The subscript S stands for segregated market. Define $P_S(v_M)=f(\hat{e}_S(v_M))-\hat{w}_S(v_M)-c(\pi_S(v_M))$. Then:

Lemma 5: $P_S$ is continuous and non-increasing in $v_M$ on $[u_C,\alpha]$. Moreover, $P_S(\alpha)<0$.

Proof: Similar arguments as those given for Lemma 3 prove the assertion.

By A.4, $P_S(u_C)>0$. Therefore, there is a utility level $v_S \varepsilon [u_C,\alpha]$ such that $P_S(v_M^*)=0$. When the market utility level for the youngest workers is $v_M^*$ but that for older workers is zero, by Lemma 3 the optimal contract is necessarily a LTLC, the youngest workers are fully employed and no worker will shirk by definition. Hence (a)-(d) are satistied. To sum up;

Proposition 2 Under A.1-A.4, there exists an equilibrium where the mode of equilibrium contract is LTLC and the labor force is fully employed. In this equilibrium, all workers are employed with LTLC's when they first enter the labor market and they will stay on the same firm throughout their lives

Note that, even if workers' age (or job experience) is observable, firms may choose a strategy which is not age specific. Therefore, with workers' age being observable, both equilibria (the equilibrium in Proposition 1 and the equilibrium in Proposition 2) are possible. It should be clear from the discussion, however, that the equilibrium decribed in

Proposition 2 is entirely different from the one described in proposition 1. Hence, the economy with the assumption of observable age (or job experience) has multiple long-run equilibria. The following proposition proves that, between these two equilibria, the equilibrium described in Proposition 2 Pareto dominates (in ex ante sense) the equilibrium described in Proposition 1.

Proposition 3: $v_M^* > u_M^* > u_C$.

Proof: Suppose that $u_C < v_M^* \leq u_M^*$ holds contrary to the assertion. Then in view of (2') and (7), both

$$u(\hat{w}^*, \hat{e}^*) = (1-\pi^*)u(\hat{w}^*, 0) - \frac{\pi^* \beta}{1-\beta}[u(\hat{w}^*, \hat{e}^*) - u_M^*]$$

$$> (1-\pi^*)u(\hat{w}^*, 0) - \frac{\pi^* \beta}{1-\beta}[u(\hat{w}^*, \hat{e}^*) - u_C], \text{ and}$$

$$u(\hat{w}^*, \hat{e}^*) \geq u_M^* \geq u_C.$$

should hold, where $\hat{w}^* = \hat{w}(u_M^*)$, $\hat{e}^* = \hat{e}(u_M^*)$, $\pi^* = \pi(u_M^*)$. We also used the fact that $\pi^* > 0$ which follows from $u(\hat{w}^*, \hat{e}^*) > 0$. Thus for sufficiently small $\varepsilon$, $(\hat{w}^* - \varepsilon, \hat{e}^*, \pi^*)$ satisfies (11b), creating higher profit for firms. It follows that $P_S(v_M^*) > P(u_M^*) = 0$. However, this is a contradiction to the fact $P_S(v_M^*) = 0$.

## 7. Conclusion

In this paper, we analyzed the labor market with asymmetric information on worker's choice of effort intensity. Each firm attempts to design the optimal rule of the game (i.e., the form of contract and the level of monitoring input) so that employed workers choose the effort level intended by the firm. Firms then compete with each other on contractual choice until the labor market is in the long-run equilibrium state.

As the result of our anaysis, different modes of labor contract as well as different rates of unemployment are shown to emerge as inevitable consequences of the multiplicity of equilibria in the same economy. Viewed this way, differences in employment practices and unemploument rates in different societies may be historical accidents and should not necessarily be ascribed to cultural dissimilarities only. If an economy happens to settle on one equilibrium and thus starts to subscribe to one particular mode of economic relations, this mode will perpetuate itself forever unless an exogeneous factor forces a change in the course of the economy. Put differently, the current form of employment practice and other characteristics of labor market exist because they have existed historically. These historic pecuriarities among different societies, which are often associated with cultural and social aspects, exist because there is an economic force which supports them as an equilibrium.

The difference in modes of employment practice we considered in this paper is that of the length of labor contacts. However, as some recent empirical studies (e.g., Koike [1978]) have revealed, in reality many European as well as American firms also practice de facto lifetime employment as much as (if not more than) Japanese do. Nevertheless, lifetime employment is socially more recognized as the form of the prevailing contract in Japan than in other countries. Moreover, lifetime employment together with a very low rate of unemployment and few labor turnovers is usually considered to be distinct for the Japanese labor market.[11/]

Finally althouth we have shown that there sometimes exist multiple long-run Nash equilibria, some may argue that our second type of equilibrium (equilibrium with segregated labor markets) is an unstablle, if not pathological, equilibrium. Suppose, for example, starting from the equilibrium situation, some old workers lose their contracts whatever the reason may be. They would certainly search for new contracts and they would accept a new contract even if the promised utility is less than the level offered for the youngest workers. Firms, facing a new type (i.e., old and jobless) of workers, would find that these old workers are exactly the same (live for the same number of periods, work under the same contracts as the ones that the firms are offering to the young workers. Such a piece of information, that the old workers can anticipate $v_M^*$ expected utility instead of zero utility, would then destroy the equilibrium condition.

Although such a criticism is well-founded in our set-up, it is the assumption of infinite life span which makes the equilibrium unstable. When the life span of workers is finite, a different kind of long-term contract may become the optimal contract. A typical form of contract in such a situation is that of the seniority wage. That is, the contract specifies that firms will pay a worker a higher wage as his experience (number of years spent within the firm) increases. Recall that it is the difference in expected utility, between those who can stay within the firm and those who have lost their contracts, that gives an incentive to work conscientiously. Given the same level of expected utility available in the external market, firms can create a larger difference in utility with the same amount of wage bill when they choose the seniority wage system instead of a wage system that is independent of workers' experience. (See, for example, Lazear [1979b].) If the seniority wage system becomes an equilibrium contract, the labor market must be truly segregated and full-employment may emerge as an equilibrium situation with the LTLCs. We will, however, leave the formal analysis with the finite life span to another occasion.

## Footnotes

*/ This is a revised and updated version of Okuno [1981a] which was circulated to a limited audience. A similar but different version was published in Japanese as Okuno [1981b]. The author is indebted to Professors Masahiko Aoki, Tsuneo Ishikawa, Leonard Mirman, Hajime Miyazaki and Shiro Yabushita for their extremely stimulating discussions and suggestions. He is also very grateful to two referees of this Journal for their constructive criticisms and helpful suggestions. Financial supports from Japanese Ministry of Education and The 21st Century Foundation are gratefully acknowledged.

1/ Viewed this way, it is a problem of an agency relationsnip with incomplete monitoring. Problems of similar nature have been studied by Mirrlees [1979], Holmstrom [1979], Shavell [1979] and others. However in their case, the monitor is supposed to infer worker's effort from imperfect (i.e., noisy) observation of their performance. Gintis-Ishikawa [1987] use such monitoring device to consider labor contract.

2/ Works cited above, i.e., Shapiro-Stiglitz, Bowles and Bulow-Summers, assume that the probability of sampling, $\pi$, is exogenous. Coupled with their assumption of no immediate penalty to shirked workers, they do not obtain the difference in the length of labor contract. Moreover, our utility function of workers is of more general form than theirs.

3/ More generally, monitoring cost would depend not only upon $\pi$, the fraction of workers who are monitored, but also upon how accurate the monitoring should be. That is, among workers who are shirking, it is usually less costly to identify those workers who are working at lower effort level than those with higher level. We do not consider this effect for the sake of simplicity of exposition.

4/ Monitoring is necessary to prevent workers from shirking. Since workers will be assumed to be homogenous, all the workers should choose the same effort level at equilibrium and hence firms can infer each worker's effort by observing the total output. If the firm uses such a reasoning and makes each worker's wage a function only of the aggregate output, however, workers will normally find it profitable to choose a behavior different from what the average workers do. Namely, a free rider problem will emerge unless either the elasiticity of individual wage function to aggregate output is set extremely large or some other disciplinary methods (e.g., workers' mutual surveillance) are employed. See Holmstrom [1982], Miyazaki [1984] and Okuno [1984] for more details.

5/ A worker's optimal strategy, in general, depends upon the strategies chosen by other workers. In the following, however, we assume that a firm designs a rule of the game (i.e., a type of contract and a ratio of monitored workers) so that any worker will choose the desired strategy regardless of the choice of strategies by other workers. In other words, we will analyze the situation where the set of strategies chosen by the firm's employees is a dominant strategy equilibrium given the contract and the monitoring input chosen by the firm.

6/ We ignore the possibility of contracts which require workers to post bonds at the outset. Allowing such a possibility would significantly alter the conclusions (such as the existence of involuntary unemployment in equilbrium) of the paper. However, we believe that, in reality, both the possibility of introducing such a clause and the amount of such a bond itself are limited because of legal restrictions, imperfectness of capital market, etc. Moreover, our ultimate conclusions--existence of either long-term labor contract or short-term labor contract as an equilibrium mode in one type of equilibrium--remains intact even if we allow such a possibility.

7/ Our assumption that firms can dismiss shirked workers without paying any wage may be unrealistic. In effect, we are assuming that the result of monitoring can be verified by a third party and hence firms can use such a practice. Alternatively, one can interpret this assumption by assuming that firms will pay bonus to workers who are not found shirking. Firms must honor the bonus payment clause of the contract because of their reputation. More specifically, firms employ a penalty wage function w(e) so that it pays $\hat{w}$ if either a worker is found to have worked satisfactorily or he is not monitored, and pays w(e) if the worker is sampled and found shirking at the level $e<\hat{e}$. However, it can be easily shown that the special form of penalty wage function defined in the text, i.e.,

$$w(e) = \begin{cases} \hat{w} & \text{if } e \geq \hat{e}, \\ 0 & \text{if } e < \hat{e}, \end{cases}$$

is not inferior to any other penalty wage function when A.3 is assumed.

8/ If we relax this assumption, the result will be affected. For example, if the capital market is complete and workers can borrow and lend freely, not only workers' behavior change but also the optimal mode of contracts becomes different, e.g., bond-posting becomes a feasibility.

9/ Properties of equilibrium also depend upon other parameters of the economy, such as; a) the shape of the von Neumann-Morgenstern utility function u, b) the discount factor ß. However, we must assume specific forms of utility function, production function and motoring cost function to obtain any clear-cut result for these comparative statics.

10/ (7) has a unique solution only when the set $\{(\hat{w},\hat{e},\pi)\varepsilon R^3_+ | \text{(7a) and (7b)}$ are sarisfied$\}$ is concave for $u_M \varepsilon [0,\alpha]$. In general, even if all u, f and $\pi$ are concave functions, this set still may not be concave. In any case, $P(u_M)$ is always well-defined.

11/ See, for example, Haitani [1976]

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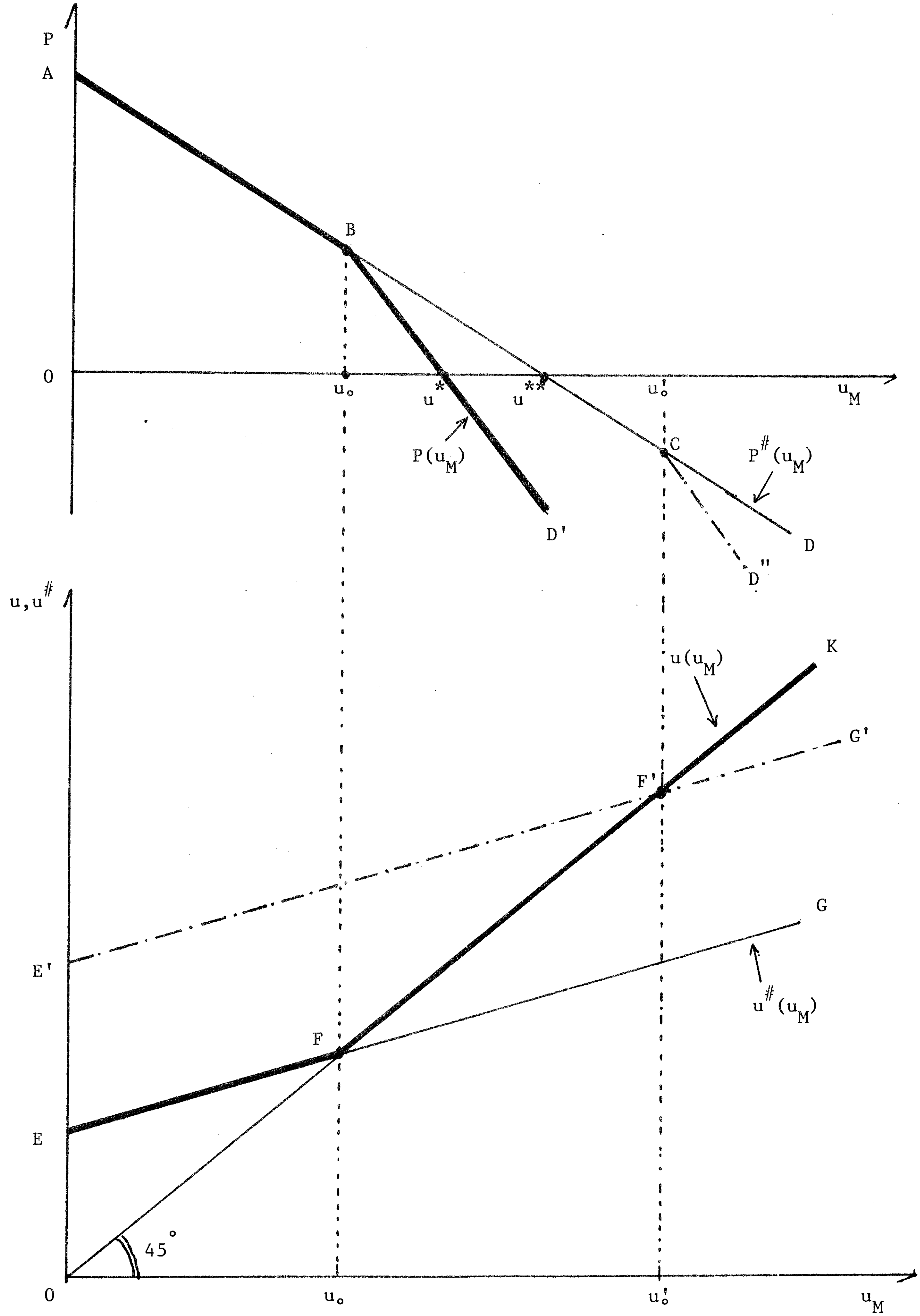
P
A
B
0
$u_o$
$u^*$
$u^{**}$
$u_o'$
$u_M$
$P(u_M)$
C
$P^{\#}(u_M)$
D'
D
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$u, u^{\#}$
K
$u(u_M)$
G'
F'
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