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ASYMMETRIC INFORMATION ON JOB SEARCH, INSURANCE, MORAL HAZARD AND EFFICIENCY OF WAGE CONTRACTS

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Kit-chun Lam *
Pak-wai Liu **

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Kit-chun Lam *
Pak-wai Liu **
Yue-chim Wong***

* Department of Economics, University of Sydney, Sydney, N.S.W. 2006, Australia

** Department of Economics, Chinese University of Hong Kong, Shatin, Hong Kong

*** Department of Economics, Chinese University of Hong Kong, Shatin, Hong Kong

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Abstract

In this paper we integrate a human capital investment model, a job search model and a principal-agent model into the labor contract theory to analyse moral hazard problems which arise from the distortion of quit incentives by the provision of wage insurance and the unobservability of job search intensity of the workers by the firms. The focus is on an asymmetry of information on job search. It is shown that whether search in the second-best contract is insufficient or excessive relative to the first-best depends on whether the contract sets wage above or below post-training marginal product, and that in turn depends on workers' ability to smooth out intertemporal consumption in the capital market and their degree of risk aversion. The provision of wage insurance tends to reduce investment inefficiency and turnover inefficiency of investment cum fixed wage contracts.

Keywords: Asymmetric information, job search, insurance, moral hazard, agency problem, wage contract.

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I. INTRODUCTION

This paper is concerned with wage insurance, quit incentives, moral hazard, and efficiency in risk sharing, turnover and investment in specific human capital. Since the work of Baily (1974) and Azariadis (1975), it has been widely recognized that one of the roles of labor contracts is to provide wage insurance for risk averse workers. It has been argued that in the absence of markets for contingency claims and third-parties offering insurance, income risks of workers are shifted to the firms through long-term contracts. Workers are insured against bad states by being offered wages above their marginal product, an insurance which they pay for by accepting wages below marginal product when the states are good.[1] Wages are thus separated from their links with productivities; their two profiles no longer coincide. Recent studies which address the divergence of wages from productivities within the context of wage insurance include Harris and Holmstrom (1982), Arnott (1982), Weiss (1984), Haltiwanger and Waldman (1986) and Berkovitch (1986).

Wage insurance offers an alternative explanation for the separation of wages and productivities and is a departure from the traditional human capital approach which dates back to Becker (1964) and elaborated by Parsons (1972), Hashimoto and Yu (1980) and Hashimoto (1981). In all their studies risk neutrality of workers is assumed and the issue of risk sharing does not arise. A synthesis of these two approaches is

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attempted in a recent study by Arnott (1982) who incorporates human capital investment into his wage insurance contract model. However, he was able to obtain only the rather weak result that multi-period employment contracts will not in general pay workers the value of their marginal product at each point in time.[2] In our paper we integrate explicitly a human capital investment model into a wage contract framework and are able to specify explicitly the conditions under which wages grow faster or slower than productivity after training.

Another role of the labor contract is to provide appropriate incentives for turnover. The original literature on contracts by Azariadis (1975) and Baily (1974) does not allow for turnover. Workers are immobile ex post and therefore cannot quit. Later work by Harris and Holmstrom (1982) assumes zero mobility costs and yields a contract which gives a non-decreasing wage structure but still no turnover. More recently Berkovitch (1986) allows for positive and variable mobility costs and is able to explain turnover as a by-product of the optimal contract but he does not address the problem of quit incentives and moral hazard. That the firms face the problem of designing wage contracts which are optimal in balancing incentives in labor turnover against efficiency in risk sharing is first addressed by Arnott and Stiglitz (1985). Since the provision of wage insurance affects workers' incentives to quit, moral hazard arises. The main purpose of Arnott and Stiglitz (1985), however, is to show that moral hazard and externality lead to market failure within a general equilibrium framework.

Our paper is also concerned with wage insurance and moral hazard which arises in the optimal contract when workers can quit but it does not deal with the externality issue. It differs from previous studies on wage insurance in that it allows for workers' job search, an activity which directly affects the probability of quit. In our model, workers search on the job.[3] The more intensively they search, the higher is the probability of finding a good offer. Workers quit when they obtain job offers with higher wages than those of their present jobs. Hence they face the uncertainty of staying with a lower wage or quitting for a higher wage.

In the contract literature there are different sources of uncertainty against which wage insurance is provided. Workers may be insured against fluctuation in product demand (Azariadis 1975 and Baily 1974), uncertainty in their own productivity (Harris and Holmstrom 1982) stochastically growing output (Weiss 1984), or job dissatisfaction (Arnott 1982 and Arnott and Stiglitz 1985). Our model differs from all previous studies in that wage insurance is provided against staying, that is, failure in searching for a better job. Staying is the "bad" state because of the lower wage while quitting is the "good" state because of the higher wage. The motivation for turnover, therefore, is better job prospects elsewhere. This is in accordance with the spirit of the job search literature but is in contrast to job dissatisfaction as the motivation for quits (see Arnott 1982, Carmichael 1983 and Arnott and Stiglitz 1985).

If information on job search were symmetric, the multi-period contract between workers and firms would stipulate level of specific training, wages over time and level of search intensity undertaken by the workers. This is called the first-best contract in our model. However, more often than not information on job search is asymmetric. Workers know how intensively they are searching for alternative jobs but not the firms. Hence search intensity cannot be part of the contract and the contract that entails is only second-best. Hence moral hazard arises not only from the distortion of quit incentives by the provision of wage insurance but also from the unobservability of job search intensity by the firms.

In the optimal contract, first-best or second-best, firms have to balance insurance and quit incentives. In a two-period world, firms pay high second-period wages to insure workers against staying by reducing the wage variation between staying and quitting. This stay insurance is paid for by workers accepting low first-period wages. The more insurance the firms provide, the lower would be the costs to the firms since risk averse workers would be willing to accept a lower expected wage for the insurance. On the other hand, it encourages excessive stay of the workers because of the higher second-period wages. Workers who stay are subsidized and that increases costs to the firms. In addition, excessive stay will further directly increase or reduce costs to the firms depending on whether second-period wages are larger or smaller than workers' marginal product. Firms must balance among these considerations. This characterises the optimisation problem in our model.

It will be shown that one major difference between the first-best and the second-best contracts is that in the former, firms can adjust wages as far as optimal to provide insurance while specifying the optimal level of search intensity to provide appropriate quit incentives. In the second-best contract, however, wages must be moderated to provide insurance and correct quit incentives at the same time.

It should be clear that the second-best contract is Pareto-inefficient in trading off insurance for quit incentives relative to the first-best. The question is under this contract will workers' job search be excessive or insufficient. The results of this paper show that the answer depends on whether the second-period wage is set below or above workers' marginal product, and that in turn depends critically on the nature of the capital market faced by the workers.

In analysing the problems posed above, we have integrated a human capital investment model, a job search model and a principal-agent model into the labor contract theory. Specifically, the second-best contract and its moral hazard problems will be solved by applying the first-order approach a la Rogerson-Mirrlees used in handling agency problems.[4]

One advantage in analysing second-best contracts of the type we introduce is that they do not have to be implicit. Contracts of this type can explicitly specify the level of training provided by the firms, the pre-training and post-training wages and are therefore enforceable by law. This avoids the enforceability problem encountered by the implicit contract literature. In fact one may observe that explicit contract of this indicated form is not uncommon in practice.

The paper is organized as follows. The model is contained in Section II. In Section III the first-best and second-best contracts when the capital market is perfect are analysed with a characterisation of the wage structures. The search intensities and wage structures of the two contracts are compared. The analysis is repeated in Section IV when the worker is assumed to have no access to the capital market. A discussion on the wage profile and sharing of investment in specific human capital is in Section V. The relation between wage insurance, investment efficiency and turnover efficiency is explored in Section VI. Some policy implications are discussed in Section VII. The paper concludes in Section VIII.

II. THE MODEL

The economy produces a single numeraire commodity with labor as the sole factor using constant returns to scale technology. The price of the commodity is stationary and is normalised to one. Firms are risk neutral and maximise expected profit. They are competitive and identical except for the differences in their match qualities with different workers.

Labor is supplied inelastically by workers with their unit of working time normalised to one. There is no disutility of effort. Workers are also identical except with respect to their match qualities with different firms.[5] They are risk averse with intertemporal utility function U(.), which is additively separable. The von Neumann-Morgenstern utility function u(.), defined over consumption, has the usual properties of being continuous and twice differentiable. Also $u' > 0$, $u'' < 0$ and $u'(0) = \infty$. The last property $u'(0) = \infty$ effectively precludes zero consumption in any state. For simplicity we assume both the subjective discount rate and the interest rate are zero.

Workers live for two periods, indexed 1 and 2. In the first period, a worker is paid wage w_1 by the firm which currently employs him. Time is spent working and investing in specific human capital in the firm. Specific human capital investment is given by the time-equivalent unit x with $0 \leq x \leq 1$. Hence x is the fraction of time in period 1 spent investing. Let m be the workers' productivity per unit time in the firm before specific human capital investment. It represents a certain match quality between the worker and the firm. Specific investment in period 1 will augment his productivity in the same firm in period 2, written as h(x), where h is the human capital production function and has the properties of $h' > 0$, $h'' < 0$ and $h(0) =$

m. Marginal product of human capital production is therefore positive but diminishing and if there is no investment in period 1, the workers' productivity in period 2 remains at m.

In period 1 the worker also spends resources in job search, its level of intensity given by expenditure s, which may be interpreted as expenditure on gathering employment information like visiting employment agencies and employers, placing advertisements in newspapers etc. At the end of the period, the worker takes one random draw from the distribution of wage offers they face and depending on its outcome, he either stays with the firm in the second period and receives wage w_2 or quits to join another firm. In the second and last period of the model, all time is spent working; there is no further investment or search.

The exchange relation between the worker and the firm is characterised by a contract agreed upon ex ante at the beginning of period 1. If information on search intensity is symmetric, a contract $\delta_I(x, w_1, w_2, s)$ which specifies the level of specific training provided by the firm, wage payments in the two periods and search intensity of the worker is feasible and is first-best.[6] More often than not, information on search intensity is private to the worker. If the firm provides wage insurance against staying and the worker is asked about his search intensity, he has an incentive to lie and overstate his search intensity and hence the probability of quit. As will be clear later, the firm will provide more insurance against staying by offering higher w_2. The worker who lies will therefore be heavily subsidised if he stays. There is no mechanism which will induce truth-telling. Hence under asymmetric information, search intensity cannot be part of the contract. In this case the ex ante contract is second-best and is characterised by $\delta_{II}(x; w_1, w_2)$.

It is assumed that the contract does not bind the worker irrevocably to the firm, involuntary servitude is prohibited. By virtue of the assumption of stationary output price, uncertainty in the product market is removed and the firm will not lay off workers.[7] The contracts under consideration, in particular the second-best contract, are basically fixed-wage cum investment contracts. They are informationally feasible and implementable. In fact they can be made explicit and hence enforceable by law.

Having characterised the contractual relation between the worker and the original firm which employs him, let us depict further what happens if the worker quits and takes another job in the second period. In this case the worker enters the spot market and will be paid according to his spot marginal product in the new firm.[8]. The wage offers he may receive depend on the match qualities. Specifically, a worker who is not very productive in one firm may be highly productive in another because of specificities. The distribution of wage offers, denoted by $F(\tilde{w}_2)$ where $\tilde{w}_2$ is the stochastic wage offer, is non-degenerate and its supports are assumed to be in $[0, \infty)$.[9] The distribution is continuously differentiable with density function $f(\tilde{w}_2)$.

It is essential to elaborate further the search technology. The worker can raise his probability of getting good wage offers by increasing his search intensity. Hence the distribution and density functions of $\tilde{w}_2$ are conditional on s. Specifically, the following assumptions on the search technology are made.

<u>Assumption 1</u>

The density functions $f(\tilde{w}_2|s)$ satisfy the monotonic likelihood-ratio condition (MLRC). That is, f_s/f is non-decreasing in $\tilde{w}_2$.

<u>Assumption 2</u>

The distribution function $F(\tilde{w}_2|s)$ satisfies the convexity of the distribution function condition (CDFC). That is $F_{ss} \geqslant 0$.

It should be noted that both assumptions are the sufficient conditions for using Rogerson-Mirrlees' first-order approach in solving agency problems. Subscript s denotes partial derivative.

Assumption 1 has the interpretation that a higher wage offer received by the worker in his draw is evidence of his greater search intensity.[10] This assumption also implies the stochastic dominance condition (SDC), i.e. $F_s \leqslant 0$.[11] It means that search shifts the distribution so that the probability of receiving a wage offer no greater than a specific value decreases as its intensity increases. We assume further that s does not shift the supports of the distribution. Assumption 2 has the interpretation of stochastic diminishing returns to search; the more intensive the search, the smaller the increase in probability of getting good offers.[12]

It should be easy to show that the optimal search strategy in our model has the standard reservation wage property.[13] The reservation wage is simply w_2 (For a proof, see Appendix 1). The worker will quit at the end of period 1 if he receives a wage offer exceeding w_2 from his draw.

It remains to motivate simultaneous work and search in our model. Standard sequential search models predict that a worker will specialise either entirely in work or entirely in search even though it is unlikely that voluntary specialisation in search is common in practice. Recently Seater (1979) and Benhabib and Bull (1983) show that allowing marginal benefit to decline with search intensity is sufficient to generate simultaneous work and search. In our model the stochastic version of diminishing returns to search is embodied in the CDFC assumption. Furthermore, unlike the conventional search models which yield specialisation as an outcome, search in our model is not time-intensive but goods-intensive. Therefore, it cannot be optimal for the worker to stay idle and specialise in search in period 1. However, spending nothing on search while specialising in work and investment in period 1 could be optimal. This would be the case if the marginal cost of search exceeds its expected marginal returns at the corner solution of $s = 0$. To conclude it is possible to have specialisation in work (and investment) with zero search or simultaneous work and search in our model.

III. OPTIMAL CONTRACT UNDER PERFECT CAPITAL MARKET

A. Wage Structure in First-Best Contract

We first analyse the case where the worker faces a perfect capital market. The worker can lend or borrow any finite amount but due to liquidity constraints, infinite amount of borrowing or lending is disallowed. With symmetric information on search intensity, the optimal contract can be characterised by investment level, wages and search intensity subject to the firm earning zero expected profit and the worker having chosen a consumption stream to maximise his utility. His utility function is written as:

$$U(x, w_1, w_2, s, c_1, c_2) = u(c_1) + F(w_2|s)u(c_2) + \int_{w_2}^{\infty} u(\tilde{c}_2) f(\tilde{w}_2|s) d\tilde{w}_2$$

where c_i is the worker's consumption in the i^{th} period and $\tilde{c}_2$ his stochastic consumption in period 2 if he quits. The first term on the RHS is the worker's utility in period 1; the second term his utility if he stays weighted by his probability of stay and the third term his expected utility if he quits in period 2. The notation can be simplified by introducing an expectation operator E with expectation taken over staying and quitting. Then the utility function becomes

$$U(x, w_1, w_2, s, c_1, c_2) = u(c_1) + Eu(c_2)$$

The following maximisation problem can now be solved:

$$\max_{\substack{x,\, w_1,\, w_2,\, s \\ c_1,\, c_2}} u(c_1) + Eu(c_2) \quad \text{.......(1)}$$

subject to

$$(1-x)m - w_1 + F(w_2|s)(h(x) - w_2) = 0 \quad \text{.......(2)}$$

$$c_1 \in \operatorname*{argmax}_{c_1' \in C_1} U(x, w_1, w_2, s, c_1', c_2) \quad \text{.......(3)}$$

$$c_2 = w_1 - s - c_1 + w_2 \quad \text{.......(4)}$$

$$\tilde{c}_2 = w_1 - s - c_1 + \tilde{w}_2 \quad \text{.......(5)}$$

$$c_1, c_2 \geqslant 0 \quad \text{.......(6)}$$

The competitive firm earns zero expected profit in equilibrium, hence the constraint in (2). Given the first-best contract δ_I (x, w_1, w_2, s), the worker will choose c_1 from the set of consumptions C_1 to maximise his utility, hence constraint (3). His consumption in period 2, c_2, can be obtained as a residual from the budget constraint (4). The budget constraint for the worker if he quits is given by (5). Constraint (6) requires that consumption be non-negative.

In this paper we will be analysing the case of simultaneous work and search and that requires that the problem has a non-zero solution for s. The following existence assumption is made.

Assumption 3

An interior solution to the first-best (second-best) problem exists with $s > 0$.[14]

Since the focus of this paper is on moral hazard problems which arise out of asymmetric information on job search, a comparison of the different search intensities under the first-best and the second-best contracts will be lost if the corner solution of $s=0$ entails in each case. It should be noted that whether zero search is optimal or not depends very much on the search technology. In particular, it can be shown that if a strong version of SDC holds, then at $s=0$, a marginal increase in search intensity shifts the distribution sufficiently in the stochastic dominance sense to more than justify the marginal increase in search costs and zero search will not be optimal. It that case simultaneous work and search is ensured (See Appendix 2). In any case the existence of a solution with $s > 0$ will be the maintained assumption throughout the paper.

Let us now characterise the solution. In solving for the first-best contract, we invoke only Assumption 3 but not Assumptions 1 and 2. By virtue of the assumption $u'(0) = \infty$, it can easily be shown that constraint (6) can never be satisfied as equalities. Also, the corner solution of s which exhausts all resources by searching leaving nothing for consumption is clearly suboptimal. This together with Assumption 3 ensures that there is an interior solution for s.

Since U is strictly concave in c_1, constraint (3) can be replaced by the first-order stationary condition

$$u'(c_1) - Eu'(c_2) = 0 \qquad (3')$$

The first-order conditions of the problem with an interior solution for s, w_1 and w_2 can now be written in the following compact form with arguments of functions suppressed where they are obvious:

$$
\begin{array}{lll}
x & : \lambda_1(-m + Fh') = 0 \ , \ x \in (0,\ 1) & \\
 & \qquad\qquad\qquad \leq 0 \ , \ x = 0 & \\
 & \qquad\qquad\qquad \geq 0 \ , \ x = 1 & \ldots\ldots(7) \\
w_1 & : Eu'(c_2) - \lambda_1 - \phi_1 Eu''(c_2) = 0 & \ldots\ldots(8) \\
w_2 & : Fu'(c_2) + \lambda_1\left[f(h-w_2) - F\right] - \phi_1 Eu''(c_2) = 0 & \ldots\ldots(9) \\
s & : D_s Eu(c_2) - Eu'(c_2) + \lambda_1 F_s(h - w_2) + & \\
 & \quad \phi_1\left[Eu''(c_2) - D_s Eu'(c_2)\right] = 0 & \ldots\ldots(10) \\
\lambda_1 & : (1-x)m - w_1 + F(h - w_2) = 0 & \ldots\ldots(11) \\
\phi_1 & : u'(c_1) - Eu'(c_2) = 0 & \ldots\ldots(12) \\
c_1 & : \phi_1\left[u''(c_1) + Eu''(c_2)\right] = 0 & \ldots\ldots(13)
\end{array}
$$

where λ_1 and ϕ_1 are Lagrange multipliers associated with constraints (2) and (3'),

where D_s is the partial differential operator of s which shifts only the distribution function while holding utility constant. That is

$$D_s Eu(c_2) = F_s u(c_2) + \int_{w_2}^{\infty} u(\tilde{c}_2) f_s d\tilde{w}_2$$

As noted by Arnott (1982), and Arnott and Stiglitz (1985), there may be multiple local optima which solve the problem. Let us denote any local optimum by δ_I (x^*, w_1^*, w_2^*, s^*), c_1^* and c_2^*. We will proceed to analyse the properties possessed by any of the optima. Our analysis which follows will involve comparisons between local optima only as is done in Arnott and Stiglitz (1985).[15]

Now (13) derives from the adjoint equation:

$$\frac{\partial \mathcal{L}_I}{\partial c_1} = \frac{\partial U}{\partial c_1} + \phi_1 \frac{\partial^2 U}{\partial c_1^2} = 0$$

where $\mathcal{L}_I$ is the Lagrangian function of the first-best problem. Hence $\phi_1 = 0$, which has the interpretation that the firm is indifferent to the worker's choice of c_1.

From (8) Lagrange multiplier $\lambda_1 = Eu'(c_2) > 0$. This is substituted into (9). The optimal wage structure is now characterised by

$$\frac{f}{F}(w_2 - h) = \frac{u'(c_2) - Eu'(c_2)}{Eu'(c_2)}$$

The proportional increase in marginal utility if the worker stays instead of quitting in period 2 must equal the excess of firm's wage cost over revenue weighted by the Mills' ratio.

Rewriting, we have

$$h - w_2 = \frac{F}{f}\frac{Eu'(c_2) - u'(c_2)}{Eu'(c_2)} \quad \text{.................................} (14)$$

But

$$\begin{aligned} Eu'(c_2) - u'(c_2) &= \int_{w_2}^{\infty} u'(\tilde{c}_2) f d\tilde{w}_2 - (1-F)u'(c_2) \\ &< (1-F)u'(c_2) - (1-F)u'(c_2) \\ &= 0 \end{aligned}$$

The inequality is due to concavity of u. Hence $h - w_2 < 0$. From (11), it follows that $w_1 < (1 - x)m$. We have proved the following proposition.

<u>Proposition 1</u>

In a perfect capital market the first-best contract sets wage below marginal product in period 1 before training and above in period 2 after training.

B. <u>Wage Structure in Second-Best Contract</u>

Now assume that information on search intensity is asymmetric and private to the worker. The second-best problem is the same as the first-best problem in (1) to (6) plus an incentive compatibility constraint (15) ensuring that the worker has chosen a search intensity from among the set of search intensities S to maximise his utility.

$$s \in \underset{s' \in S}{\text{argmax}}\ U(x, w_1, w_2, s', c_1, c_2) \quad \text{.............................(15)}$$

The optimum will be denoted by $\hat{c}_{II}(\hat{x}, \hat{w}_1, \hat{w}_2)$, $\hat{s}$, $\hat{c}_1$ and $\hat{c}_2$.

The problem is formally the same as the principal-agent problem. The firm provides wage insurance and specific training for the worker but the worker has the unilateral decision-making authority on how intensively he searches. His search intensity affects the probability of quits and thus the firm's insurance pay-out and the outcome of its investment in the worker. A new source of moral hazard is introduced into the problem.

Assumptions 1 and 2 which are sufficient for the use of the first-order approach in solving agency problems are not sufficient for our second-best problem. Further restriction on the search technology are needed in order that constraint (15) can be replaced by its first-order stationary condition. Assumption 2 on CDFC is now strengthened as follows.

<u>Assumption 4</u>

$\partial^2 U/\partial s^2 < 0$ for every s.

Assumption 4 is a strong version of CDFC since

$$\frac{\partial^2 U}{\partial s^2} = D_s^2\, Eu(c_2) + Eu''(c_2) - 2D_s Eu'(c_2) \quad \text{........................(16)}$$

The first term on the RHS of (16) is non-positive; the second term is negative but the third term is non-negative (see Appendix 3). $\partial^2 U/\partial s^2$ will be negative as required if $D_s{}^2 Eu(c_2)$ is strongly negative, which would be the case if the distribution function F is strongly convex.

Given Assumptions 1 to 4 and the previous result that c_1 and c_2

must be positive, the first-order conditions of the second-best problem can be written as

$$x \quad : \lambda_2(-m + Fh') = 0,\ x \in (0,\ 1)$$
$$\leqslant 0,\ x = 0$$
$$\geqslant 0,\ x = 1 \qquad \ldots\ldots(17)$$

$$w_1 \quad : Eu'(c_2) - \lambda_2 + \mu\left[D_s Eu'(c_2) - Eu''(c_2)\right] - \phi_2 Eu''(c_2) = 0 \quad \ldots(18)$$

$$w_2 \quad : Fu'(c_2) + \lambda_2\left[f(h-w_2) - F\right] + \mu\left[F_s u'(c_2) - Fu''(c_2)\right] - \phi_2 Eu''(c_2) = 0 \quad \ldots\ldots(19)$$

$$\lambda_2 \quad : (1-x)m - w_1 + F(h - w_2) = 0 \quad \ldots\ldots(20)$$

$$\mu \quad : D_s Eu(c_2) - Eu'(c_2) = 0 \quad \ldots\ldots(21)$$

$$\phi_2 \quad : u'(c_1) - Eu'(c_2) = 0 \quad \ldots\ldots(22)$$

$$s \quad : \lambda_2 F_s(h - w_2) + \mu\frac{\partial^2 U}{\partial s^2} = 0 \quad \ldots\ldots(23)$$

$$c_1 \quad : \phi_2\left[u''(c_1) + Eu''(c_2)\right] = 0 \quad \ldots\ldots(24)$$

where λ_2 is the Lagrange multiplier associated with the zero profit constraint, μ and ϕ_2 are the multipliers associated with the first-order stationary conditions of s and c_1 which replace (15) and (3), and Equations (23) and (24) are adjoint equations for μ and ϕ_2 respectively.

From (24), $\phi_2 = 0$ and has the same interpretation as before. On the other hand, the firm will not be indifferent to the worker's choice of intensity. From (23)

$$F_s(h - w_2) = -\frac{\mu}{\lambda_2}\frac{\partial^2 U}{\partial s^2}$$

By Assumption 4, $\partial^2 U/\partial s^2 < 0$. Hence if $\mu/\lambda_2 > 0$, then $F_s(h - w_2) > 0$. But this is the marginal increase in expected profit of the firm due to s. Therefore, if $\mu/\lambda_2 > 0$ the firm would like to see the worker increase his search intensity at the second-best optimum. This is because $F_s(h - w_2) > 0$ and $F_s \leqslant 0$ by SDC imply $h - w_2 < 0$. The firm will be paying wage above marginal product in period 2 and hence would like the worker to search more intensively to increase the probability of quit if the firm could maximise profit.

Equations (17) to (24) can be solved to give the second-best solution. Specifically, the wage structure of the second-best contract can be characterised by

Proposition 2

In a perfect capital market, if the worker's absolute risk aversion is constant, increasing or at most weakly decreasing, the second-best contract will set wage below marginal product in period 1 before training and above in period 2 after training.

Before proving Proposition 2, we first introduce a lemma.

Lemma

$$\frac{f_s(w_2|s)}{f(w_2|s)} \geqslant \frac{F_s(w_2|s)}{F(w_2|s)} \quad \text{for all } w_2 > 0$$

The proof of the Lemma follows from MLRC (See Appendix 4). We can now prove Proposition 2.

Proof

From (18) and (23), we solve for λ_2 which can be written as

$$\lambda_2 = \frac{VEu'(c_2)}{V + F_s(h - w_2)\left[D_s Eu'(c_2) - Eu''(c_2)\right]}$$

where $V \equiv \partial^2 U/\partial s^2 < 0$ by Assumption 4.

Substitute λ_2 and μ into (19) and solve algebraically for $h - w_2$. We have

$$h - w_2 = \frac{VF\left[Eu'(c_2) - u'(c_2)\right]}{VfEu'(c_2) + F_s A(x, w_1, w_2, s, c_1, c_2)} \quad \ldots\ldots\ldots\ldots\ldots\ldots(25)$$

where

$$A(x, w_1, w_2, s, c_1, c_2) \equiv Fu'(c_2)\left[D_s Eu'(c_2) - Eu''(c_2)\right] -$$

$$Eu'(c_2)\left[F_s u'(c_2) - Fu''(c_2)\right] \ldots\ldots\ldots(26)$$

It can be shown that $h - w_2 < 0$ under rather weak assumptions on the worker's risk aversion. The numerator on RHS of (25) is positive because

$$VF\left[Eu'(c_2) - u'(c_2)\right] = VF\left[Fu'(c_2) + \int_{w_2}^{\infty} u'(\tilde{c}_2) f d\tilde{w}_2\right] - VFu'(c_2)$$

$$> VF\left[Fu'(c_2) + (1-F)u'(c_2)\right] - VFu'(c_2)$$

$$= 0$$

The inequality is due to concavity of u. Now in the denominator $VfEu'(c_2) < 0$ and $F_s \leqslant 0$. It remains to show that $A \geqslant 0$. Consider

$$D_s Eu'(c_2) - Eu''(c_2) = F_s u'(c_2) + \int_{w_2}^{\infty} u'(\tilde{c}_2) f_s d\tilde{w}_2 - Fu''(c_2) - \int_{w_2}^{\infty} u''(\tilde{c}_2) f d\tilde{w}_2$$

$$= Fu'(c_2)\left[\frac{F_s}{F} + \sigma(c_2)\right] + \int_{w_2}^{\infty} u'(\tilde{c}_2)\left[\frac{f_s}{f} + \sigma(\tilde{c}_2)\right] f d\tilde{w}_2$$

where $\sigma = -u''/u'$ is the Arrow-Pratt measure of absolute risk aversion.

Hence

$$A = Fu'(c_2)\{Fu'(c_2)\left[\frac{F_s}{F} + \sigma(c_2)\right] + \int_{w_2}^{\infty} u'(\tilde{c}_2)\left[\frac{f_s}{f} + \sigma(\tilde{c}_2)\right] f d\tilde{w}_2 -$$

$$Eu'(c_2)\left[\frac{F_s}{F} + \sigma(c_2)\right]\}$$

$$= Fu'(c_2)\{\int_{w_2}^{\infty} u'(\tilde{c}_2)\left[\frac{f_s}{f} + \sigma(\tilde{c}_2)\right] f d\tilde{w}_2 - \left[\frac{F_s}{F} + \sigma(c_2)\right]\int_{w_2}^{\infty} u'(\tilde{c}_2) f d\tilde{w}_2\}$$

By MLRC, $f_s(\tilde{w}_2 | s)/f(\tilde{w}_2 | s)$ is non-decreasing in $\tilde{w}_2$. If $\sigma(\tilde{c}_2)$ is either constant, increasing or at most weakly decreasing then $f_s(\tilde{w}_2|s)/f(\tilde{w}_2|s) + \sigma(\tilde{c}_2)$ will also be non-decreasing in $\tilde{w}_2$. Hence

$$\int_{w_2}^{\infty} u'(\tilde{c}_2)\left[\frac{f_s}{f} + \sigma(\tilde{c}_2)\right] f d\tilde{w}_2 \geqslant \left[\frac{f_s(w_2|s)}{f(w_2|s)} + \sigma(c_2)\right]\int_{w_2}^{\infty} u'(\tilde{c}_2) f d\tilde{w}_2$$

$$\geqslant \left[\frac{F_s(w_2|s)}{F(w_2|s)} + \sigma(c_2)\right]\int_{w_2}^{\infty} u'(\tilde{c}_2) f d\tilde{w}_2$$

The second inequality follows from the Lemma. Therefore $A \geq 0$ and $h - w_2 < 0$. Again $w_1 < (1-x)m$ follows from the zero profit constraint.

Q.E.D.

It should be noted that since wage is set below marginal product in period 1 and above in period 2 in both the first-best and second-best contracts, and post-training marginal product always exceeds pre-training marginal product, the optimal wage profile is rising over time in both contracts.

The economic meaning of Propositions 1 and 2 is clear. The firm tends to set w_2 relatively high as to be above post-training marginal product to provide greater insurance for the worker by reducing the variation in his income between staying and quitting. This is because risk averse worker desires to smooth out his income across states through the contract. He can then borrow or lend in the perfect capital market to also smooth out his consumption over time. This is in contrast to the case where the worker has no access to the capital market which we will analyse in Section IV. In that situation, the worker's desire to reduce risk across states must be balanced by his desire to smooth out consumption over time.[16]

Our results on the two contracts show that optimal insurance is partial, not full, and under the optimal contract, there will be quits at the end of period 1. This result is different from those of Weiss (1984) and Haltiwanger and Waldman (1986). In their models the alternative wage in the second period, which is simply the spot marginal product, is assumed to be constant, i.e. the distribution of wage offers is degenerate. Second-period wage of good (able or successful) workers is constrained to be at least as large as the alternative wage for reason of feasibility to prevent all workers from being bid away by other firms in period 2. This rules out the possibility of turnover from their models.[17] Their results then show that in a perfect capital market, full insurance is optimal and the second-period wage of good workers is set equal to marginal product. The major difference in our model is that turnover is not ruled out by its set-up. Turnover is motivated by the existence of a non-degenerate distribution of wage offers supported by $[0, \infty)$.[18]

While both the first-best and the second-best contracts set w_2 above marginal product, there is one difference between them. In the latter contract, the result depends on the parameters of the worker's utility function but not the former. This, as we will show, is due to the result that the worker searches too little in the second-best contract relative to the first-best. The explanation will become clear after the comparison in the following section.

C. Insufficient Job Search in Second-Best Contract

Since wage is set below marginal product before training and above after training. The firm will earn a surplus if the worker quits after training. It can be made better off if the worker searches more intensively to quit while the worker can be made no worse off by compensating him for the extra search expenses. Pareto efficiency, therefore, requires a relatively high level of search intensity. However, with asymmetric information, the worker out of private interest searches only to the level that maximises his utility. This is insufficient to generate the efficient level of quits that can be achieved under a first-best contract. This result is summarised as follows.

Proposition 3

At the first-best optimum, under a perfect capital market if information on search were to become asymmetric, the worker would (locally) want to search not more intensively. Hence second-best search is insufficient relative to the first-best.

Proof

At the first-best optimum, Equation (10) which is the first-order condition for s of the first-best problem is satisfied. That is,

$$D_s Eu(c_2^*) - Eu'(c_2^*) = -\lambda_1 F_s(h - w_2^*) \leq 0$$

The inequality holds because $\lambda_1 > 0$, $h - w_2^* < 0$ and invoking Assumption 1, $F_s \leq 0$. Now if information on search became asymmetric, at the first-best optimum Equation (21), the first-order condition for s of the second-best problem, will not be satisfied. By the inequality, s^* tends to be too large for the second-best solution.

Q.E.D.

This result depends crucially on the fact that the equilibrium wage structure has w_2 exceeding marginal product in a perfect capital market. In Section IV, it will be shown that the opposite is true if w_2 is less than marginal product when the worker has no access to the capital market. In that case, second-best search is excessive relative to the first-best.

With the result of Proposition 3, it is now easier to understand why the result of Proposition 1 is independent of the degree of risk aversion but not the result in Proposition 2. In the first-best contract, given any w_2 the firm can induce any level of quits by specifying an appropriate level of search intensity in the contract. Hence as long as the worker is risk averse but regardless of how his risk aversion varies with income, it is always optimal to set a high w_2 to reduce variation in income between quitting and staying and at the same time specify an optimal level of search intensity to induce the efficient level of quits. However, in the second-best contract, search intensity cannot be part of the contract. It turns out that the worker's search is insufficient in this case. To induce efficient level of quits, w_2 must be set lower relative to its first-best level, but this imposes more risk on the worker, as wage insurance is traded off for quit incentives. In general, it is still optimal to set w_2 above marginal product. However, if the worker's risk aversion falls rapidly with income, it is possible that it is optimal to set w_2 sufficiently low as to be below marginal product, thus reducing substantially wage insurance in favor of quit incentives.

This leads us to the comparison of the levels of insurance provided by the two contracts.

D. Under-provision of Wage Insurance in Second-Best Contract

Relative to the first-best, the second-best contract tends to set w_1 too high and w_2 too low. This is because second-best search is insufficient to induce the efficient level of quits. Hence the second-best contract must trade off insurance for quit incentives by setting w_2 lower relative to its first-best level. By the zero-profit constraint, w_1 must be set relatively higher. Insurance is under-provided in the second-best contract. This result is contained in Proposition 4.

Proposition 4

At the second-best optimum under the same assumption on the worker's risk aversion as in Proposition 2 and a perfect capital market, if information on search intensity were to become symmetric, the firm would (locally) want to provide at least as much insurance by weakly increasing w_2 and weakly decreasing w_1 offered.

Proof

See Appendix 5.

IV. OPTIMAL CONTRACT UNDER IMPERFECT CAPITAL MARKET

In this Section we relax the extreme assumption of a perfect capital market. A more realistic assumption is that the worker can save and lend but cannot borrow in the capital market. The lack of access to borrowing can be justified on the grounds that human capital cannot be used as collateral in borrowing. Under this relaxed assumption, it can be shown that the worker will not save and lend and the problem is identical to the case where the worker cannot lend or borrow.

Proposition 5

When the worker can lend but not borrow, the first-best (second-best) contract is identical to that when there is no lending and borrowing (under the assumption on risk aversion in Proposition 2).

Proof

See Appendix 6.

Therefore, we need only to analyse the contract when the worker has no access to the capital market. Now since the worker cannot lend or borrow to smooth out his consumption over time, the optimal wage structure, besides providing insurance against staying, must now also take into consideration the worker's desire to even out consumption over time. It is not difficult to see that the wage structure will be less sharply rising than the perfect capital market case as smoothing out consumption across states must be balanced against smoothing out over time. In fact it can shown that under certain assumptions on the worker's risk aversion, the results are directly opposite to those of the perfect capital market case; period 2 wage is set below marginal product.

The sensitivity of the optimal wage profiles to the capital market assumptions was first pointed out by Weiss (1984) and Haltiwanger and Waldman (1986) using different contract models. In our model since the efficiency of job search depends on the wage structure and its relation to productivity, our results on job search are also sensitive to the capital market assumptions.

A. Wage Structure in First-Best Contract

The first-best contract when the worker cannot lend or borrow can be obtained by solving the following maximisation problem:

$$\max_{x,\, w_1,\, w_2,\, s} \quad u(w_1 - s) + Eu(w_2) \quad \text{.......................(27)}$$

subject to

$$(1 - x)m - w_1 + F(h - w_2) = 0 \quad \text{.......................(28)}$$

$$w_1 - s,\; w_2 \geq 0 \quad \text{.......................(29)}$$

In solving the problem we invoke Assumption 3 but not Assumptions 1 and 2. Following the same reasoning as before, (29) cannot be binding and there is an interior solution for s. The first-order conditions of the problem can now be written as

$$x \quad : \psi_1(-m + Fh') \begin{cases} = 0, & x \in (0, 1) \\ \leq 0, & x = 0 \\ \geq 0, & x = 1 \end{cases} \quad \text{.......................(30)}$$

$$w_1 \quad : u'(w_1 - s) - \psi_1 = 0 \quad \text{.......................(31)}$$

$$w_2 \quad : Fu'(w_2) + \psi_1\left[f(h - w_2) - F\right] = 0 \quad \text{.......................(32)}$$

$$s \quad : -u'(w_1 - s) + D_s Eu(w_2) + \psi_1 F_s(h - w_2) = 0 \quad \text{.......................(33)}$$

$$\psi_1 \quad : (1 - x)m - w_1 + F(h - w_2) = 0 \quad \text{.......................(34)}$$

where ψ_1 is the Lagrange multiplier associated with (28).

The optimal wage structure satisfies the following proposition.

Proposition 6

If the worker has no access to the capital market, the first-best contract sets wage above marginal product in period 1 before training and below in period 2 after training.

Proof

From (31),

$$\psi_1 = u'(w_1 - s)$$

This can be substituted into (32) to yield

$$h - w_2 = \frac{F}{f} \frac{u'(w_1 - s) - u'(w_2)}{u'(w_1 - s)} \quad \text{.................................(35)}$$

We can prove $h - w_2 > 0$ by contradiction. Suppose not and $h - w_2 < 0$. Then (35) implies $u'(w_1 - s) < u'(w_2)$, that is $w_1 - s > w_2$ by concavity of u. On the other hand, from the zero profit constraint, $w_1 < (1-x)m$ because $h - w_2 < 0$. Therefore, $w_1 - s < (1-x)m - s$. We now have the following relations

$$w_2 > h(x) \geq h(0) = m > (1 - x)m - s > w_1 - s$$

We have a contradiction. Hence $h - w_2 > 0$. Q.E.D.

B. Wage Structure in Second-Best Contract

When information on job search is asymmetric, the following incentive compatibility constraint on search intensity must be added to the first-best problem in (27) to (29) to give the second-best problem:

$$s \in \operatorname*{argmax}_{s' \in S} U(x, w_1, w_2, s') \quad \text{...(36)}$$

Now under Assumption 2, U is strictly concave in s.[19] Hence Assumptions 1 to 3 are sufficient for the solution without having to invoke Assumption 4. The first-order conditions of the second-best problem are

$$x \quad : \psi_2(-m + Fh') = 0, \ x \in (0, 1)$$
$$\leqslant 0, \ x = 0$$
$$\geqslant 0, \ x = 1 \quad \ldots\ldots(37)$$

$$w_1 \quad : u'(w_1 - s) - \psi_2 + \eta u''(w_1 - s) = 0 \quad \ldots\ldots(38)$$

$$w_2 \quad : Fu'(w_2) + \psi_2\left[f(h - w_2) - F\right] + \eta F_s u'(w_2) = 0 \quad \ldots\ldots(39)$$

$$\psi_2 \quad : (1 - x)m - w_1 + F(h - w_2) = 0 \quad \ldots\ldots(40)$$

$$\eta \quad : -u'(w_1 - s) + D_s Eu(w_2) = 0 \quad \ldots\ldots(41)$$

$$s \quad : \psi_2 F_s(h - w_2) + \eta\left[u''(w_1 - s) + D_s^{\,2} Eu(w_2)\right] = 0 \quad \ldots\ldots(42)$$

where ψ_2 is the Lagrange multiplier associated with the zero profit constraint, η is the multiplier associated with the first-order condition (41) which replaces constraint (36) and (42) is the adjoint equation for solving η.

In general the optimal wage structure can have w_2 larger or smaller than post-training marginal product. To get a more definite result, we can specify the sufficient condition for having w_2 smaller than marginal product in the following proposition.

Proposition 7

If the worker has no access to the capital market and is not very risk averse (Specifically $\sigma(w_1 - s) \leqslant -F_s(w_2|s)/F(w_2|s)$), the second-best contract sets wage above marginal product in period 1 before training and below in period 2 after training.

Proof

See Appendix 7.

It should be noted again that the result on period 2 wage in relation to productivity is dependent on utility parameters in the second-best contract but not the first-best contract.

C. Excessive Job Search in Second-Best Contract

At the first-best optimum, since wage w_2 is less than marginal product, the firm would like to have the worker stay in period 2 so as to recoup its investment in the worker. But under asymmetric information, job search is excessive as far as first-best efficiency is concerned. Relative to the first-best, the firm would like to have the worker search less and quit less frequently. Analogous to Proposition 3, we have

Proposition 8

At the first-best optimum, if the worker has no access to the capital market and information on search were to become asymmetric, he would (locally) want to search at least as intensively. Hence second-best search is excessive.

Proof

The proof is similar to that of Proposition 3. At the first-best optimum, (33) is satisfied. That is

$$-u'(w_{1n}^* - s_n^*) + D_s Eu(w_{2n}^*) = \psi_1 F_s(h - w_{2n}^*) \geq 0$$

where $(x_n^*, w_{1n}^*, w_{2n}^*, s_n^*)$ is the first-best contract when the worker has no access to the capital market. The inequality is due to ψ_1, $h - w_{2n}^* > 0$ and $F_s \leq 0$. If information on search became asymmetric, at the first-best optimum the first-order condition on search (41) of the second-best problem will not be satisfied. In fact s_n^* tends to be too small for the second-best solution. Q.E.D.

D. Over-provision of Wage Insurance in Second-Best Contract

Here we consider only the case where we have determinate result on the wage structure, that is the case where the worker is not very risk averse. The result in the following proposition is opposite to that of Proposition 4. Relative to the first-best, second-best wage insurance is excessive.

Proposition 9

At the second-best optimum, under the assumption that the worker has no access to the capital market and is not very risk averse as in Proposition 7, if information on search intensity were to become symmetric, the firm would (locally) want to provide not more insurance by weakly decreasing w_2 and weakly increasing w_1 offered.

The proof follows the same laborious algebraic procedures of the proof for Proposition 4 (see Appendix 8).

The results of Section IV can now be summarised by the following discussion. When the worker cannot lend or borrow, he would like to smooth out consumption over time by accepting a flatter wage profile. This would have to be at the expense of less smoothness in income between quitting and staying. Hence in the first-best contract, consumption over time is smoothed out by setting period 2 wage so low as to be below post-training marginal product. Efficient level of quits is achieved by specifying an appropriate search intensity to be undertaken by the worker. However, in the second-best contract, search intensity cannot be part of the contract. The worker searches excessively. In order to recoup its investment in the worker, the firm must set w_2 higher than its first-best level to discourage quits. This provides more wage insurance to the worker but also makes his consumption stream over time more uneven. If the worker is not very risk averse, he is relatively less concerned with smoothing out wage across states than with smoothing out consumption over time. In that case, it is optimal to still set w_2 below post-training marginal product. In other cases, sufficiently large risk aversion may require setting w_2 above marginal product to achieve sufficient smoothing of income across states.

V. WAGE PROFILE AND SHARING OF INVESTMENT

One of the major points of contention concerning wage profile is whether it rises faster or slower than productivity over time. Early work of Becker (1964) and those of Parson (1972) and Hashimoto (1981) indicate that when specific investment is shared between risk neutral worker and the firm, wage rises slower than productivity. However, extensions by Donaldson and Eaton (1976), Nickell (1976) and Ohashi (1983) allow for the wage profile to rise faster than productivity.

A second line of approach, due to Lazear (1979, 1981), is based on an incentive compatibility argument. Wage must rise faster than productivity to provide the incentive for workers not to shirk. A synthesis of the human capital approach and incentive approach is given by Kuhn (1986).

Wage insurance offers an alternative approach. Our model integrates the wage insurance approach and the human capital approach. The results show that when the worker is risk averse, specific human capital investment is neither necessary nor sufficient in generating wage profiles which rise slower than productivity. When wage insurance is provided, whether wage rises faster or slower than productivity depends on the nature of the capital market in the case of the first-best contract and also on the degree of risk aversion in the case of the second-best contract. The desire for insurance, the degree of risk aversion and the ability of the worker to smooth out intertemporal consumption by borrowing and lending will determine how fast wage will rise relative to productivity.

In a perfect capital market the worker's share of the cost of investment under the contract can be written as

$$\rho_c = \frac{m - w_1}{mx} = \frac{mx - F(h - w_2)}{mx} > 1$$

since $h - w_2 < 0$. The worker's share of the returns to investment is given by

$$\rho_r = \frac{w_2 - m}{h - m} > 1$$

On the other hand, when the worker has no access to the capital market, in both the first-best and the second-best contracts (as long as risk aversion is sufficiently small), both ρ_c and $\rho_r < 1$ because $h - w_2 > 0$. However, the conventional human capital analysis of Hashimoto (1981) based on the sharing of specific human capital investment when there are quits but no layoffs would have the risk neutral worker bear the full share of costs and returns. The provision for insurance therefore requires the worker to bear a larger share of the investment when he has access to a perfect capital market and the firm to take a larger share when the worker has no access.

VI. EFFICIENCY IN RISK SHARING, INVESTMENT AND TURNOVER

We have shown so far our investment cum fixed wage contracts are inefficient in risk sharing in that not all risks are shifted from the risk averse worker to the risk neutral firm. Insurance provided in the contract is partial, not full, because of moral hazard problems. In this section we will examine further whether there are investment efficiency and turnover efficiency.

The criterion for investment efficiency is that resources will not be wasted by specific human capital being rendered useless as a result of quits. Therefore, it would require investment to take place only if there will be no turnover. Now an optimal contract in all the cases we have studied satisfies the following first-order condition on investment.

$$-m + Fh' \begin{cases} = 0, & x \in (0, 1) \\ \leq 0, & x = 0 \\ \geq 0, & x = 1 \end{cases}$$

which specifies that investment takes place only if its expected marginal return Fh' is no less than its marginal cost m. Therefore a contract is investment-efficient if the following is satisfied.

$$h'(x) \geq m \text{ , } F(w_2|s) = 1 \text{ and } 0 < x \leq 1 \qquad (43)$$

None of our contracts satisfies (43) because optimal w_2 always entails $F(w_2|s) < 1$ as infinite wage payments are not possible. Under any of the contracts considered, there will be quits but investments are not necessarily zero. Hence specific human capital will be destroyed. However, contracts which set w_2 high are, relatively speaking, less inefficient in investment since the probability of specific investment being wasted as a result of quits is less. Hence among the contracts considered, the first-best contract in a perfect capital market tends to be the least inefficient in investment. Since the provision of wage insurance in general requires w_2 to be set relatively high in any contract, we can conclude that wage insurance tends to reduce investment inefficiency of the investment cum wage contracts.

In contrast to the lack of investment efficiency, some of our contracts have turnover efficiency. According to the criterion of Hall and Lazear (1984), turnover is efficient if the worker quits when his spot marginal product in another firm exceeds his post-training marginal product in the original firm. Therefore, match qualities are improved through quitting. Hence turnover is always efficient if a contract sets wage above post-training marginal product, as in the first-best contract and second-best contract under certain weak assumptions on workers' risk aversion in the perfect capital market case. This is in contrast to the results of Hall and Lazear (1984) which show that fixed wage contracts are always not turnover-efficient under risk neutrality. In our model, wage insurance requires that the wage be set so high as to exceed marginal product in some contracts, and turnover efficiency is achieved.

On the other hand, when workers have no access to the capital market, the contracts which prevail when workers are not very risk averse tend to set wage below marginal product. In this case workers will be quitting sometimes when their spot marginal products are actually less than their post-training marginal products in the present firms. Quits are inefficiently excessive.

Since the provision of wage insurance requires that w_2 be set relatively high in any contract, it reduces the probability of inefficient quits and thus turnover inefficiency.

The results in this Section can be summarised in the following Proposition.

Proposition 10

The provision of wage insurance tends to reduce investment inefficiency and turnover inefficiency of investment cum fixed wage contracts.

VII. POLICY IMPLICATIONS

Tentative policy implications can be drawn from results in this paper. Our analysis suggests that inefficiency in the contract market can be reduced in a number of ways. Suppose search activities are not completely unobservable to the firms and there is a component of verifiable job search along the line suggested by Strand (1985), there is a case for the firms to subsidise or penalise verifiable search depending on whether search is insufficient or excessive. Even if job search is unobservable to the firms, in the case of the perfect capital market where search is insufficient, the firm can offer subsidies in kind by providing job market information to the workers. This will lower their search costs and more the solution closer to the first-best.

Risk-sharing inefficiency, investment inefficiency and turnover inefficiency can all be reduced, if workers are able to borrow and lend. In the credit market, workers' ability to borrow is limited because human capital cannot be used as collateral. This limitation can be alleviated if employees form credit unions among themselves. Firms may also lend or advance wage payments using workers' pension as collateral.

When a worker quits, resources devoted to specific human capital investment are wasted even though quitting itself may be efficient. If firms can devise a screening or self-selection mechanism which differentiates workers according to their propensity to quit and provides specific training only to non-quitters, investment inefficiency can be eliminated.

It should be emphasised that this discussion on policies is only cursory. Our wage contract is rather complex in that it has to balance among risk sharing efficiency, intertemporal efficiency in consumption, turnover efficiency and investment efficiency. Any policy recommendation which reduces inefficiency at one margin may introduce new sources of inefficiency at another. An in-depth analysis of policy impacts will be necessary but it will be the subject of a separate paper.

VIII. <u>CONCLUSION</u>

In this paper we integrate a human capital investment model, a job search model and a principal-agent model into the labor contract theory to analyse the moral hazard problems which arise from the distortion of quit incentives by the provision of wage insurance and the unobservability of job search intensity of the workers by the firms. The focus is on an asymmetry of information on job search. The first-best and second-best contracts under different capital market assumptions are compared. It is shown that whether second-best search is insufficient or excessive relative to the first-best depends on whether the contract sets wage above or below post-training marginal product, and that in turn depends on the workers' ability to smooth out intertemporal consumption in the capital market and their degree of risk aversion. Wage insurance offers an alternative explanation of the relative steepness of the wage and productivity profiles. It tends to reduce investment inefficiency and turnover inefficiency of investment cum fixed wage contracts.

There are several limitations in our model, the elimination of which suggests directions for extensions and further work. First, the assumptions on search technology are rather strong, in particular Assumption 4. They are imposed to yield tractable results. It would be interesting to see if relaxing them affect the main results at all. Second, we have not dealt with adverse selection in our model. An extension in that direction would be useful. Third, there is no layoff in our model. Hence we cannot deal with problems of layoff and unemployment. Finally, we analyse only the partial equilibrium in the contract market. A general equilibrium analysis which endogenises the wage offer distribution in the direction suggested by Rothschild (1973) would be useful but appears exceedingly difficult.

Appendix 1

Reservation Wage of Search Model

In our simple search model, there is only one draw from the wage offer distribution at the end of period 1. Hence searching always stops after one search. The relevant decision of the searcher then is whether to stay or quit to accept the job given a wage offer $\tilde{w}_2$. Let w_r be a critical number with the following property

$$\text{quit if } \tilde{w}_2 > w_r$$

$$\text{stay if } \tilde{w}_2 \leqslant w_r$$

Then w_r is the reservation wage. In the case of a perfect capital market the utility of the worker following the reservation wage rule is written as

$$U(w_r) = u(c_1) + F(w_r|s)u(c_2) + \int_{w_r}^{\infty} u(\tilde{c}_2)f(\tilde{w}_2|s)d\tilde{w}_2$$

where c_i is the worker's consumption in the i^{th} period and $\tilde{c}_2$ his stochastic consumption in period 2 if he quits and they are related through budget constraints as follows:

$$c_2 = w_1 - s - c_1 + w_2$$

$$\tilde{c}_2 = w_1 - s - c_1 + \tilde{w}_2$$

The optimal reservation wage is obtained by solving $U'(w_r) = 0$. That is

$$f(w_r|s)u(c_2) - f(w_r|s)u(c_{2r}) = 0$$

where

$$c_{2r} = w_1 - s - c_1 + w_r$$

Hence $c_{2r} = c_2 \Rightarrow w_r = w_2$.

The optimal reservation wage is the period 2 wage in the present firm.

Condition for Non-zero Search

It can be shown that at both the first-best and second-best optimal values of x, w_1 and w_2, if $\partial U/\partial s > 0$ at $s = 0$, zero search will not be optimal.

Consider a perfect capital market. The case of the second-best problem is straightforward. $\partial U/\partial s > 0$ violates the weak inequality of $\partial U/\partial s \leq 0$ required for a corner solution of $s = 0$. The first-best case is slightly more complicated. A corner solution of $s = 0$ requires that the following first-order condition from (10) be satisfied:

$$\frac{\partial \mathcal{L}_I}{\partial s} = \frac{\partial U}{\partial s} + \lambda_1 F_s(h - w_2) + \phi_1 \frac{\partial^2 U}{\partial s^2} \leq 0$$

From the analysis which follows in the text, it can be shown that $\phi_1 = 0$, $\lambda_1 > 0$, $F_s \leq 0$ by Assumption 1 and $h - w_2 < 0$ from Proposition 1. In particular, the result of $h - w_2 < 0$ does not depend on whether a corner or an interior solution for s entails. Hence if $\partial U/\partial s > 0$, $\partial \mathcal{L}_I/\partial s > 0$ and a corner solution of $s = 0$ is precluded.

But the condition of $\partial U/\partial s > 0$ implies

$$\frac{\partial U}{\partial s} = D_s Eu(c_2) - Eu'(c_2) > 0$$

where D_s is the partial differential operator of s which shifts only the distribution function holding utility constant. That is, $D_s Eu(c_2) > Eu'(c_2)$ at $s = 0$, which means that the marginal expected returns to search due to a shift in distribution exceeds the marginal expected cost of search. This inequality will be satisfied if there is strong SDC at $s = 0$.

Appendix 3

Signs of $D_s{}^2Eu(c_2)$ and $D_sEu'(c_2)$

We need to show $D_s{}^2Eu(c_2)$, $D_sEu'(c_2) \leqslant 0$.

Consider

$$Eu(c_2) = Fu(c_2) + \int_{w_2}^{\infty} u(\tilde{c}_2)fd\tilde{w}_2$$

Since $u(\tilde{c}_2)$ is increasing in $\tilde{w}_2$, there exists $w_2 < w_2{}^m < \infty$ and $c_2{}^m = w_1 - s - c_1 + w_2{}^m$ such that

$$Eu(c_2) = Fu(c_2) + u(c_2^m)\int_{w_2}^{\infty} fd\tilde{w}_2$$

$$= Fu(c_2) + u(c_2^m)(1 - F)$$

Now apply the partial differential operator D_s twice, we have

$$D_s^2\ Eu(c_2) = F_{ss}\left[u(c_2) - u(c_2^m)\right] \leqslant 0$$

since $F_{ss} \geqslant 0$ by CDFC and $u(c_2) < u(c_2{}^m)$.

Also,

$$Eu'(c_2) = Fu'(c_2) + \int_{w_2}^{\infty} u'(\tilde{c}_2)fd\tilde{w}_2$$

Since $u'(\tilde{c}_2)$ is decreasing in $\tilde{w}_2$, there exists $w_2 < w_2{}^a < \infty$ and $c_2{}^a = w_1 - s - c_1 + w_2{}^a$ such that

$$Eu'(c_2) = Fu'(c_2) + u'(c_2{}^a)\int_{w_2}^{\infty} fd\tilde{w}_2$$

$$= Fu'(c_2) + u'(c_2{}^a)(1 - F)$$

Apply D_s, we have

$$D_sEu'(c_2) = F_s\left[u'(c_2) - u'(c_2{}^a)\right] \leqslant 0$$

since $F_s \leqslant 0$ by SDC and $u'(c_2) > u'(c_2{}^a)$ by concavity of u.

Appendix 4

Proof of Lemma

Let

$$\frac{f_s(w_2|s)}{f(w_2|s)} = \alpha$$

where α is any value, then by MLRC

$$f_s(w_2|s) = \alpha f(w_2|s) \Rightarrow f_s(\tilde{w}_2|s) \leq \alpha f(\tilde{w}_2|s), \ \forall\ \tilde{w}_2 < w_2$$

$$\Rightarrow \int_0^{w_2} f_s(\tilde{w}_2|s)\,d\tilde{w}_2 \leq \alpha \int_0^{w_2} f(\tilde{w}_2|s)\,d\tilde{w}_2$$

$$\Rightarrow F_s(w_2|s) \leq \alpha F(w_2|s)$$

$$\Rightarrow \frac{F_s(w_2|s)}{F(w_2|s)} \leq \alpha$$

Q.E.D.

Appendix 5

Proof of Proposition 4

At the second-best optimum, $(\hat{x}, \hat{w}_1, \hat{w}_2, \hat{s}, \hat{c}_1, \hat{c}_2)$, the first-order condition (19) with respect to w_2, is satisfied:

$$Fu'(\hat{c}_2) + \lambda_2[f(h - \hat{w}_2) - F] + \mu[F_s u'(\hat{c}_2) - Fu''(\hat{c}_2)] = 0 \quad \text{.......(A5.1)}$$

Substitute in λ_2 and μ as in the proof for Proposition 2, we have

$$Fu'(\hat{c}_2) + Eu'(\hat{c}_2)[f(h - \hat{w}_2) - F] = \frac{-F_s(h - \hat{w}_2)A}{V} \geqslant 0$$

since $F_s \leqslant 0$, $h - \hat{w}_2$, $V < 0$ and $A \geqslant 0$.

But the first-order condition with respect to w_2 of the first-best problem, Equation (9), is not satisfied at the second-best optimum. Let the Lagrangian function of the first-best problem be $\mathcal{L}_I$. Then at the second-best optimum, after substituting in λ_I (9) is given by

$$\left(\frac{\partial \mathcal{L}_I}{\partial w_2}\right)_{II} = Fu'(\hat{c}_2) + Eu'(\hat{c}_2)[f(h - \hat{w}_2) - F] \geqslant 0 \quad \text{................(A5.2)}$$

where subscript II denotes that the term is evaluated at the second-best optimum. Hence we conclude that at the second-best optimum, if information on search were to become symmetric, the firm would (locally) want to weakly increase w_2 to provide at least as much insurance. This proves the first half of the Proposition.

The proof of the second half concerning w_1 is similar. At the second-best optimum, the first-order condition (18) with respect to w_1, is satisified,

$$Eu'(\hat{c}_2) - \lambda_2 + \mu[D_s Eu'(\hat{c}_2) - Eu''(\hat{c}_2)] = 0 \quad \text{....................(A5.3)}$$

Now λ_2 and μ can be solved simultaneously from (19) and (23) in terms of other variables. Substitute λ_2 and μ into (A5.3), we have after algebraic manipulations,

$$Eu'(\hat{c}_2) + \frac{Fu'(\hat{c}_2)}{f(h-\hat{w}_2) - F} = \frac{-F_s(h-\hat{w}_2)A}{V[f(h-\hat{w}_2) - F]} \leq 0$$

The first-order condition with respect to w_1 of the first-best problem, Equation (8), is now not satisfied at the second-best optimum. In fact, substituting in λ_1, (8) yields

$$\left(\frac{\partial \mathcal{L}_I}{\partial w_1}\right)_{II} = Eu'(\hat{c}_2) + \frac{Fu'(\hat{c}_2)}{f(h-\hat{w}_2) - F} \leq 0$$

Hence if information on search were to become symmetric, the firm would (locally) want to weakly reduce w_1 offered. Q.E.D.

Proof of Proposition 5

The first-best maximisation problem can be written as Equations (1) to (6) as in the perfect capital market case plus the following constraint which bars borrowing

$$w_1 - s \geqslant c_1 \text{ ....(A6.1)}$$

We need to prove that (A6.1) must satisfy as equality, $w_1 - s = c_1$. That is, the worker will not reduce consumption in period 1 in order to save and lend. Then from the budget constraint $c_2 = w_1 - s - c_1 - w_2$, we have $w_2 = c_2$. The first-best problem is now identical to the first-best problem when the worker has no access to the capital market. The same proof holds for the second-best problem. Hence the Proposition is proved if we can prove that $w_1 - s = c_1$. This is done by contradiction.

Suppose $w_1 - s > c_1$, constraint (A6.1) is not binding and the first-best problem is identical to that of the perfect capital market case. From Propositon 1, we have $h - w_2 < 0$. It follows from the zero profit constraint that $w_1 < (1-x)m$. Hence we have the following string of relations:

$$w_2 > h(x) \geqslant h(0) = m > (1-x)m - s > w_1 - s$$

From the budget constraint $c_2 = w_1 - s - c_1 - w_2$, since $w_1 - s > c_1$, we have $c_2 > w_2$. Hence

$$c_2 > w_2 > w_1 - s > c_1$$

We conclude $c_2 > c_1$.

But from (12), the first-order condition for c_1,

$$\begin{aligned} u'(c_1) &= Eu'(c_2) \\ &= Fu'(c_2) + \int_{w_2}^{\infty} u'(\tilde{c}_2) f d\tilde{w}_2 \\ &< Fu'(c_2) + u'(c_2)(1 - F) \\ &= u'(c_2) \end{aligned}$$

where the inequality is due to the concavity of u. Therefore,

$$u'(c_1) < u'(c_2) \Rightarrow c_1 > c_2$$

Hence we have a contradiction. Q.E.D.

Appendix 7

Proof of Proposition 7

The algebraic procedures of the proof are identical to those of the proof for Proposition 2. ψ_2 and η are solved simultaneously from (38) and (42) and substituted into (39). We have after re-arranging terms,

$$h - w_2 = \frac{TF}{Tf - FF_s u'(w_2)\left[\frac{F_s}{F} + \sigma(w_1 - s)\right]} \cdot \frac{u'(w_1 - s) - u'(w_2)}{u'(w_1 - s)} \quad \ldots\ldots\text{(A7.1)}$$

where

$$T \equiv u''(w_1 - s) + D_s^{\,2}Eu(w_2) < 0$$

If the worker is not very risk averse so that

$$\frac{F_s(w_2|s)}{F(w_2|s)} + \sigma(w_1 - s) \leqslant 0$$

then $\text{sgn}(h - w_2) = \text{sgn}[u'(w_1 - s) - u'(w_2)]$. We can prove $h - w_2 > 0$ by contradiction using the same arguments in the proof for Proposition 6. $w_1 > (1-x)m$ follows from the zero profit constraint. Q.E.D.

Appendix 8

Proof of Proposition 9

The proof follows the same procedures as the proof for Proposition 4. At the second-best optimum $(\hat{x}_n, \hat{w}_{1n}, \hat{w}_{2n}, \hat{s}_n, \hat{c}_{1n}, \hat{c}_{2n})$, the first-order condition (39) with respect to w_2, is satisfied.

$$Fu'(\hat{w}_{2n}) + \psi_2[f(h-\hat{w}_{2n}) - F] + \eta F_s u'(\hat{w}_{2n}) = 0 \quad \text{.................(A8.1)}$$

Substitute in ψ_2 and η and solving, we have

$$Fu'(\hat{w}_{2n}) + u'(\hat{w}_{1n} - \hat{s}_n)[f(h - \hat{w}_{2n}) - F]$$

$$= \frac{FF_s(h - \hat{w}_{2n})u'(\hat{w}_{2n})u'(\hat{w}_{1n} - \hat{s}_n)}{T}\left[\frac{F_s}{F} + \sigma(\hat{w}_{1n} - \hat{s}_n)\right]$$

$$\leqslant 0 \quad \text{..................(A8.2)}$$

since $T < 0$, F_s, $\left[\frac{F_s}{F} + \sigma(\hat{w}_{1n} - \hat{s}_n)\right] \leqslant 0$ and $h - \hat{w}_{2n} > 0$.

Denote the Lagrangian function of the first-best problem by $\mathcal{L}_{In}$ Then

$$\left(\frac{\partial \mathcal{L}_{In}}{\partial w_2}\right)_{II} = Fu'(\hat{w}_{2n}) + u'(\hat{w}_{1n} - \hat{s}_n)[f(h - \hat{w}_{2n}) - F] \leqslant 0 \quad \text{........(A8.3)}$$

Now consider the first-order condition (38) with respect to w_1 at the second-best optimum after substituting in ψ_2 and η.

$$u'(\hat{w}_{1n} - \hat{s}_n) - \frac{Fu'(\hat{w}_{2n})}{F - f(h-\hat{w}_{2n})} = \frac{-FF_s(h-\hat{w}_{2n})u'(\hat{w}_{2n})u'(\hat{w}_{1n}-\hat{s}_n)}{T[F - f(h-\hat{w}_{2n})]}\left[\frac{F_s}{F} + \sigma(\hat{w}_{1n} - \hat{s}_n)\right]$$

$$\text{..........(A8.4)}$$

Signs of all terms on RHS are already known except that of $F - f(h - \hat{w}_{2n})$. But $h - \hat{w}_{2n}$ is given by (A7.1). Hence

$$F - f(h-\hat{w}_{2n}) = \frac{-F^2F_s u'(\hat{w}_{2n})\left[\frac{F_s}{f} + \sigma(\hat{w}_{1n} - \hat{s}_n)\right]}{Tf - FF_s u'(\hat{w}_{2n})\left[\frac{F_s}{F} + \sigma(\hat{w}_{1n} - \hat{s}_n)\right]} \cdot \frac{u'(\hat{w}_{1n} - \hat{s}_n) - u'(\hat{w}_{2n})}{u'(\hat{w}_{1n} - \hat{s}_n)}$$

$$\geqslant 0 \quad \text{...........(A8.5)}$$

since $[u'(\hat{w}_{1n} - \hat{s}_n) - u'(\hat{w}_{2n})]/u'(\hat{w}_{1n} - \hat{s}_n) > 0$ by the proof in Appendix 7. Hence we conclude

$$u'(\hat{w}_{1n} - \hat{s}_n) - \frac{Fu'(\hat{w}_{2n})}{F - f(h-\hat{w}_{2n})} \geqslant 0$$

Therefore,

$$\left(\frac{\partial \mathcal{L}_{In}}{\partial w_1}\right)_{II} = u'(\hat{w}_{1n} - \hat{s}_n) - \frac{Fu'(\hat{w}_{2n})}{F - f(h-\hat{w}_{2n})} \geqslant 0 \quad \text{....................(A8.6)}$$

Q.E.D.

Footnotes

(1) For a discussion of long term contracts, see Holmstrom (1983).

(2) See Propositions 1 to 3 of Arnott (1982).

(3) For an analysis of searching while employed, see Burdett (1978), Mortensen (1978), Seater (1979) and Benhabib and Bull (1983).

(4) See Rogerson (1985) and Mirrlees (1975).

(5) By assuming that workers and firms are identical, we abstract from adverse selection problems which may arise if workers have different proneness to quit.

(6) Information on search intensity may be symmetric and available to the firm if search is time-intensive and the worker takes time away from work to search. Then search time is just the residual after netting investment time from working time. Strand (1985) distinguishes between verifiable and non-verifiable search expenses of the worker.

(7) Many studies which focus on wage insurance but not unemployment simply assume that the contract binds the firm from discharging workers. See, for example, Arnott (1982), Harris and Holmström (1982), Weiss (1984), Arnott and Stiglitz (1985), Haltiwanger and Waldman (1986) and Berkovitch (1986). Our paper, therefore, is not concerned with explaining layoffs and unemployment as would be the aim of the conventional implicit contract literature.

(8) In a two-period world, firms which hire workers only in the second period will have no choice but to pay them according to their spot marginal product. As discussed in Arnott and Stiglitz (1985), a two-period structure will eliminate the problem of Pareto inefficiency of the equilibrium contract arising from externalities.

(9) Investment in specific human capital will raise the worker's productivity in the firm but not elsewhere, thus increasing his comparative advantage in staying in the firm. However, it is assumed that the distribution of match qualities are sufficiently disperse so that even though specific investment may reduce quit probability, it does not completely eliminate the possibility of a better match elsewhere.

(10) For an economic interpretation of MLRC, see Milgrom (1981).

(11) For a proof of this result, see Rogerson (1985) and Whitt (1980).

(12) The empirical work of Chirinko (1982) shows that returns to job search diminish, thus lending support to the assumption of CDFC.

(13) This is in contrast to the results of Burdett (1978) and Benhabib and Bull (1983). In their models of search while employed a reservation wage does not exist but searchers have switch points. The difference is again due to the fact that search is time-intensive in their models but not in ours.

(14) Note that this assumption corresponds to Assumption (A.10) of Rogerson (1985).

(15) See Arnott and Stiglitz (1985), pp. 445-450.

(16) For a discussion of this tradeoff in a different model, see Weiss (1984).

(17) A similar assumption on a degenerate wage offer distribution and a feasibility constraint on wage are also imposed by Freeman (1977)

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