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WAGE STRUCTURE WITH MORAL HAZARD IN JOB SEARCH

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Abstract

In this paper we analyse the structure of wages of workers in contract firms for a two-period economy in which there are interfirm mobility and job search. A contract firm provides specific training for a worker during the first period, which increases his productivity if he stays in the second period, but the worker may quit to join a spot market firm after a successful search. We consider four regimes which are classified according to the nature of capital markets faced by the worker and the form of informational asymmetry concerning job search between the contract firm and the worker.

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Kit-Chun Lam, Pak-Wai Liu and Yue-Chim Wong*

I. INTRODUCTION

This paper examines the structure of intertemporal wage profiles in relation to the productivity profiles in a two-period economy. Specifically, it analyses the wage structure in an economy in which there are contracting, specific training, interfirm mobility and privately observed job search and wage offers. This characterisation of the economy is motivated by what goes on in the labor market; namely specificity in production motivates joint investments in specific human capital between workers and firms; the recouping of these returns requires long term attachment and hence a contract to govern the exchange relation; the contract, however, cannot preclude workers, who take private search actions and receive private outside wage offers, from quitting.

The backbone of our model is laid out as follows. Identical workers enter into ex ante contracts with contract firms which stipulate the level of specific training that contract firms provide in the first period and intertemporal wages. Specific training enhances workers' second-period productivity in contract firms. Contract firms' investments in training, however, are affected by workers' mobility between contract firms and spot market firms. Specifically, workers search in the first period

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for higher paying second-period jobs in the spot market and will quit if their search is successful. The more intensively they search, the higher their expected maximum spot market wage offers. These offers are private to workers. This paper derives results on intertemporal consumption smoothing and insurance in wage contracts when workers' search is observable or unobservable under different assumptions on their borrowing constraints in capital markets.

One of the major stylised facts concerning labor earnings is that the intertemporal wage profile is rising. The human capital literature (Becker, 1964, and Parsons, 1972) offers a productivity-based explanation. Another explanation is based on an incentive compatibility argument (Lazear, 1979, 1981).

When there are specific investments that necessitate long-term worker attachment to the firm, the desire for wage insurance and consumption smoothing in an intertemporal contract must be taken into consideration within the context of a contract. Studies which take this approach emerge as a branch of the implicit contract literature which focus on wage structure but not on employment. These include Freeman (1977), Harris and Holmström (1982), Weiss (1984) and Haltiwanger and Waldman (1986). Their main concern is the provision of insurance through the contract against the uncertainty workers face concerning their own future productivity under different capital market assumptions. One of their main results is that the wage profile is non-decreasing. For instance, Harris and Holmström (1982) show that the threat of quitting will force the wage to be bid up. The rising earnings profile can be generated purely by an

insurance effect.

This paper follows the same general approach but will address two deficiencies in these other studies. First, with the exception of a brief discussion in Weiss (1984) there has been no treatment of consumption smoothing in these studies. The reason for this is because most previous studies are mainly concerned with insurance against different outcomes of the workers' productivity over time but not with the intertemporal structure of wage. However, in an intertemporal contract consumption smoothing should be a major concern as it will have to be reconciled with the rising wage profile. Besides, the intertemporal wage structure may be affected by tension between consumption smoothing and insurance. Our paper will deal with these issues.

Second, previous studies typically assume that workers can quit ex ante but ex post there is no mobility. For reason of feasibility, these models typically constrain the wage to prevent all workers from being bid away by other firms so that there is no turnover ex post. The lack of interfirm mobility, besides being counterfactual, characterises an inefficient labor market which is uninteresting. In this paper we explicitly allow for interfirm mobility which arises as the outcome of costly private search.[1] This enables us to analyse the intertemporal wage structure in the presence of tension between productive efficiency on the one hand, and consumption smoothing or insurance on the other as well as how it may be affected by the moral hazard of search.

The main results of this paper are as follows:

(i) Given investments in firm-specific skills, the sole reason for a rising wage profile is the presence of stochastic external alternatives which can be realised by search.

(ii) Tension which arises out of moral hazard between productive efficiency on the one hand, and consumption smoothing (insurance) on the other, will accentuate (attenuate) the slope of the wage profile but in all cases the profile remains upward-sloping.

(iii) When workers cannot borrow in capital markets consumption smoothing dominates and the equilibrium contract will prescribe a rising wage profile which is flatter than the productivity profile.

(iv) When workers can borrow in capital markets wage insurance dominates and the wage profile will be steeper than the productivity profile.

(v) The results in (ii), (iii) and (iv) are robust with respect to whether search effort is observable or unobservable to the firm.

There are several novelties in this paper. First, it explicitly considers intertemporal contracts and allow for the inclusion of human capital accumulation. Second, the model incorporates a two-fold moral hazard problem which arises from private wage offers and private search. Third, it embeds an agency problem within an implicit contract.[2] As a matter of fact this paper brings together disparate strands of the labor economics literature and its related literature: implicit contract theory à la Azariadis-Baily, specific human capital -model à la Becker-Oi, principal-agent theory à la Mirrlees-

Holmström, job search theory à la Lippman-McCall, interfirm mobility model à la Arnott-Stiglitz and intertemporal liquidity model.

The rest of the paper is organized as follows. The model is contained in Section II. In Section III contracts under symmetric and asymmetric information on search when workers have no access to capital markets are analysed with a characterisation of the wage structures. The analysis is repeated in Section IV when workers are assumed to have access to capital markets. A discussion on the wage profile is in Section V. The paper concludes in Section VI.

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. There are no productivity shocks. Firms are competitive, risk neutral and maximise expected profit. There are two types of firms, contract firms and spot market firms. Contract firms are identical; jobs in these firms can be considered as routine. Spot market firms, however, are different and have varied skill requirements; these firms have different match qualities with different workers.[3]

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 spot market firms. 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. At the beginning of the first period, a worker enters into a wage contract with a contract firm which pays him wages w_1 and w_2 in the two periods. In the first period, time is spent working and investing in specific human capital in the firm. All training costs are time costs. 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 which is observable to both parties. Let m be the workers' first-period productivity per unit time in the contract firm. Specific training 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 with a strictly concave technology. It 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. The workers' productivity profile over time in the contract firm is, therefore, rising due to the presence of specific human capital investment (provided that it is non-zero).

In period 1 the worker also spends out-of-pocket resources

in job search with its level of intensity given by expenditure s, which may be intepreted as outlay on gathering employment information like visiting employment agencies and employers, placing advertisements in newspapers etc.[4] At the end of the period, the worker will receive wage offers from spot market firms and depending on its outcome, he either stays with the contract firm in the second period and receives wage w_2 or quits to join a spot market firm.[5] 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. Its nature depends on the information possessed by the two parties. If information on the worker's realized wage offers is public, the contract is called first-best. However, in this paper we will concentrate on symmetry and asymmetry of information on job search intensity. Therefore, throughout this paper we will assume that information on realised wage offers is always private to the worker and the first-best contract will not be considered further.[6] We will analyse only second-best and third-best contracts.

If information on search intensity is symmetric, the contract that entails, $\delta_{II}(x, w_1, w_2, s)$, will stipulate the level of specific training provided by the firm, wage payments in the two periods and search intensity of the worker and will be called second-best in this paper. More often than not, information on search intensity is also private to the worker. If the firm provides wage insurance against staying by setting

w_2 as an increasing function of the worker's stated search effort 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. The worker who lies will therefore be subsidised if he stays. There is no mechanism which will induce truth-telling. Hence when information is private, search intensity cannot be part of the contract. In this case the ex ante contract is third-best and is characterised by $\delta_{III}(x, w_1, w_2)$.

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 contract firm will not lay off workers.[7] The contracts under consideration, in particular the third-best contract, are basically fixed-wage cum investment contracts. Since only level of training provided by the firm and wages over time are specified, they can be made explicit and hence are informationally feasible, implementable and enforceable by law. No recontracting at the end of the first period is permissible.

Having characterised the contractual relation between the worker and the contract firm, 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. The wage offers he may receive are stochastic and depend on match qualities with spot market firms. Specifically, a worker who is not very productive in one spot market firm may be highly productive in another because of specificities.[8] The distribution of maximum

wage offers which the worker recevies is denoted by $F(\tilde{w}_2)$ where $\tilde{w}_2$ is the stochastic maximum wage offer. The distribution is non-degenerate and its supports are assumed to be in $[0, \infty)$. It is continuously differentiable with density function $f(\tilde{w}_2)$.

We must now 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 denoted by $F(\tilde{w}_2|s)$ and $f(\tilde{w}_2|s)$. More importantly, the following assumption on the search technology is made.

Assumption 1

The density function $f(\tilde{w}_2|s)$ satisfies the strict monotonic likelihood-ratio condition (MLRC). That is, f_s/f is increasing in $\tilde{w}_2$.[9]

Subscript s denotes partial derivative. MLRC is in fact related to the search literature. It is implied by standard models of offer arrival if the arrival rate is taken to be increasing in search intensity. It also implies the strict stochastic dominance condition (SDC), i.e. $F_s < 0$.[10] 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; search strictly increases the prospect of a good wage offer. We will assume further that s does not shift the supports of the distribution.

It is easy to show that the optimal search strategy in our model has the standard reservation wage property.[11] The reservation wage is simply w_2.

III. CONTRACTS WITH NO ACCESS TO CAPITAL MARKETS

We first analyse the structure of the equilibrium contract under the assumption that the worker can save and lend but cannot borrow in capital markets. The lack of access to borrowing facilities can be justified on the ground that human capital cannot be used as collateral in borrowing. Under this assumption, it can be shown that the worker will not save and lend and the problem is identical to the case where he can neither lend nor borrow.

Proposition 1[12]

Contracts are unaffected by the admissibility of saving and lending by the worker.

Proposition 1 is not a new result. Harris and Holmström (1982) proved the same result in a different model. It suggests that the worker will not save in period 1 even if he has the opportunity to do so. Suffice it to say that the worker always desires to smooth out consumption over time. If borrowing facilities in financial institutions are not available so that the worker cannot borrow to even out intertemporal consumption, it is optimal for the contract firm to become a lender and provide banking services by tailoring the wage profile to suit his consumption plans. Hence saving opportunities will not be taken up by the worker.

A. Wage Structure in Second-Best Contract

With the result of Proposition 1, we need only to analyse the contract when the worker has no access at all to capital markets. The worker's utility function is

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

$$= u(w_1 - s) + Eu(w_2)$$

where the first term on the RHS of the first equation is his utility in period 1; the second term is his utility in period 2 if he stays weighted by his probability of stay; the third term is his expected utility if he quits in period 2. The expectation operator E with expectation taken over staying and quitting is introduced to simplify notations, which is defined as follows:

$$Eu(w_2) \equiv F(w_2|s)u(w_2) + \int_{w_2}^{\infty} u(\tilde{w}_2)\ f(\tilde{w}_2|s)d\tilde{w}_2$$

When search intensity is observable to the contract firm, the second-best contract can be characterised by investment level, wages and search intensity subject to the contract firm earning zero expected profit at the equilibrium in the competitive market. The following second-best problem can be solved.

$$\underset{x,\ w_1,\ w_2,\ s}{\text{Max}} \quad u(w_1 - s) + Eu(w_2) \quad \ldots\ldots\ldots\ldots\ldots\ldots(1)$$

subject to

$$(1 - x)m - w_1 + F(w_2|s)(h(x) - w_2) = 0 \quad \ldots\ldots\ldots\ldots(2)$$

$$w_1 - s,\ w_2 \geq 0 \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots(3)$$

where (2) is the zero profit constraint and constraint (3) requires non-negative consumption.

Whether positive or zero search effort is optimal depends on the search technology. Initially we will be analysing the case of positive search effort. For that purpose the following existence assumption is made. The case of zero search will be discussed later.

Assumption 2

Equilibrium contracts, whether second-best or third-best, entails $s > 0$.

In solving the second-best problem we invoke Assumption 2 but not Assumption 1. By virtue of the assumption $u'(0) = \infty$, constraint (3) cannot be satisifed as equalities. Hence s must be less than w_1. This together with Assumption 2 ensures that there is an interior solution for s. The first-order conditions of the problem with interior solutions for s, w_1 and w_2 can now be written in the following compact form; the arguments of functions are suppressed where they are obvious.

$$x : \psi_1(-m + Fh') \begin{cases} = 0, & x \in (0, 1) \\ \leq 0, & x = 0 \\ \geq 0, & x = 1 \end{cases} \quad \ldots\ldots\ldots\ldots\ldots\ldots (4)$$

$$w_1 : u'(w_1 - s) - \psi_1 = 0 \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots (5)$$

$$w_2 : Fu'(w_2) + \psi_1[f(h - w_2) - F] = 0 \quad \ldots\ldots\ldots\ldots (6)$$

$$s : -u'(w_1 - s) + D_s Eu(w_2) + \psi_1 F_s(h - w_2) = 0 \quad \ldots (7)$$

$$\psi_1 : (1 - x)m - w_1 + F(h - w_2) = 0 \quad \ldots\ldots\ldots\ldots\ldots (8)$$

where ψ_1 is the Lagrange multiplier associated with (2) and D_s is the partial differential operator of s which shifts only the distribution function while leaving utility unchanged. That is

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

There may be multiple local optima which solve the problem. We will proceed to analyse the properties possessed by any of the optima (including the global ones). The equilibrium wage structure satisfies the following proposition.

Proposition 2

If the worker has no access to capital markets, the second-best

contract sets the wage above marginal product in the first period and below it in the second period.

Proof

From (5),

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

This can be substituted into (6) to yield

$$h - w_2 = \frac{F}{f} \frac{u'(w_1 - s) - u'(w_2)}{u'(w_1 - s)} \qquad \text{.....(9)}$$

We can prove $h - w_2 > 0$ by contradiction. Suppose not and $h - w_2 \leq 0$. Then (9) implies $u'(w_1 - s) \leq u'(w_2)$, that is $w_1 - s \geq w_2$ by concavity of u. On the other hand, from the zero profit constraint, $w_1 \leq (1 - x)m$ because $h - w_2 \leq 0$. Therefore, $w_1 - s \leq (1-x)m - s$. We now have the following relations.

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

$$\Rightarrow \quad w_2 > w_1 - s$$

We have a contradiction. Hence $h - w_2 > 0$. From the zero profit constraint, it follows that $w_1 > (1 - x)m$. Q.E.D.

Proposition 2 and its proof show that the net wage (wage net of search expenses) profile is rising over time with $w_2 > w_1 - s$ but is flatter than the productivity profile. This result is similar to that in Weiss (1984) which did not consider private wage offers and search. The economic meaning of our result, though more complicated, is richer and nevertheless clear. The worker's marginal rate of substitution of w_2 for w_1 derived from (5) and (6) is

$$\frac{\partial U / \partial w_2}{\partial U / \partial w_1} = \frac{Fu'(w_2)}{u'(w_1 - s)} < F \qquad \text{.....(10)}$$

which means that the worker is trading off between period 1 consumption and period 2 consumption if he stays without regard for the consumption if he quits. That is, the worker desires a wage contract which evens out the consumption stream over time but not one which insures his consumption between staying and quitting. The motive for consumption smoothing is dominant and wage insurance is not a concern here. The firm responds by setting w_1 and w_2 in the contract without reference to the worker's expected outcome if he quits. In order to even out consumption over time, the second-best contract sets w_2 so low as to be below the post-training marginal product.

However, only incomplete consumption smoothing is provided.[13] If there were complete smoothing the expected marginal utility of consumption over time would be equated at the margin; i.e. the marginal rate of substitution of w_2 for w_1 should be unity and given that there is uncertainty in the level of consumption in period 2, a declining net wage profile would entail with $w_1 - s > w_2$.[14]

The reasons for incomplete consumption smoothing and a flatter wage profile than the productivity profile should be clear. The contract firm provides banking services but it has to specify second-period wage without knowing the worker's external wage offers. The provision of banking services affect the stay decision of the worker. We have a phenomenon akin to moral hazard. In setting wages consumption smoothing requires that w_2 be set relatively low but when w_2 is below marginal product, productive inefficiency appears as the worker will be quitting when his marginal product is higher inside the contract

firm than outside. Therefore, to reduce inefficient quits, w_2 must be set relatively high. The contract must trade off consumption smoothing against "stay incentives" and attain the (constrained) efficient level of stays by stipulating an appropriate level of w_2 and search intensity. The tension between productive efficiency and consumption smoothing accentuates the slope of the wage profile. However w_2 would not be set so high as to be above marginal product for if it were, there would be loss in consumption smoothing as well as due to productive inefficiency from an opposite direction since the worker would now be staying in the contract firm when his marginal product is higher outside.

B. Wage Structure in Third-Best Contract

Now assume that information on search intensity is asymmetric and private to the worker. The third-best problem is the same as the second-best problem in (1) and (3) plus an incentive compatibility constraint (11) which ensures that the worker has chosen a search intensity from among the set of search intensities S to maximise his utility.

$$s \in \underset{s' \in S}{\text{argmax}}\ U(w_1, w_2, s') \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (11)$$

The problem is now formally the same as the principal-agent problem. The contract firm provides banking services and specific training for the worker but the worker has the unilateral decision-making authority on how intensively he searches. His search effort affects the probability of quits and thus the contract firm's pay-out and the outcome of its investment in the worker. Another source of moral hazard is

introduced into the problem.

For convenience, we would like to use the first-order approach to solve this principal-agent problem; i.e. to solve it after replacing the incentive compatibility constraint (11) by its first-order stationary condition. Mirrlees (1975) and Rogerson (1985) show that the monotonic likelihood-ratio condition (MLRC) and the convexity of the distribution function condition (CDFC) which requires $F_{ss} \geq 0$ are sufficient for the use of the first-order approach. More recently Jewitt (1988) proposes a less restrictive set of conditions which include MLRC. Unfortunately for our problem at hand, we have to make a more restrictive assumption on the utility function and the search technology in order that the first-order approach is valid.

Assumption 3

Utility function U is concave in search.

It may be noted that a strong version of CDFC is sufficient for Assumption 3 to hold since

$$\frac{\partial^2 U}{\partial^2 s} = u''(w_1 - s) + D^2_s \, Eu(w_2)$$

This will be negative if $D^2_s \, Eu(w_2) < 0$ which can be easily be shown to hold if there is strong CDFC.

Invoking Assumptions 1 to 3, the first-order conditions of the third-best problem are

$$x : \psi_2(-m + Fh') = 0, \; x \in (0, 1)$$
$$\leq 0, \; x = 0$$
$$\geq 0, \; x = 1 \quad \ldots\ldots\ldots\ldots\ldots\ldots (12)$$

$$w_1 : u'(w_1 - s) - \psi_2 - \eta u''(w_1 - s) = 0 \quad \ldots\ldots\ldots\ldots (13)$$

$$w_2 : Fu'(w_2) + \psi_2[f(h - w_2) - F] + \eta F_s u'(w_2) = 0 \quad \ldots (14)$$

$$\psi_2 : (1 - x)m - w_1 + F(h - w_2) = 0 \quad \ldots\ldots\ldots\ldots\ldots (15)$$

$$\eta \quad : \quad -u'(w_1 - s) + D_s Eu(w_2) = 0 \quad \ldots\ldots\ldots\ldots\ldots\ldots (16)$$

$$s \quad : \quad \psi_2 F_s(h - w_2) + \eta[u''(w_1 - s) + D_s^2 Eu(w_2)] = 0 \quad \ldots (17)$$

where ψ_2 is the Lagrange multiplier associated with the zero profit constraint. η is the multiplier associated with the first-order condition (16) which replaces constraint (11), and (17) is the adjoint equation for solving η.

The wage structure of the third-best contract can be characterised by

Proposition 3

If the worker has no access to capital markets, the third-best contract sets the wage above marginal product in the first period and below it in the second period.

This proposition follows directly from the following two lemmas which we will prove.

Lemma 1

If the worker has no access to capital markets and the contract firm cannot control s, any contract which sets w_1 below the marginal product and w_2 above it can be Pareto dominated by a contract which sets wages equal to the respective marginal products.

Lemma 2

If the worker has no access to capital markets, the third-best contract will not set wages equal to the respective marginal products.

Proof of Lemma 1

Let subscript II denote the situation where job search is observable so that the contract firm can control and specify s in the contract, and subscript III denote the situation where

search is private so that the contract firm cannot control s. Further let superscript m denote the case where w_1 and w_2 are set equal to the respective marginal products and superscript a the case where w_2 is set strictly above the marginal product and w_1 strictly below it.

The proof proceeds in three steps. First, we claim that

$$U^m_{II} > U^a_{II} \qquad (18)$$

To verify this we will first constrain w_2 to be no less than the marginal product and w_1 to be no greater. The second-best problem (1) to (3) is now modified by adding two more constraints on the wage profile as follows:

$$w_1 \leq (1 - x)m \qquad (19)$$

$$w_2 \geq h(x) \qquad (20)$$

Let α_1 and α_2 be the Lagrange multipliers associated with (19) and (20) respectively. The relevant Kuhn-Tucker conditions of the modified second-best problem are

$$x \; : \; \psi_1(-m + Fh') - \alpha_1 - \alpha_2 h' \begin{cases} = 0, & x \in (0, 1) \\ \leq 0, & x = 0 \\ \geq 0, & x = 1 \end{cases} \qquad (21)$$

$$w_1 \; : \; u'(w_1 - s) - \psi_1 - \alpha_1 = 0 \qquad (22)$$

$$w_2 \; : \; Fu'(w_2) + \psi_1[\bar{f}\,(h - w_2) - F] + \alpha_2 = 0 \qquad (23)$$

$$\alpha_1((1 - x)m - w_1) = 0 \qquad (24)$$

$$\alpha_2(w_2 - h) = 0 \qquad (25)$$

$$\alpha_1, \alpha_2 \geq 0 \qquad (26)$$

First we note that by virtue of the zero profit constraint, (19) and (20) must be satisfied either both as equalities or both as inequalities. It is impossible to have one satisfied as equality and the other as inequality.

We now show that both constraints (19) and (20) must satisfy as equalities so that $\alpha_1, \alpha_2 > 0$. Suppose not, then $w_1 < (1 - x)m$ and $w_2 > h$ and $\alpha_1 = \alpha_2 = 0$. Then (22) and (23) can be solved simultaneously to give (9), but we have shown in the proof of Proposition 2 that (9) implies $w_1 > (1 - x)m$ and $w_2 < h$. Hence we have a contradiction. Therefore constraints (19) and (20) are binding implying that the equilibrium contract in the modified problem must set wages equal to the respective marginal products. When the contract firm can control s, any contract which sets w_2 strictly above the marginal product and w_1 strictly below it is inferior to one which sets wages equal to marginal products.

Second, we want to show

$$U^m_{II} = U^m_{III} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (27)$$

This result follows from modifying the second-best and the third-best problems by imposing $w_1 = (1 - x)m$ and $w_2 = h(x)$ as constraints. We note from (17), the first-order condition of s of the modified third-best problem, that $\eta = 0$ because $w_2 = h$. This has the interpretation that the contract firm is indifferent to the worker's choice of s when wages are set equal to marginal products. The modified third-best problem is now identical to the modified second-best problem, implying identical solutions, hence (27).

Third, we claim that

$$U^a_{II} > U^a_{III} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (28)$$

Now we modify the second-best and the third-best problems by imposing two constraints: $w_1 < (1 - x)m$ and $w_2 > h(x)$. Then for any constraint-satisfying contract offered by the contract

firm when it cannot control s, there exists a constraint-satisfying contract offered by the contract firm when it controls s which Pareto dominates it. This follows from the fact that η is non-zero in the modified third-best problem when wages are not equal to marginal products. Hence solutions to the modified second-best and third-best problems differ on a set of non-zero measure. The second-best solution is strictly better.

Finally, (18), (27) and (28) imply

$$U^m_{III} > U^a_{III} \quad \text{.....(29)}$$

Q.E.D.

Proof of Lemma 2

See Appendix.

Similar to the results of the second-best contract, the equilibrium net wage profile of the third-best contract is also rising and consumption smoothing is therefore incomplete. The rising net wage profile can be deduced from the first-order conditions. Since $\psi_2 > 0$, $F_s < 0$, $h - w_2 > 0$ and $u''(w_1 - s) + D^2_s Eu(w_2) < 0$ (by Assumption 3), then from (17), $\eta < 0$. Hence deriving from (13) we have

$$u'(w_1 - s) = \psi_2 + \eta u''(w_1 - s) > \psi_2$$

and from (14),

$$u'(w_2) = \psi_2 \left[\frac{F - f(h - w_2)}{F}\right] - \frac{\eta F_s u'(w_2)}{F} < \psi_2$$

Therefore, $u'(w_1 - s) > u'(w_2)$ implying $w_2 > w_1 - s$.

C. Consumption Smoothing, "Stay Incentives" and Search Incentives

In the third-best situation, a second source of moral hazard is introduced due to the fact that the contract firm cannot observe the worker's search intensity. The wage contract affects

the worker's search decisions. The effect of the wage profile on the worker's search decisions in the third-best contract can be analysed by comparative statics on (16). When search effort is private, given the wage parameters in the contract, the worker will search to a level which maximises his expected utility and (16) is satisfied. Changing the wage profile in the contract will have an incentive (or disincentive) effect on search.

Substituting w_1 in (16) by $(1 - x)m + F(h - w_2)$ and totally differentiating (16) with respect to w_2, we obtain

$$\left(\frac{ds}{dw_2}\right)_{II} = \frac{u''(w_1 - s)[f(h - w_2) - F] - F_s u'(w_2)}{u''(w_1 - s) + D_s{}^2 Eu(w_2)} < 0 \quad \ldots(30)$$

This derivative is negative when evaluated at the second-best optimum (denoted by subscript II); the numerator is positive because $f(h - w_2) - F < 0$ from (5) and (6) and F_s, $u''(w_1 - s) < 0$ while the denominator is $\partial^2 U / \partial s^2 < 0$. This is because at the second-best optimum an increase in w_2 has the effect of increasing marginal costs of search in the first period while reducing its marginal returns in the second period. This discourages search and hence the negative derivative. Put in another way, consumption smoothing will have to be traded off against disincentives for search since search incentives are reduced by raising w_2.

Proposition 3 indicates that moral hazard stemming from private search effort does not vitiate against the second-best result of setting the second-period wage below marginal product given in Proposition 2. This is because while private search aggravates productive inefficiency by encouraging inefficient quits, incentives for it can be reduced by raising w_2. The

third-best contract therefore sets w_2 higher than w_1 to reduce inefficient quits both directly by raising the reservation wage and indirectly by discouraging search. This is done at the expense of some consumption smoothing. The balance between "stay incentives" and search disincentives on the one hand and consumption smoothing on the other is achieved before w_2 exceeds marginal product.

Let us summarise the results obtained so far. When the worker cannot borrow, the motive for consumption smoothing via the wage contract is dominant. The tension between consumption smoothing and productive efficiency accentuates the slope of the wage profile. The wage profile is upward-sloping but flatter than the productivity profile. These results are robust with respect to whether search is observable or not.

IV. CONTRACTS WITH LENDING AND BORROWING

We now relax the assumption that the worker cannot borrow and assume that he has access to capital markets. To simplify matters we will only deal with capital markets where lenders will not bear default risk arising from uncertainty on debtors' ability to repay. There is no collateral. Borrowers must borrow against assured future income and therefore there will be no bankruptcy risk and credit rationing. In our model the worker has an assured income equal to the sum of contract wages $w_1 + w_2$ in the two periods and that is the maximum amount that he can borrow in period 1.

A. Wage Structure in Second-Best Contract

When the worker can lend and borrow, his utility function

is

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

where c_i is the worker's consumption in the i^{th} period and c_2 his stochastic consumption in period 2 if he quits.

The second-best problem can be characterised by

$$\underset{\substack{x,\ w_1,\ w_2,\ s \\ c_1,\ c_2}}{\text{Max}} \quad u(c_1) + Eu(c_2) \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots(31)$$

subject to

$$(1 - x)m - w_1 + F(w_2|s)(h(x) - w_2) = 0 \quad \ldots\ldots\ldots\ldots\ldots\ldots(32)$$

$$c_1 \in \underset{c'_1 \in C_1}{\text{argmax}}\ U(w_1, w_2, s, c'_1, c_2) \quad \ldots\ldots\ldots\ldots\ldots\ldots(33)$$

$$c_2 = w_1 - s - c_1 + w_2 \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots(34)$$

$$\tilde{c}_2 = w_1 - s - c_1 + \tilde{w}_2 \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots(35)$$

$$c_1, c_2 \geq 0 \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots(36)$$

$$c_1 \leq w_1 + w_2 \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots(37)$$

Given the second-best contract the worker will choose c_1 from the consumption set C_1 to maximise his utility, hence constraint (33). His consumption in period 2, c_2, can be obtained as a residual from the budget constraint (34). The budget constraint for the worker if he quits is given by (35). Constraint (36) requires that consumption be non-negative. The restriction on borrowing only against assured future claims is given by constraint (37).

Let us now characterise the solution. In solving for the second-best contract, we invoke only Assumption 2 but not Assumptions 1 and 3. By the same argument as before, constraints

(36) and (37) 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 2 ensures that there is an interior solution for s.

Since U is strictly concave in c_1, constraint (33) can be replaced by the first-order stationary condition

$$u'(c_1) - Eu'(c_2) = 0 \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (33')$$

where

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

The first-order conditions of the problem with an interior solution for s, w_1 and w_2 can now be written as

$$x : \lambda_1(-m + Fh') \begin{cases} = 0, & x \in (0, 1) \\ \leq 0, & x = 0 \\ \geq 0, & x = 1 \end{cases} \quad \ldots\ldots\ldots\ldots\ldots\ldots (38)$$

$$w_1 : Eu'(c_2) - \lambda_1 - \phi_1 Eu''(c_2) = 0 \quad \ldots\ldots\ldots\ldots\ldots\ldots (39)$$

$$w_2 : Fu'(c_2) + \lambda_1[f(h - w_2) - F] - \phi_1 Eu''(c_2) = 0 \quad \ldots (40)$$

$$s : D_s Eu(c_2) - Eu'(c_2) + \lambda_1 F_s(h - w_2) + \phi_1[Eu''(c_2) - D_s Eu'(c_2)] = 0 \quad \ldots\ldots\ldots\ldots\ldots (41)$$

$$\lambda_1 : (1 - x)m - w_1 + F(h - w_2) = 0 \quad \ldots\ldots\ldots\ldots\ldots\ldots (42)$$

$$\phi_1 : u'(c_1) - Eu'(c_2) = 0 \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (43)$$

$$c_1 : \phi_1[u''(c_1) + Eu''(c_2)] = 0 \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots (44)$$

where λ_1 and ϕ_1 are Lagrange multipliers associated with constraints (32) and (33'). From (44), $\phi_1 = 0$, which has the interpretation that the firm is indifferent to the worker's choice of c_1.

The second-best wage structure can be characterised by

Proposition 4

If the worker can lend and borrow, the second-best contract sets the wage below marginal product in the first period and above it in the second period.

Proof

From (39) Lagrange multiplier $\lambda_1 = Eu'(c_2) > 0$. This is substituted into (40). The equilibrium wage structure is now characteristised by

$$h - w_2 = \frac{F}{f} \frac{Eu'(c_2) - u'(c_2)}{Eu'(c_2)} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (45)$$

But

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

$$< (1-F)u'(c_2) - (1-F)u'(c_2) = 0$$

The inequality is due to concavity of u. Hence $h - w_2 < 0$. From (42), it follows that $w_1 < (1 - x)m$. Q.E.D.

When the worker can lend and borrow, consumption over time can always be evened out regardless of the wage profile. It is easy to see from (43) that $Eu'(c_2) = u'(c_1)$ which implies $u'(c_1) < u'(c_2)$ (see proof of Proposition 4) and $c_1 > c_2$. That is, expected marginal utility of consumption over time is equated at the margin and complete smoothing of consumption over time is achieved yielding a declining consumption profile. Free of consideration for consumption smoothing, the motive for insuring second-period consumption now dominates. Since staying is the "bad" state because of the lower wage and quitting the "good" state because of the higher wage, the worker will seek to insure his consumption against staying. This can be readily observed

by examining the worker's marginal rate of substitution of w_2 for w_1.

$$\frac{\partial U/\partial w_2}{\partial U/\partial w_1} = \frac{Fu'(c_2)}{Eu'(c_2)}$$

The worker is trading off between expected consumption for staying and expected consumption over staying and quitting in period 2.

Now insurance requires w_2 be set relatively high so as to even out variation in consumption between the two states: staying and quitting. But when w_2 is set above marginal product, productive inefficiency due to excessive inefficient stays sets in as the worker will be staying in the contract firm when his productivity is higher outside. The contract must therefore trade off insurance against quit incentives and stipulate an appropriate level of w_2 and search intensity to achieve the (constrained) efficient level of quits. The tension between productive efficiency and insurance therefore attenuates the slope of the wage profile but it is still rising and steeper than the productivity profile. It would not be flatter than the productivity profile for if it were, there would be loss in both insurance and productive efficiency as excessive inefficient quits would now be encouraged.

It should be clear that the insurance provided is incomplete. The contract firm cannot provide complete insurance by matching w_2 with the worker's external wage offer because it is stochastic and, a fortiori, because it cannot be verified. Hence we have the standard result of incomplete insurance when there is moral hazard.

B. Wage Structure in Third-Best Contract

When search is private an incentive constraint on search intensity (46) must be added to the second-best problem to yield the third-best problem.

$$s \in \underset{s' \in S}{\text{argmax}} \quad (w_1, w_2, s', c_1, c_2) \quad \ldots\ldots\ldots\ldots\ldots\ldots (46)$$

The problem can be solved under Assumptions 1 to 3.

The equilibrium wage structure satisfies Proposition 5.

Proposition 5

If the worker can lend and borrow, the third-best contract will set the wage below marginal product in the first period and above it in the second period.

As in the case where the worker has no access to capital markets, this proposition follows directly from two lemmas. The proofs are analogous to those of Lemmas 1 and 2 and will not be reproduced here.

Lemma 3

If the worker can lend and borrow and the contract firm cannot control s, any contract which sets w_1 above marginal product and w_2 below it can be Pareto dominated by a contract which sets wages equal to the respective marginal products.

Lemma 4

If the worker can lend and borrow, the third-best contract will not set wages equal to the respective marginal products.

C. Wage Insurance, Quit Incentives and Search Incentives

The second-best and third-best outcomes can now be compared. When the worker can lend and borrow complete consumption smoothing is assured. The worker now desires insurance against

staying which the contract firm provides via the contract. But the wage profile affects the worker's quit decisions; hence we have the conventional moral hazard problem in insurance. Since the second-period wage is set above marginal product, the contract must reduce inefficient stays in the contract firm; insurance has to be traded off against quit incentives. Therefore, insurance can only be incomplete. In the third-best contract, it will have to be further balanced against search incentives as well.

In summary, when the worker can lend and borrow, the motive for insurance dominates. The tension between consumption smoothing and productive efficiency attentuates the slope of the wage profile. The wage profile will be rising and steeper than the productivity profile. These results are also robust with respect to whether search is observable or not.

V. SPECIFIC INVESTMENTS, SEARCH AND WAGE PROFILE

In all the contracts under consideration the interior solution for specific human capital investment x is given by

$$h'(x) = \frac{-m}{F(w_2|s)}$$

By virtue of the concavity of h and the stochastic dominance conditon $F_s < 0$ the more intensive the search, the smaller is the optimal specific investment. This is because search effort increases the probability of quit which renders any specific investment useless. Hence it is optimal to invest less when the search effort is large.

Despite the attentuating effect of search specific human

capital investments always induce a productivity profile which is rising over time but they are neither necessary nor sufficient for generating a rising wage profile. Notwithstanding investments in firm-specific skills and rising productivity over time, the sole reason for an upward-sloping wage profile is the presence of stochastic external alternatives which can be realised only by carrying out the search option. If there is no incentive to search, the wage profile will be flat.

This point is illustrated by relaxing the assumption that optimal search is positive (Assumption 2) and let zero search be optimal under some specified search technology. Also assume that no wage offer will arrive unless there is search effort. Therefore there will be no quits. When the worker cannot borrow it is trivial to show that in this case the equilibrium wage profile will be flat as there will be complete consumption smoothing. When the worker can lend and borrow, a flat wage profile also entails since no insurance is necessary. In this latter case there will be no unique solution; any wage profile which breaks even for the firm is admissible at the equilibrium. In either case the wage profile will be flat when the worker does not find it optimal to take advantage of stochastic external alternatives. This implies that the wage profile will become rising for reason of productive efficiency only if there are stochastic alternatives that the worker can realise and quits. This result is similar to that of Harris and Holmstrom (1982) but contrasts sharply against the human capital explanation of the rising wage profile as a consequence of investment sharing between the worker and the firm.

VI. CONCLUSION

In this paper we brought together a human capital investment model, a job search model, a principal-agent model, an interfirm mobility model and an intertemporal liquidity model and a labor contract model to analyse the intertemporal wage structure. The main finding of paper is that the motive for consumption smoothing dominates and the equilibrium contracts always set the wage above marginal product in the first period and below it in the second period if the worker has no access to capital markets. The desire to insure second-period consumption dominates and the reverse is true for the wage profile if the worker can lend and borrow. These results are not affected by whether search is observable.

There are several limitations in our model, elimination of which suggests directions for extensions and further work. First, Assumption 3 on search technology is rather strong. It is imposed to yield tractable results. It would be interesting to see if it can be relaxed. Second, there is no layoff in our model and we have not dealt with layoffs and unemployment. In this connection it should be noted that Arnott, Hosios and Stiglitz (1988) have given these problems an extensive treatment in their model. Finally, there is no provision for severance payment in our contract although we have made some brief comments on how such provision may affect our results. The analysis of a full-blown model with severance payments for both layoffs and quits would be the next logical step.

Appendix

Proof of Lemma 2

From (13) and (17) solve simultaneously for ψ_2 and η, and substitute into (14). We have after re-arranging terms,

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

where

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

by Assumption 3 and $\sigma(w_1 - s)$ is the Arrow-Pratt measure of absolute risk aversion

$$\sigma \equiv - \frac{u''(w_1 - s)}{u'(w_1 - s)}$$

We can prove $h - w_2 \neq 0$ by contradiction. Suppose $h = w_2$. This implies $u'(w_2) = u'(w_1 - s)$ or $w_2 = w_1 - s$ by concavity of u. On the other hand, from the zero profit constraint, $h = w_2$ implies $w_1 = (1-x)m$ or $w_1 - s = (1-x)m-s$. We now have the following relations:

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

Hence a contradiction.

Q.E.D.

Footnotes

1. Recent work of Ito (1988), Arnott, Hosios and Stiglitz (1988) and Arvan (1989) incorporate costly private search in their models to resolve some of the difficulties in the traditional implicit contract literature concerning quits, layoffs, overemployment and underemployment. Our paper addresses different issues.

2. This approach is also independently taken by Arvan (1989) in his recent work.

3. An alternative is to interpret the model as applying to a group of workers with a specific quality of match in a contract firm, on the assumption that the match quality is observable as soon as a worker joins a contract firm. These workers are assumed to have different match qualities with spot market firms. For a similar assumption that workers are homogeneous in one firm but heterogeneous outside, see Roy (1951) and Ito (1988).

4. This paper allows search intensity to be either private or common knowledge. If search costs are modelled as time costs and therefore the worker takes time away from work to search, search effort will always be observable to the firm since search time will be just the residual after netting investment time from work time. In this connection note that Strand (1985) distinguishes between verifiable and non-verifiable monetised search expenses of the worker.

5. Severance payments for voluntary quits in the form of fixed lump sum penalty are uncommon among industries (possible exceptions are the entertainment and sports industries). But

they may appear in the form of an indirect quit penalty through non-vested pension plans. For a comment on how the presence of severance payment as a contract parameter may affect our results, see footnote 13.

6. The assumption on private wage offers is natural. For a justification, see Ito (1988). Other studies which make this assumption include Kahn (1985), Moore (1985), and Arnott, Hosios and Stiglitz (1988).

7. Many studies which focus on wage insurance but not unemployment simply assume that the contract binds the firm from discharging the worker. See, for example, Arnott (1982), Harris and Holmström (1982), Weiss (1984), Arnott and Stiglitz (1985), Haltiwanger and Waldman (1986) and Berkovitch (1986). Here we part company with Arnott, Hosios and Stiglitz (1988), and Arvan (1989). Our paper is not concerned with explaining layoffs and unemployment as would be the aim of traditional implicit contract literature. For a detailed argument why a model with voluntary quits is important for studying in the implicit contract literature as opposed to a model with involuntary unemployment, see Ito (1988).

8. Investment in specific human capital will raise the worker's productivity in the contract firm but not elsewhere, thus increasing his comparative advantage in staying in the contract firm. However, it is assumed that the distribution of match qualities among spot market firms 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.

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

10. See Rogerson (1985).

11. For a simple proof that our model has the standard reservation wage property, see Lam, Liu and Wong (1987).

12. The proff is straightforward and will not be reproduced here. See Lam, Liu and Wong (1987).

13. If the contract allows severance payment, it can be utilised as a penalty to reduce inefficient quits. Less consumption smoothing will need to be traded off in favor of appropriate quit incentives but it will still be incomplete because wage offers are stochastic and privately observed. See Lam, Liu and Wong (1989).

14. If there is no uncertainty, a flat wage profile would be the result of complete consumption smoothing.

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SCHOOL OF BUSINESS

BUSINESS RESEARCH CENTRE

The Business Research Centre (BRC) is an integral part of the School of Business. It facilitates the following functions:

Research
Consultancy
Executive Training

Objectives of the BRC :

(1) To facilitate and coordinate research among faculty members of the School of Business.

(2) To encourage the exchange of ideas and joint research programmes between the Hong Kong Baptist College and other higher education and commercial institutions in Hong Kong and overseas.

(3) To encourage and promote the development of research projects that are academically rigorous and have high practical value to the business community.

(4) To tighten the linkage between the business community and the School of Business through consultancy activities and executive training.

The School of Business has about 50 faculty members specializing in various areas including:

Accounting
Economic Analysis & Forecasting
Financial Analysis
Security Analysis & Portfolio Management
Marketing
Personnel Management
Organisation Development
Production Management
Mangement Information Systems
Strategic Planning
Business Law
International Business
China Trade & Investment

Feel free to contact us if you are interested in the services provided by the BRC.
All correspondence regarding the BRC should be addressed to :

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