1984

Wages, Effort and Incentive-Compatibility in Life-Cycle Employment Contracts

Peter Kuhn

Follow this and additional works at: https://ir.lib.uwo.ca/economicscsier_wp

Part of the [Economics Commons](#)

Citation of this paper:

Kuhn, Peter. "Wages, Effort and Incentive-Compatibility in Life-Cycle Employment Contracts." Centre for the Study of International Economic Relations Working Papers, 8430C. London, ON: Department of Economics, University of Western Ontario (1984).

ISSN 0228-4235
ISBN 0-7714-0568-5

CENTRE FOR THE STUDY OF INTERNATIONAL ECONOMIC RELATIONS

WORKING PAPER NO. 8430 *C*

WAGES, EFFORT AND INCENTIVE-COMPATIBILITY IN
LIFE-CYCLE EMPLOYMENT CONTRACTS

Peter Kuhn

This paper contains preliminary findings from research work still in progress and should not be quoted without prior approval of the author.

DEPARTMENT OF ECONOMICS
THE UNIVERSITY OF WESTERN ONTARIO
LONDON, CANADA
N6A 5C2

WAGES, EFFORT, AND INCENTIVE-COMPATIBILITY IN
LIFE-CYCLE EMPLOYMENT CONTRACTS

Peter Kuhn
Department of Economics
University of Western Ontario
London Canada

July, 1984

I. INTRODUCTION

The issue of how incentive compatibility problems affect the structure of compensation profiles in long-term employment contracts has received considerable attention in recent years, in a number of important pieces like Lazear (1979, 1981), Hashimoto and Yu (1980), Harris and Holmstrom (1981), Hall and Lazear (1984), and Malcolmson (1984). Unfortunately, it remains difficult to draw a set of general conclusions from these models for at least two reasons. First, they differ considerably in their formulation and can produce different predictions regarding wage and productivity profiles, for reasons that are sometimes hard to discover.¹ Second, existing models tend to either severely limit the possible range of contract structures by assuming only two periods (Hall and Lazear, Hashimoto and Yu), or to not be able to characterize contract structure very precisely (Lazear).

This paper presents a simple model of employment contracting in a continuous-time context that allows for a fairly explicit characterization of contract structure to be made. It also shows how many of the differences in the conclusions of the above models stem from differences in the kinds of malfeasant, "contract-breaking" behavior that are allowed, and shows that unfortunately none of those models allows for a fully general and symmetric menu of such behavior to exist. When the malfeasance issue is treated symmetrically in the present context, two main results emerge: First, the fairly widely-accepted conclusion that incentive-compatibility requires wages to rise faster than marginal productivity (e.g., Lazear 1979, 1981) no longer holds in general. Second, it is in fact easy to generate realistic cases in which wages can rise faster, slower, and even at exactly the same rate as productivity during different finite segments of the same contract--so contract structure may in fact be considerably more complex than is usually assumed.

The paper begins in Section II with a brief review of the enforceability issue and of the employment contracting literature, showing how the existing literature can be classified according to what kinds of malfeasant behavior are taken into account. The structure of a more comprehensive model is set out in Section III. Section IV draws out some basic implications of this model and shows how some earlier models can be seen as special cases of it. The new model is solved out and analyzed in Section V, which considers some of its comparative statics as well.

II. REVIEW: INCENTIVE COMPATIBILITY IN EMPLOYMENT CONTRACTS

In general, any contract between a firm and a worker over a period of time T , involves an agreement on both what the firm supplies to a worker--a complex bundle of wages, fringes, and working conditions which we assume is summarized by the measure $w(t)$ --and what the worker supplies in return, which we might loosely term "effort", or $h(t)$. Two major sets of influences determine the structure this contract will take. First, there may be a set of factors determining an optimal contract structure in the absence of any enforceability constraints. These include the possible desire for risk-sharing between workers and firms, the fact that progressive taxation or imperfect capital markets may induce an optimal distribution of earnings over time, or the fact that acquisition and depreciation of human capital and variations in disutility of work may dictate an optimal intensity of effort over time.

Second are the costs or constraints imposed by the fact that incentives exist, ex post, for the parties to break contractual commitments made ex ante. In principle, there are at least four different ways this can occur: First, workers may quit the firm in order to avoid their contractual obligations to the firm if they can do better elsewhere. Second, firms may dismiss workers to whom they owe more than they expect to receive for the same reason. We shall refer to these two activities henceforth as "unilateral withdrawal" from the contract, or "Type 1" malfeasance. Third, workers

at some point during the contract may "shirk", i.e., decide to supply less effort than was initially agreed upon, or to raise their wages by stealing or other means. Finally, the firm at any point might "exploit" workers, i.e., begin to let working conditions deteriorate, fail to increase wages at the agreed-upon rate, or demand speed-ups or stretch-outs not expected when the "contract" was made. These last two activities might be called "malfeasance by trying to alter the terms of the contract," or simply "Type 2" malfeasance.

Unfortunately, even though all of the above problems can at least potentially impose serious constraints on the structure of contracts, they are rarely if ever all considered together in the literature. Early formal implicit contracts models (e.g. Baily (1974), Azariadis (1975)) implicitly assumed full enforceability, thus ignoring the incentive-compatibility issue entirely. These were followed by models which allowed workers but not firms to withdraw from contracts, such as Grossman (1978), Holmstrom (1980) and Harris and Holmstrom (1981).² There have also existed a number of models which allow workers and firms both to withdraw, including Becker's original argument about specific human capital (1964, pp.21-22), as well as Hashimoto and Yu (1980) and Hall and Lazear (1982). Finally, a large number of recent models have dealt with the issue of shirking, or Type-2 malfeasance by workers. These include Eaton and Rosen (1981), Lazear (1979, 1981), Lazear and Rosen (1981), and Stiglitz and Weiss (1983). None of these models allows for any kind of malfeasance by firms, except for the interesting case of Lazear (1979, 1981) which allows firms to withdraw from contracts only, but never to "exploit" workers. Apparently, the possibility of Type-2 malfeasance by firms has never been considered in any model of life-cycle employment contracting.

The present paper explores the consequences of treating malfeasance symmetrically in the context of a simple, well-known model of employment contracting--that of Lazear (1979, 1981). The focus is thus on contracts in which the compensation profile, coupled with a policy of disciplinary dismissals, is used as an incentive device. This device, also modeled in Stiglitz and Weiss (1983), is used rather than for example, a system of piece rates or "ex post settling up" because it is cheaper to determine whether malfeasance has occurred than to measure the precise amount and adjust the contract terms accordingly, or because the ex post settling up process is itself not incentive-compatible. The main alterations to Lazear's model, aside from the broader treatment of malfeasance, are the fact that the effort levels specified for workers in the contract--and hence workers' productivity--are endogenized here, and that the solution to the model is much more explicitly characterized. The model is solved only for the case of complete certainty, and while the need for this abstraction is unfortunate, it does allow us to increase the generality of the model in these other directions, and even helps to make the basic intuition regarding how malfeasance affects contract structure more apparent.

III. MODEL STRUCTURE

We assume a world of complete certainty where workers are identical. Workers join a firm for a fixed period of time T which may include a retirement period and in doing so implicitly agree on a contract stipulating the path of total compensation paid to workers, $w(t)$, and total labor supply, including "effort", $h(t)$. The labor market is competitive, with a large number of (potential) firms willing to offer an "optimal" contract to a worker of any age, which pays the worker the present value of his or her marginal product, but immobilities of factors are allowed to exist due to hiring costs, search costs for new jobs, or specific human capital.

The structure of the model is outlined below in two stages. First, the maximand for the optimal contract and the zero-profit constraint are introduced. Second, the constraints that malfeasance places on the structure of the optimal contract are developed. For simplicity throughout the presentation, all magnitudes will be expressed in terms of their present value as of the reference point, $t=0$.

1. Utility and Profits in the Optimal Contract

Workers' instantaneous utility at time t in our model is assumed to be given by

$$W(t) = \{U(w(t)) - \frac{1}{a(t)} V(h(t))\} e^{-\delta t} \quad (1)$$

$$U' > 0, U'' < 0; V' > 0, V'' > 0$$

where δ is the workers' subjective discount rate, U is utility of compensation and can be thought of as embodying the effects of both imperfect capital markets and progressive taxation on the desire to smooth income, V is disutility of effort, and $a(t)$ is a function allowing workers' preferences for leisure to vary over the life cycle (e.g., $a' < 0$ would imply that older workers are more averse to effort than younger workers).

The firm's instantaneous profits are given by:

$$\Pi(t) = \left\{ \frac{1}{b(t)} Q(h(t)) - w(t) \right\} e^{-rt} \quad (2)$$

$$Q' > 0, Q'' < 0$$

where Q is the production function, r is the market interest rate available to firms, and $b(t)$ allows the worker's productivity to vary over the life cycle due to both the accumulation and depreciation of human capital.

Given this simple apparatus, we can now define the optimal long-term labor contract as follows. In a competitive labor market with identical firms, contracts offered by a firm must maximize the expected present value of utility of entering workers (otherwise the firm will attract no new workers) subject to three types of constraints. First, the present value of profits must equal zero. Second, we require that the equilibrium contract not be cheated on in any way by either party, that is, it is incentive-compatible. This is because neither workers nor firms will agree to a $(w(t), h(t))$ path that they know cannot be realized.³ Finally, while it is at least conceptually possible to have $w(t)$ negative, we must impose a non-negativity constraint on $h(t)$. Thus, when H is a hiring cost incurred at $t=0$ by the firm, the optimal contract satisfies:

$$\text{Max}_{w(t), h(t)} \int_0^T \left\{ U(w(t)) - \frac{1}{a(t)} V(h(t)) \right\} e^{-\delta t} dt \quad (3)$$

subject to

$$\int_0^T \left\{ \frac{1}{b(t)} Q(h(t)) - w(t) \right\} e^{-rt} dt - H \geq 0 \quad (4)$$

and both to $h \geq 0$ and the set of incentive-compatibility constraints we develop below. In equations (3) and (4), if disutility of effort,

$\frac{1}{a(t)}$, rises with t and productivity, $\frac{1}{b(t)}$, declines after a certain age, contracts will tend to include a period near their end where the non-negativity constraint on h is binding. This will have $h=0$ but possibly $w > 0$ and is of course the "retirement period" whose length can thus, in principle, be endogenized in the model.

2. The Effect of Malfeasance on Contracts

We begin here by presenting the constraints imposed by "type-2" malfeasance on contract structure, and then show that type-1 constraints can easily be seen as special cases which are never binding. To do so, we assume, as Lazear (1979, 1981) does for firms, that both parties to the employment contract adopt a policy of terminating the contract if the other cheats.⁴ Conditions needed to prevent worker and firm malfeasance of this type are then respectively:

$$\begin{array}{l} \text{to prevent} \\ \text{worker} \\ \text{malfeasance:} \end{array} \quad \int_{\tau=t}^T \left\{ U(w(\tau)) - \frac{1}{a(\tau)} V(h(\tau)) \right\} e^{-\delta\tau} d\tau \geq \overline{PVW}_t (He^{-rt}) + [\theta - S] e^{-\delta t}, \quad \forall t \quad (5)$$

$$\begin{array}{l} \text{to prevent} \\ \text{firm} \\ \text{malfeasance:} \end{array} \quad \int_{\tau=t}^T \left\{ \frac{1}{b(\tau)} Q(h(\tau)) - w(\tau) \right\} e^{-r\tau} d\tau \geq \beta e^{-rt}, \quad \forall t \quad (6)$$

where the left-hand side of both conditions gives the benefits of staying in the firm and not cheating, whereas the right-hand side gives the benefits of cheating and being "terminated" by the other party. The parameter S is a fixed job changing cost (such as search and travel expenses) borne directly and immediately by the worker, while the direct benefits from malfeasance are θ for workers and β for firms, which again follows the treatment of worker malfeasance in Lazear (1979, 1981). The quantity θ , for example, might thus be thought of as the amount (in utility units) of money a bank employee can extort, or on-the-job leisure a factory worker can appropriate, before being discovered and terminated by the company. It will be useful in dealing with θ and β to introduce the function $A(\cdot)$ which allows us to convert units of worker malfeasance [measured in utility units] into their cost in terms of profits. Thus $A(\theta e^{-rt})$ is just the cost to the employer of θ units of worker malfeasance. Another interpretation of this is

that $A(0e^{-rt})$ is the amount of profits that must be foregone (which may be negative if S is high enough) in order to give the worker the utility increment inside the brackets.

Finally, $\overline{PVW}_t(\cdot)$ is a kind of indirect utility function which arises from the competitive market context of the model. It gives the best present value of utility obtainable from a contract designed over the period from t to T , subject to the constraint that the present value of profits as of $t=0$ over that period equals $(\cdot)$, and subject to all the relevant malfeasance problems during that period. Thus $\overline{PVW}_t(He^{-rt})$ represents the best the worker can do if he leaves his present firm at time t , re-incurs a hiring cost, and works for another firm that earns zero profits counting the initial hiring cost for the rest of his working life.⁵ It can be shown to have the following properties: First, in solving for the optimal contract it can be properly treated as exogenous for $t = 0$ to T , and second, $\overline{PVW}_t(\cdot)$ is strictly decreasing in its argument. Third, it is important to note that the function $b_t(\tau)$ is indexed by t , meaning that a worker's productivity at date τ in an alternative firm can depend on when he left the original firm. This allows for the existence of specific human capital; it is shown in an earlier version of this paper that specific human capital is equivalent to an increasing separation cost, S , with time of separation from the original firm.

To see how type-1 malfeasance conditions are special cases of type-2 in this situation, consider the conditions that must hold to prevent "quits", or "unilateral withdrawal" from the contract by both parties:

$$\begin{aligned} \text{to prevent worker} \quad & \int_{\tau=t}^T \{U(w(\tau)) - \frac{1}{a(\tau)} V(h(\tau))\} e^{-\delta\tau} d\tau \geq \overline{PVW}_t(He^{-rt}) \\ \text{withdrawal} \quad & - S e^{-\delta t}, \quad \forall t \end{aligned} \quad (7)$$

$$\begin{aligned} \text{to prevent firm} \quad & \int_{\tau=t}^T \left\{ \frac{1}{b(\tau)} Q(h(\tau)) - w(\tau) \right\} e^{-r\tau} d\tau \geq 0 \\ \text{withdrawal} \quad & \quad \quad \quad \forall t \end{aligned} \quad (8)$$

and note that these are identical to (5) and (6) with the direct benefits to malfeasance, β and θ , both equal to zero. In other words, as long as "shirking" and "exploiting" the other party are just like quitting (in the sense that they result in immediate termination of the contract), except that they also confer an immediate benefit due to shirking itself, both parties will prefer shirking over quitting if they intend to cheat. It is easy to see then that type-1 malfeasance constraints are never binding when the full range of behaviors is allowed both parties, and that failing to include a symmetrical treatment of type-2 malfeasance might have serious consequences for contracts models, some of which are noted in Section IV below.

IV. WILL WAGES RISE FASTER THAN MARGINAL PRODUCTS?

This section interprets two earlier types of contracts models--the first represented by Becker (1964), Hashimoto and Yu (1980), and Hall and Lazear (1984); the second by Becker and Stigler (1974) and Lazear (1979, 1981)--as special cases of the present one. The reasons why the conclusions of these models differ from each other and from the present one then become very clear. The analysis consists simply of examining the feasible sets of contracts in a highly simplified version of the present model.

For present purposes, consider a version of our model that keeps effort, $h(t)$, exogenous as in earlier literature. In particular, imagine $h(t)$ and $a(t)$ are both constant and exogenous over the entire life of the contract, but that productivity in the present firm, $\frac{1}{b(t)}$, is monotonically increasing. Denote the (now exogenous) spot marginal product of the worker as $MP(t)$. Suppose also that $b_t(\tau)$ is such that an individual's productivity in alternative employment is constant over time and the same in all alternative firms. This yields a well-defined alternative spot marginal product (which

usually does not exist in this world--see footnote 5) equal to $\tilde{w}$ for all t . The curves $MP(t)$ and $\tilde{w}(t)$ are shown in Figure 1(a). They are deliberately chosen to represent Becker's specific human capital problem. Finally, for simplicity in graphing the models imagine workers care only about the present value of earnings, not their distribution over time, and set $r = \delta = 0$. We consider what each of the types of models above indicate about the feasible set of wage profiles in turn.

Becker, Hashimoto and Yu, and Hall and Lazear all present models in which a wage profile is designed so as to prevent wasteful quits and dismissals in a specific human capital setting. Thus, only type-1 malfeasance is allowed, but it is treated symmetrically. In terms of our model, the contract must satisfy (5) and (6) with $\theta = \beta = 0$ or:

$$\text{to prevent} \quad \int_{\tau=t}^T (w(\tau) - \tilde{w}(\tau)) \equiv PVW - \overline{PVW} \geq 0 \quad (9)$$

quits:

and

$$\text{to prevent} \quad \int_{\tau=t}^T (MP(\tau) - w(\tau)) \equiv PVMP - PVW \geq 0 \quad (10)$$

dismissals:

In Figure 1(a), what this means is that for any candidate wage profile, say w_1 , areas A and B (the areas between it and $\tilde{w}$ and w_1 , and w_1 and MP , respectively from any t , say t_1 , up to T) must both be non-negative for all t . Profile w_1 , the sharing arrangement proposed by Becker, clearly satisfies this criterion. In Figure 1(b), the same requirement can be expressed by the condition that the time path of the remaining present value of wages, PVW , fall between the curves $\overline{PVW}$ and $PVMP$.

In sum, when the only possible kind of malfeasance is to leave the contract, wage profiles will be constructed such that ex post rents to both workers and firms are always non-negative. This does not necessarily imply that wages rise more slowly than productivity at all times during the contract, but does imply something like it in an "average" sense, which is clearly what Becker meant.

Lazear, drawing on Becker and Stigler (1974), presents a model in which a wage profile is designed to prevent worker shirking without incurring excessive withdrawals by firms. Thus, in his case $\theta > 0$ because workers derive benefits from shirking. At the same time, firms can cheat only by withdrawing from the contract, and by assumption this is assumed not to yield positive benefits but in fact to cause "reputation costs". This is equivalent to setting $\beta < 0$ in (6). Thus, the incentive-compatibility conditions in Lazear's model are:

$$\begin{array}{ll} \text{to prevent} & \int_{\tau=t}^T [w(\tau) - \tilde{w}(\tau)] \equiv PVW - \overline{PVW} \geq \theta \\ \text{shirking:} & \end{array} \quad (11)$$

$$\begin{array}{ll} \text{to prevent} & \int_{\tau=t}^T [MP(\tau) - w(\tau)] \equiv PVMP - PVW \geq \beta \\ \text{dismissals:} & \end{array} \quad (12)$$

with $\theta > 0$ and $\beta < 0$. In other words, ex post rents to workers now must be strictly positive to prevent shirking, but ex post rents to firms may now be negative, since firms face "reputation costs". This shifts the entire feasible area for contracts in Figure 1(b) upwards, where it becomes the entire shaded area, and allows for the possibility of wage profiles such as w_2 . Indeed, if θ and $-\beta$ are both positive random variables as in Lazear, so some malfeasance does occur in equilibrium, it is easy to see that equilibrium contracts will never have ex post rents to firms positive, since one could then reduce worker malfeasance without increasing firm malfeasance by lowering those rents.

Figure 1

In sum, when firms face exogenously imposed "reputation costs" and are allowed to cheat workers only by terminating them, wage profiles will be constructed so that ex post rents to workers are always strictly positive and ex post rents to firms are non-positive. This is Lazear's result, which he refers to loosely as having wages "below marginal product at the beginning of the contract and above it at the end".

Finally, consider the implications in this context of the present model, which treats malfeasance symmetrically and allows for a full range of malfeasant behavior, so $\beta > 0$ in (12). Ex post rents to workers and firms now must both be strictly positive, and the range of feasible contracts is thus restricted to the darkly shaded area in Figure 1(b). There is no longer any reason to expect wages to rise faster or more slowly than marginal products, and the set of feasible contracts is smaller and entirely inside the sets considered earlier. In fact, the set of feasible contracts can easily be empty, and will in general preclude the existence of pensions. Thus the inclusion of type-2 malfeasance by firms can in fact have serious consequences for contract structure in this simple world, some of which are explored below.

V. SOLVING FOR THE OPTIMAL CONTRACT

This section attempts to demonstrate the usefulness of a more general model of incentive compatibility in labor contracting by solving out the model outlined in Section III. It is able to show, among other things, how optimal wage profiles can be steeper than marginal product profiles in some portions of the contract and less steep in others. It also endogenizes

the life-cycle effort profile, is able to show exactly how enforceability problems compromise contract structure, and provides some interesting comparative statics and suggestive examples concerning the applicability of the model to empirical issues.

We proceed by first deriving optimality conditions in the general model, then considering an example where the life-cycle productivity profile has an inverted U-shape, and finally considering some simple comparative statics within this example.

1. First-Order Conditions in the General Model

The optimal contract problem as represented so far is not amenable to standard dynamic optimization techniques, but can be rewritten in a way that is. We shall do two things. First, to be able to incorporate the constraints on remaining present values or utility and profits we define the variables:

$$\omega(t) = \int_{\tau=t}^T W(\tau) e^{-r\tau} \quad (13)$$

$$q(t) = \int_{\tau=t}^T \frac{1}{b(\tau)} Q(h(\tau)) e^{-r\tau} \quad (14)$$

which are, respectively, the remaining present values (at the firm's discount rate) of output and wages. These shall serve as state variables, with their rates of change,

$$\dot{c} = \dot{\omega} = -w(t) e^{-rt} \quad (15)$$

$$\dot{d} = \dot{q} = -\frac{1}{b(t)} Q(h(t)) e^{-rt} \quad (16)$$

as controls. Second, in order to keep the dimensionality of the problem, which is to maximize (3) subject to (4), (5) and (6), as limited as possible and to make it easily presentable in graphical form, we note that only (5) cannot be easily written in terms of q , ω , c and d . To

do this, note that (5) states that the remaining present value (as of $t=0$) of the objective function must exceed some minimum level, $PVW(He^{-rt}) + [\theta - S]e^{-\delta t}$ at all t , and that by the principle of optimality the solution path $[q(t), \omega(t)]$ must maximize the remaining value of the objective function at any t , given that it starts on the optimal path. This implies that in order for the remaining present value of utility to exceed $PVW(He^{-rt}) + [\theta - S]e^{-\delta t}$ it is both necessary and sufficient that the remaining present value of profits over that interval be less than the minimum needed to achieve that level of discounted utility. The whole problem can now be written:

$$\text{Max}_{c,d} \int_{t=0}^T \{U(-c^{rt}) - \frac{1}{a(t)} V(Q^{-1}[-db(t)e^{rt}])\} e^{-\delta t} dt \quad (17)$$

subject to

$$\dot{\omega} = c \quad (18)$$

$$\dot{q} = d \quad (19)$$

$$q(0) - \omega(0) - H = 0 \quad (20)$$

$$q - \omega \leq He^{-rt} - A\{(\theta - S)e^{-\delta t}\}e^{-rt} \quad (21)$$

$$q - \omega \leq (\beta)e^{-rt} \quad (22)$$

where (20) is the zero profit constraint (2) which has now become an initial condition on the state variables at $t=0$. Conditions (21) and (22) are the worker and firm malfeasance constraints (5) and (6), which have become inequality constraints on the state variables in a optimal control problem with c and d as controls. Condition (21) uses the function $A(\cdot)$ and the equivalence $PV\Pi_t[PVW_t(H)] = He^{-rt}$ to stipulate the critical level of profits above which worker malfeasance will occur.

Associating the multipliers λ_w and λ_q with (18) and (19) respectively, η_w and η_f with (21) and (22) respectively, and setting up the Hamiltonian, we can derive necessary conditions for an optimum of the form:

$$U'(w)e^{(r-\delta)t} = \lambda_w \quad (23)$$

$$\frac{b(t)}{a(t)} \frac{V'(h)}{Q'(h)} e^{(r-\delta)t} = -\lambda_q \quad (24)$$

$$\dot{\lambda}_w = \eta_f - \eta_w \quad (25)$$

$$\dot{\lambda}_q = \eta_w - \eta_f \quad (26)$$

$$\eta_w \{q - w - H e^{-rt} + A \left\{ \left(\frac{\theta}{P_f} - S \right) e^{-\delta t} \right\} e^{-rt} \} = 0 \quad (27)$$

$$\eta_f \{q - w - \beta e^{-rt} \} = 0 \quad (28)$$

The general solution to the contracting problem has two interesting properties which are most easily seen by differentiating (23) and (24) and examining the resulting equations for $\dot{w}$ and $\dot{h}$:

$$\dot{w} = \left(-\frac{U'}{U} \right) (r-\delta) + \dot{\lambda}_w \frac{e^{(\delta-r)t}}{U''} \quad (29)$$

$$\dot{h} = \frac{1}{\frac{V''}{V'} - \frac{Q''}{Q'}} \left\{ \frac{\dot{a}}{a} - \frac{\dot{b}}{b} + \delta - r \right\} + (-\dot{\lambda}_q) \frac{a}{b} e^{(\delta-r)t} \left(\frac{V''Q' - V'Q''}{Q'^2} \right) \quad (30)$$

First, consider what the solutions would look like if for some reason--for example, extremely high H and S --malfeasance constraints were never binding on the contract. We call this the "first-best" contract, and note from (25) and (26) that it will have $\dot{\lambda}_w = \dot{\lambda}_q = 0$. Equations (29) and (30) then indicate a key result: In first-best contracts, where malfeasance constraints do not impinge on contract structure, the rates of change of wages and effort are totally independent of each other,⁶ each being determined by a different set of influences. In particular,

whether or not the compensation profile is rising depends only on whether the firm's discount rate exceeds workers' and has nothing to do with productivity or value-of-leisure trends $\frac{\dot{a}}{a}$ and $\frac{\dot{b}}{b}$. On the other hand, effort profiles allocate h independently of w and will tend to utilize workers more intensively when their productivity is increasing ($\frac{\dot{b}}{b}$ falling) and when their valuation of effort is decreasing ($\frac{\dot{a}}{a}$ rising). The degree of variability in w and h over time is reduced by greater "concavity" of $U(w)$ and by greater "convexity" of $V(h)$ and "concavity" of $Q(h)$ respectively, where these degrees of curvature are measured by the coefficients of absolute risk aversion of these functions.

Second, we can characterize actual "second best" solutions to the contracting problem as consisting in general of sections where (21) and (22) are binding and sections where they are not. Thus, the introduction of malfeasance into contracts, through the η 's and λ 's of the problem, will make w and h profiles interdependent and will mean there are portions of the contract where one of the parties to the contract is just indifferent between cheating and not doing so. The actual way in which second-best contracts deviate from first-best ones depends significantly on the cycle of life-cycle productivity patterns, and this is examined in the following section.

It should be clear from the analysis thus far, however, that not only can the optimal contract have wages rising either more or less quickly than marginal productivity, but that both these trends can occur in different parts of the contract, depending on the shapes of $a(t)$ and $b(t)$, r and δ , and on where the malfeasance constraints are binding.

2. An Example

To say more about the shape of life cycle wage and effort profiles, we need to know where the incentive-compatibility constraints (21) and (22) are binding. To know that, we need to stipulate more about the shape of the life cycle productivity and value of leisure profiles as well as about discount rates. We consider the case of no discounting ($\delta = r = 0$) and of constant disutility of effort over the life cycle ($\dot{a} = 0$). Productivity $[1/b(t)]$ is assumed to have an inverted U shape--i.e., workers' productivity at first rises during a "learning" period to a high level at mid-life, and then falls again as workers approach retirement, as is predicted, for example, in Ben Porath's (1967) model of human capital with depreciation. Finally, for simplicity, we shall, where convenient, assume the utility, disutility-of-effort, and production functions have the "constant absolute risk aversion" form $y = a^k$, which makes the solutions of (29) and (30) particularly easy to describe.

The shape of first-best wage and effort profiles in our example is easily derived from either (23) and (24) with constant λ 's or from (29) and (30) with both $\dot{\lambda}$'s equal to zero. Because $\delta = r$, first-best wage profiles are completely flat (the standard result in pure intertemporal income allocation problems of this kind) whereas first-best effort profiles, like productivity, have an inverted U shape--since it pays to use the worker more intensively at times when he is more productive. This is shown in parts (a) and (b) of Figure (2).

The spot profit profile associated with the first-best contract is shown in Figure (2.c) and the path of remaining present value of profits this implies is shown in Figure (2.d). For the case of a hump-shaped life cycle productivity path, Figure (2.d) shows that if the first-best contract

violates the malfeasance constraints (shown as minimum and maximum $q-w$ levels) at all, it will tend to violate the worker malfeasance constraint first--near the start of the contract--and the firm malfeasance constraint later, as shown. In other words, because imperfect capital markets and/or progressive income taxes make it desirable to keep wages constant over the life cycle, but the worker's productivity is concentrated in mid-life, the employment contract we would most like to achieve is vulnerable to opportunistic behavior in two ways: Near the end of the worker's employment, at a point like (d), firms have already collected most of the effort due them by the worker but still owe the worker a constant wage. Firms will be tempted to cheat on the older workers since they have little to lose by doing so. Near the start of the contract (at a point like b), young workers have just completed what we might call a "training period" during which their productivity was low, but at the same time their wages were high. They now face a period of increasing effort but constant wages during which they must "repay" the "wage advance" received earlier. Since they have little to lose from being dismissed at that point, workers will be tempted to cheat here. We shall concern ourselves henceforth with cases in which both malfeasance constraints are violated by the first-best contract, since this is the most interesting of the possible cases and it is always easy to see what happens in the absence of constraints by looking at unconstrained paths.

Intuitively, it is fairly easy at this point to see what actual second-best contracts will look like relative to first-best ones, simply by noting that any such contract must lie within the constraints of Figure (2.d). In order to eliminate the firm malfeasance problem, second-best contracts must

FIGURE 2

Graphical depiction of first- and second-best contracts when life-cycle productivity is hump-shaped.

have higher discounted profits--i.e., lower wages and higher effort--near the end. In order to eliminate the worker malfeasance problem, these contracts must "pay for a smaller amount of workers' training"--i.e., not provide such high wages and low effort up front, and not demand as much effort at such a low wage at mid-life. All this means is that in general we would expect second-best wage profiles to be more "peaked" towards mid-life, and second-best effort profiles to be less peaked, than first-best ones. Examples of such contracts are shown in Figures 2.a and b ; the fact that the solution to our problem will in general look like this is shown more formally in the Appendix. Interestingly, the actual wage profile in our example has five distinct segments: one (between 0 and t_1) where wages are above productivity and rising less rapidly, one (between t_1 and t_2) where wages equal output exactly and both are rising, one (between t_2 and t_3) where wages are below productivity and rising less rapidly, one (between t_3 and t_4) where wages are below productivity and falling less rapidly, and finally one where wages again equal productivity and both are falling (t_4 to T). Thus it appears that any of the conclusions of earlier contracting models can be generated in different segments of the same contract when a general treatment of malfeasance is allowed and the model is solved out more fully.

3. Comparative Statics and Extensions

In this section we briefly comment on the effects of changing various parameters and assumptions of the model. Since the effects of doing so are complex and depend on the functional forms of $a(t)$ and $b(t)$, the discussion is largely informal, focusing on the effects of parameters on the first-best paths, the constraints, and on where those constraints are likely to bind.

We consider the effect of changing θ , β , S , H , r , δ , the shapes of $U(h)$, $V(h)$, and $Q(h)$, and the assumption of credible policies of dismissal in response to cheating in turn.

Increasing both θ and β --the benefits from cheating--affects the contract only by moving the constraints in Figure 2.d close together. This restricts the scope of admissible contracts, making wage profiles more peaked, and forcing the wage and output profiles to correspond more closely to one another. Increasing the mobility cost S relaxes the worker malfeasance constraint and means wages need not rise so rapidly near the start of contracts. Increasing H has a more complex effect: it both relaxes the worker malfeasance constraint and raises the entire first-best q - w profile, so its effects on the worker malfeasance problem are ambiguous, but it relaxes the firm malfeasance constraint. (Thus we might expect firms with higher hiring costs to pay their older workers more, and to be more likely to provide pensions.) Increasing r or lowering δ increases the slope of the first-best wage profile and reduces the slope of the first-best effort profile. Higher r thus means the worker-malfeasance constraint is less likely to be violated, and higher δ means the same for the firm-malfeasance constraint. Their effects on whether the other constraints are violated are unclear, since the constraint in question is altered by r and δ as well. In general, greater "curvature" of the U , Q and V functions (in the sense of their absolute risk aversion coefficients) will imply flatter wage and effort profiles; in our case this makes it less likely the first-best contract violates the malfeasance constraints since it will entail less variation in spot profits over time, but it also increases the cost of satisfying those constraints should they in fact be violated.⁷

Finally, it is interesting to speculate on the validity of the assumption, made for example throughout Lazear (1979, 1981), Stiglitz and Weiss (1983) and the present piece, that the policies pursued by agents of terminating the contract should the other agent cheat are themselves effective and credible. While a formal, repeated-game analysis such as Kreps and Wilson (1982) is required to give a definitive answer to that question, it is apparent from the present model that the absence of such credible threats can pose serious problems for the life-cycle contracting process. In fact, it can easily make the set of feasible contracts empty.⁸ Analysis of factors which may affect the credibility of threats (such as firm size or unionism, which are in some sense related to the number of repetitions of the contracting game) might thus generate some interesting implications for cross-sectional variation in contract structure. While these seem promising avenues for further research, they are unfortunately beyond the scope of the present paper.

APPENDIX

We proceed in two stages. First, we state Proposition 1, and show that it generates the types of profiles shown in Figure 2. Second, we prove Proposition 1.

AI. Proposition 1 and its Effects:

Proposition 1 states that: The second-best present value of profits $(q - w)$ path must coincide with the worker-malfeasance constraint for one continuous period of time only. When point h is defined as the inflection point of the first-best $(q - w)$ path (see Figure 2(d)), this segment must begin between points b and c , and end before h . Similarly, second-best $(q - w)$ must coincide with the firm-malfeasance constraint for one continuous period only, which starts after h and ends e .

Proposition 1 is sufficient for us to be able to conclude that the multipliers η_w and η_f attached to the malfeasance constraints have paths of the form shown in Figure (2.e): each has one non-zero segment, and that for η_w occurs before that for η_f . The consequences of this for $\dot{w}$ and $\dot{h}$ can then be easily seen by substituting (25) and (26) into (29) and (30), which for our simple example gives:

$$\dot{w} = (\eta_w - \eta_f) \left[\frac{-1}{U''(w)} \right] \quad (A1)$$

$$\dot{h} = \frac{1}{\frac{V''}{V'} - \frac{Q''}{Q'}} \left(-\frac{\dot{b}}{b} \right) + (\eta_f - \eta_w) \frac{1}{b} \left[\frac{V''Q' - V'Q''}{Q'^2} \right] \quad (A2)$$

The terms in square brackets in (A1) and (A2) are both positive. Equations (A1) and (A2) indicate the following: Second-best wage and effort paths in our example will be parallel to first-best paths ($\dot{w} = 0$, $\dot{h} = \frac{1}{\frac{V''}{V'} - \frac{Q''}{Q'}} \left(-\frac{\dot{b}}{b} \right)$)

over all intervals except for two. Somewhere near the start of the contract, the worker malfeasance constraint is binding on contract structure ($\eta_w > 0$) which means that wages must rise more quickly, and effort must rise more slowly than in first-best contracts at that time. And somewhere near the end of the contract, the opposite is true, because the firm malfeasance constraint is binding: wages must fall and effort must drop less slowly than in first-best contracts. This is shown by the wage and effort paths in Figure (2.a) and (b), which we have already justified intuitively.

AII. PROOF OF PROPOSITION 1:

We shall begin by establishing two simple results.

Result 1: On junction points where the second-best present value of profits path (henceforth 2B) joins or leaves the malfeasance constraints, 2B will be tangent to the constraints.

Proof: This follows directly from the continuity of λ_w and λ_f in (23)-(26), and incidentally implies (from (23) and (24)) that w and h are continuous paths--i.e., there are no sudden "promotions" with jumps in wages and duties. This continuity in the controls is in fact a general result for any state-variable inequality-constrained problem which, like the present one, is strictly and globally concave in the controls (see, for example, McIntyre and Paiewonsky, 1967, p. 408, or Kamien and Schwartz, 1981, pp. 216-219).

Result 2: The second derivative of the second-best path (2B) has the same sign as that of the first-best (1B) on any unconstrained segment.

Proof: From the definition of $q - \omega$, the second derivative of the present value of profits, with $r = \delta = 0$, is simply $-\dot{\pi}(t)$, which can be written:

$$-\dot{\pi}(t) = \frac{\dot{b}}{b} Q(h) - \frac{1}{b} Q'(h) \dot{h} + \dot{w} \quad (A3)$$

But on unconstrained segments of 2B, $\dot{w} = 0$ (from (29)), and $\dot{h}$ is the same as it is in 1B (from (30), with $\frac{V''}{V}$ and $\frac{Q''}{Q}$ both constants). Now, when productivity is rising ($\frac{\dot{b}}{b} < 0$) we know this means $\dot{h}$ is positive, so from (A3), $-\dot{\pi}(t) < 0$, or $(q - \omega)$ is concave in both 1B and 2B. The opposite applies when $\frac{\dot{b}}{b} > 0$.

We can now demonstrate the following different points in turn:

1. The second-best $(q - \omega)$ path cannot touch the worker malfeasance constraint (WM) after h , nor can it touch the firm-malfeasance constraint (FM) before h .
 2. If 2B touches WM before h , it can only do so over one continuous period, and similarly for FM after h .
 3. 2B must touch WM before h , and FM after h .
 4. The periods of coincidence with the constraints can further be narrowed down, such that 2B must join WM between b and c , and may not leave FM before e .
1. In our example, both WM and FM are horizontal straight lines. After h , 2B must be convex by Result (2), but must also be tangent to WM at junction points by Result (1). But this is impossible if the path is to remain feasible. Thus 2B can neither join nor leave WM after h .

Finally, note that 2B cannot stay on WM for the entire period after h, because it must end at $q - \omega = 0$. A similar argument rules out coincidence of 2B with FM before h.

2. Now consider the area before h, where 1B and unconstrained sections of 2B must be concave. By concavity, it is impossible for 2B to leave WM and then return again, so it can only coincide with WM once. The same applies to FM after h.
3. We shall establish the result for WM, before h, by considering the nature of the 2B path from a to a point g, which is defined as the point on cd where 2B crosses 1B. (It is easy to show this point must exist and is unique.)
 - (i) Imagine for the moment that 2B went from a to g without touching any constraints. Both η_f and η_w would then be zero over that range in (25) and (26), which means that the optimal paths for w and h will be the same as in the first-best solution (1B), since the Euler equations are the same and so are the initial and terminal conditions.¹ But this path violates WM, so it is not a feasible solution. Therefore, 2B must touch some constraint between a and g. Now if g occurs before h, this establishes our result. To cover the possibility that g is after h, we need to make the following argument:
 - (ii) Imagine now that the only constraint 2B hit in the period ag was FM and denote this path A. Consider the effects of removing FM. By (i) above, the solution must now change drastically enough to hit WM. Call this

¹These include two transversality conditions which essentially give optimal combinations of w and h for a given π at the beginning and end points of the paths.

path B. Now, before we removed FM, both A and B were feasible, but A was chosen. After FM was removed, both A and B are still feasible, but now B is chosen. Since we cannot be indifferent between two different paths, A and B, when the Hamiltonian is strictly and globally concave in the controls, as it is here, this is a contradiction. Thus 2B must hit WM in the period ag, and our third point is completely established since the segment fg was ruled out in point (1).

4. Suppose that 2B hit WM before b. This means 2B must touch 1B at some other point besides a along ab (for example, point b). But this means there are two different optimal paths from a to this new point, both of which are feasible whether or not WM is imposed, which is again a contradiction. Suppose that 2B did not hit WM until after c. This means it must cross ed at some point before h. If we label this point g, then the same argument as in 3(i) above applies to the path ag. But since 2B can hit WM only once in ah, this is impossible. The proof that 2B cannot leave FM before e is entirely parallel.

NOTES

¹For example, Lazear's model predicts wages to be rising more rapidly than the worker's actual in-firm productivity, while Hashimoto and Yu's (which is essentially a formalization of Becker's (1964, pp. 21-22) discussion of specific human capital) has wages rising more rapidly than alternative wages but less rapidly than actual, in-firm productivity.

²Type-1 malfeasance by firms in risk-sharing models with state-contingent layoffs such as Grossman, Baily and Azariadis should be thought of as firms dismissing more workers in a given state than promised--which they have an incentive to do since the wage exceeds the marginal product in "bad" states. This is typically never allowed in those models.

³More to the point, doing so under full information implies that one is implicitly agreeing to a different contract--one in which $w(t)$ and $h(t)$ are stipulated as lower than in the original contract.

⁴The effects of relaxing this assumption are examined in Section V.

⁵We develop the alternative present value of utility stream, $\overline{PVW}$, explicitly here, rather than assuming a fixed alternative wage path, not only because it puts the model into a general-equilibrium context, but because when a worker's productivity (or value of leisure) varies over the life cycle and all firms offer optimal long term contracts, the concept of a single alternative wage or utility level at time t no longer exists as a well-defined entity.

⁶Except in the sense that, were the parameters of the problem to be changed, the initial conditions for the two separate first-order differential equations (29) and (30), i.e., $w(0)$ and $h(0)$, would change.

⁷If we consider decreasing the curvature of these functions, an interesting special case of the model occurs when we let U be linear and set $r = \delta$, i.e., the case of perfect capital markets and proportional income taxation. In this situation, it can be shown that, so long as an incentive compatible contract exists at all, then a first-best contract can always be achieved by setting $h(t)$ at the preferred level and manipulating $w(t)$ to satisfy the incentive-compatibility conditions. The same of course is true if any good (besides w) which enters the utility function of both parties in the same linear fashion is introduced in the model, but is not true when other types of goods are introduced that may be exchanged between firms and workers.

⁸To see this, simply note that constraints (5) and (6), when cheaters are never dismissed, reduce to $0 \geq (\theta - S)e^{-\delta t}$ and $0 > \beta e^{-rt}$ respectively, of which the second is impossible to satisfy in our model. When cheaters are dismissed with some positive probability, the set of feasible contracts can be non-empty, but is smaller than the set considered in this paper. A more formal analysis of this issue is provided in an earlier version of this paper, available on request.

References

- Azariadis, C., "Implicit Contracts and Underemployment Equilibria,"
Journal of Political Economy (December 1975), pp. 1183-1202.
- Baily, N. N., "Wages and Employment Under Uncertain Demand," Review of Economic Studies (January 1974), pp. 37-50.
- Becker, G., Human Capital, New York: Columbia University Press. (1964)
 (1st ed.).
- Becker, G. and G. Stigler, "Law Enforcement, Malfeasance, and Compensation of Enforcers," Journal of Legal Studies (January 1974), pp. 1-18.
- Ben Porath, Y., "The Production of Human Capital and the Life Cycle of Earnings," Journal of Political Economy, No. 4 (1967), pp. 352-365.
- Eaton, J. and H. S. Rosen, "Pensions, Agency and the Structure of Executive Compensation," mimeo (June 1981).
- Grossman, H. I., "Risk Shifting, Payoffs, and Seniority," Journal of Monetary Economics (November 1978), pp. 661-686.
- Hall, R. and E. Lazear, "The Excess Sensitivity of Quits and Layoffs to Demand," Journal of Labor Economics (April 1984).
- Harris, M. and B. Holmstrom, "Ability, Performance and Wage Dynamics," mimeo (1981).
- Hashimoto, M. and B. T. Yu, "Specific Capital, Employment Contracts, and Wage Rigidity," Bell Journal of Economics (Autumn 1980), pp. 536-549.
- Holmstrom, B., "Equilibrium Long-Term Labor Contracts," Northwestern University, Kellogg Graduate School of Management, Discussion Paper No. 414 (January 1980).
- Kamien, M. and N. Schwartz, Dynamic Optimization: the Calculus of Variations and Optimal Control in Economics and Management, New York: North Holland (1981).

Kreps, D. and R. Wilson, "Reputation and Imperfect Information," Journal of Economic Theory (August 1982), pp. 253-279.

Lazear, E., "Why is there Mandatory Retirement," Journal of Political Economy (December 1979), pp. 1261-1284.

Lazear, E., "Agency, Earnings Profiles, Productivity and Hours Restrictions," American Economic Review (September 1981).

Lazear, E. and H. S. Rosen, "Rank-Order Tournaments as Optimum Labor Contracts," Journal of Political Economy (October 1981).

Malcolmson, J.M., "Work Incentives, Hierarchy, and Internal Labor Markets," Journal of Political Economy (June 1984), pp. 486-507.

McIntyre, J. and B. Paiewonsky, "On Optimal Control with Bounded State Variables," Advances in Control Systems, Vol. 5, New York: Academic Press (1967), pp. 389-419.

Stiglitz, J. and A. Weiss, "Incentive Effects of Terminations," American Economic Review, (December 1983).

1981

- 8101C Markusen, James R. Factor Movements and Commodity Trade as Compliments: A Survey of Some Cases.
- 8102C Conlon, R.M. Comparison of Australian and Canadian Manufacturing Industries: Some Empirical Evidence.
- 8103C Conlon, R.M. The Incidence of Transport Cost and Tariff Protection: Some Australian Evidence.
- 8104C Laidler, David. On the Case for Gradualism.
- 8105C Wirick, Ronald G. Rational Expectations and Rational Stabilization Policy in an Open Economy
- 8106C Mansur, Ahsan and John Whalley Numerical Specification of Applied General Equilibrium Models: Estimation, Calibration, and Data.
- 8107C Burgess, David F., Energy Prices, Capital Formation, and Potential GNP
- 8108C DSU Jimenez, E. and Douglas H. Keare. Housing Consumption and Income in the Low Income Urban Setting: Estimates from Panel Data in El Salvador
- 8109C DSU Whalley, John Labour Migration and the North-South Debate
- 8110C Manning, Richard and John McMillan Government Expenditure and Comparative Advantage
- 8111C Freid, Joel and Peter Bwitt Why Inflation Reduces Real Interest Rates

1982

- 8201C Manning, Richard and James R. Markusen Dynamic Non-Substitution and Long Run Production Possibilities
- 8202C Feenstra, Robert and Ken Judd Tariffs, Technology Transfer, and Welfare
- 8203C Ronald W. Jones, and Douglas D. Purvis: International Differences in Response to Common External Shocks: The Role of Purchasing Power Parity
- 8204C James A. Brander and Barbara J. Spencer: Industrial Strategy with Committed Firms
- 8205C Whalley, John, The North-South Debate and the Terms of Trade: An Applied General Equilibrium Approach
- 8206C Roger Betancourt, Christopher Clague, Arvind Panagariya CAPITAL UTILIZATION IN GENERAL EQUILIBRIUM
- 8207C Mansur, Ahsan H. On the Estimation of Import and Export Demand Elasticities and Elasticity Pessimism.
- 8208C Whalley, J. and Randy Wigle PRICE AND QUANTITY RIGIDITIES IN ADJUSTMENT TO TRADE POLICY CHANGES: ALTERNATIVE FORMULATIONS AND INITIAL CALCULATIONS
- 8209C DSU Jimenez, E. SQUATTING AND COMMUNITY ORGANIZATION IN DEVELOPING COUNTRIES: A CONCEPTUAL FRAMEWORK

1982

- 8210C Grossman, G.M. INTERNATIONAL COMPETITION AND THE UNIONIZED SECTOR
- 8211C Laidler, D. FRIEDMAN AND SCHWARTZ ON MONETARY TRENDS - A REVIEW ARTICLE
- 8212C Imam, M.H. and Whalley, J. INCIDENCE ANALYSIS OF A SECTOR SPECIFIC MINIMUM WAGE IN A TWO SECTOR HARRIS-TODARO MODEL.
- 8213C Markusen, J.R. and Melvin, J.R. THE GAINS FROM TRADE THEOREM WITH INCREASING RETURNS TO SCALE.
- 8214C INDUSTRIAL ORGANIZATION AND THE GENERAL EQUILIBRIUM COSTS OF PROTECTION IN SMALL OPEN ECONOMIES.
- 8215C Laidler, D. DID MACROECONOMICS NEED THE RATIONAL EXPECTATIONS REVOLUTION?
- 8216C Whalley, J. and Wigle, R. ARE DEVELOPED COUNTRY MULTILATERAL TARIFF REDUCTIONS NECESSARILY BENEFICIAL FOR THE U.S.?
- 8217C Bade, R. and Parkin, M. IS STERLING M3 THE RIGHT AGGREGATE?
- 8218C Kosch, B. FIXED PRICE EQUILIBRIA IN OPEN ECONOMIES.

1983

- 8301C Kimbell, L.J. and Harrison, G.W. ON THE SOLUTION OF GENERAL EQUILIBRIUM MODELS.
- 8302C Melvin, J.R. A GENERAL EQUILIBRIUM ANALYSIS OF CANADIAN OIL POLICY.
- 8303C Markusen, J.R. and Svensson, L.E.O. TRADE IN GOODS AND FACTORS WITH INTERNATIONAL DIFFERENCES IN TECHNOLOGY.
- 8304C Mohammad, S. Whalley, J. RENT SEEKING IN INDIA: ITS COSTS AND POLICY SIGNIFICANCE.
- 8305C DSU Jimenez, E. TENURE SECURITY AND URBAN SQUATTING.
- 8306C Parkin, M. WHAT CAN MACROECONOMIC THEORY TELL US ABOUT THE WAY DEFICITS SHOULD BE MEASURED.
- 8307C Parkin, M. THE INFLATION DEBATE: AN ATTEMPT TO CLEAR THE AIR.
- 8308C Wooton, I. LABOUR MIGRATION IN A MODEL OF NORTH-SOUTH TRADE.
- 8309C Deardorff, A.V. THE DIRECTIONS OF DEVELOPING COUNTRIES TRADE: EXAMPLES FROM PURE THEORY.
- 8310C Manning, R. ADVANTAGEOUS REALLOCATIONS AND MULTIPLE EQUILIBRIA: RESULTS FOR THE THREE-AGENT TRANSFER PROBLEM.

- 8311C DSU Mohammad, S. and Whalley, J. CONTROLS AND THE INTERSECTORAL TERMS OF TRADE IN INDIA.
- 8312C Brecher, Richard A. and Choudhri, Ehsan U. NEW PRODUCTS AND THE FACTOR CONTENT OF INTERNATIONAL TRADE.
- 8313C Jones, R.W., Neary, J.P. and Ruane, F.P. TWO-WAY CAPITAL FLOWS: CROSS-HAULING IN A MODEL OF FOREIGN INVESTMENT.
- 8314C DSU Follain, J.R. Jr. and Jimenez, E. THE DEMAND FOR HOUSING CHARACTERISTICS IN DEVELOPING COUNTRIES.
- 8315C Shoven, J.B. and Whalley, J. APPLIED GENERAL EQUILIBRIUM MODELS OF TAXATION AND INTERNATIONAL TRADE.
- 8316C Boothe, Paul and Longworth David. SOME IRREGULAR REGULARITIES IN THE CANADIAN/U.S. EXCHANGE MARKET.
- 8317C Hamilton, Bob and Whalley, John. BORDER TAX ADJUSTMENTS AND U.S. TRADE.
- 8318C Neary, J. Peter, and Schweinberger, Albert G. FACTOR CONTENT FUNCTIONS AND THE THEORY OF INTERNATIONAL TRADE.
- 8319C Veall, Michael R. THE EXPENDITURE TAX AND PROGRESSIVITY.
- 8320C Melvin, James R. DOMESTIC EXCHANGE, TRANSPORTATION COSTS AND INTERNATIONAL TRADE.
- 8321C Hamilton, Bob and Whalley, John. GEOGRAPHICALLY DISCRIMINATORY TRADE ARRANGEMENTS.
- 8322C Bale, Harvey Jr. INVESTMENT FRICTIONS AND OPPORTUNITIES IN BILATERAL U.S.-CANADIAN TRADE RELATIONS.
- 8323C Wonnacott, R.J. CANADA-U.S. ECONOMIC RELATIONS--A CANADIAN VIEW.
- 8324C Stern, Robert M. U.S.-CANADIAN TRADE AND INVESTMENT FRICTIONS: THE U.S. VIEW.
- 8325C Harrison, Glenn, H. and Kimbell, Larry, J. HOW ROBUST IS NUMERICAL GENERAL EQUILIBRIUM ANALYSIS?
- 8326C Wonnacott, R.J. THE TASK FORCE PROPOSAL ON AUTO CONTENT: WOULD THIS SIMPLY EXTEND THE AUTO PACT, OR PUT IT AT SERIOUS RISK?
- 8327C Bradford, James C. CANADIAN DEFENCE TRADE WITH THE U.S.
Conklin, David. SUBSIDY PACTS.
Rugman, Alan M. THE BEHAVIOUR OF U.S. SUBSIDIARIES IN CANADA: IMPLICATIONS FOR TRADE AND INVESTMENTS.

1983

- 8328C Boyer, Kenneth D. U.S.-CANADIAN TRANSPORTATION ISSUES.
- 8329C Bird, Richard M. and Brean, Donald J.S. CANADA-U.S. TAX RELATIONS: ISSUES AND PERSPECTIVES.
- 8330C Moroz, Andrew R. CANADA-UNITED STATES AUTOMOTIVE TRADE AND TRADE POLICY ISSUES.
- 8331C Grey, Rodney de C. and Curtis, John. INSTITUTIONAL ARRANGEMENTS FOR U.S.-CANADIAN NEGOTIATIONS. PART I: CANADA-U.S. TRADE AND ECONOMIC ISSUES: DO WE NEED A NEW INSTITUTION? PART II: INSTITUTIONAL ARRANGEMENTS FOR MANAGING THE CANADA-U.S. ECONOMIC RELATIONSHIP.

1984

- 8401C Harrison, Glenn W. and Manning, Richard. BEST APPROXIMATE AGGREGATION OF INPUT-OUTPUT SYSTEMS.
- 8402C Parkin, Michael. CORE INFLATION: A REVIEW ESSAY.
- 8403C Blomqvist, Åke, and McMahon, Gary. SIMULATING COMMERCIAL POLICY IN A SMALL, OPEN DUAL ECONOMY WITH URBAN UNEMPLOYMENT: A GENERAL EQUILIBRIUM APPROACH.
- 8404C Wonnacott, Ronald. THE THEORY OF TRADE DISCRIMINATION: THE MIRROR IMAGE OF VINERIAN PREFERENCE THEORY?
- 8405C Whalley, John. IMPACTS OF A 50% TARIFF REDUCTION IN AN EIGHT-REGION GLOBAL TRADE MODEL.
- 8406C Harrison, Glenn W. A GENERAL EQUILIBRIUM ANALYSIS OF TARIFF REDUCTIONS.
- 8407C Horstmann, Ignatius and Markusen, James R. STRATEGIC INVESTMENTS AND THE DEVELOPMENT OF MULTINATIONALS.
- 8408C Gregory, Allan W. and McCurdy, Thomas H. TESTING THE UNBIASEDNESS HYPOTHESIS IN THE FORWARD FOREIGN EXCHANGE MARKET: A SPECIFICATION ANALYSIS.
- 8409C Jones, Ronald W. and Kierzkowski, Henryk. NEIGHBORHOOD PRODUCTION STRUCTURES WITH APPLICATIONS TO THE THEORY OF INTERNATIONAL TRADE.
- 8410C Weller, Paul and Yano, Makoto. THE ROLE OF FUTURES MARKETS IN INTERNATIONAL TRADE: A GENERAL EQUILIBRIUM APPROACH.
- 8411C Brecher, Richard A. and Bhagwati, Jagdish N. VOLUNTARY EXPORT RESTRICTIONS VERSUS IMPORT RESTRICTIONS: A WELFARE-THEORETIC COMPARISON.

- 8412C Ethier, Wilfred J. ILLEGAL IMMIGRATION.
- 8413C Eaton, Jonathon and Gene M. Grossman. OPTIMAL TRADE AND INDUSTRIAL POLICY UNDER OLIGOPOLY.
- 8414C Wooton, Ian. PREFERENTIAL TRADING AGREEMENTS - A 3xn MODEL.
- 8415C Parkin, Michael. DISCRIMINATING BETWEEN KEYNESIAN AND CLASSICAL THEORIES OF THE BUSINESS CYCLE: JAPAN 1967-1982
- 8416C Deardorff, Alan V. FIRless FIRwoes: HOW PREFERENCES CAN INTERFERE WITH THE THEOREMS OF INTERNATIONAL TRADE.
- 8417C Greenwood, Jeremy. NONTRADED GOODS, THE TRADE BALANCE, AND THE BALANCE OF PAYMENTS.
- 8418C Blomqvist, Ake and Sharif Mohammad. CONTROLS, CORRUPTION, AND COMPETITIVE RENT-SEEKING IN LDCs.
- 8419C Grossman, Herschel I. POLICY, RATIONAL EXPECTATIONS, AND POSITIVE ECONOMIC ANALYSIS.
- 8420C Garber, Peter M. and Robert G. King. DEEP STRUCTURAL EXCAVATION? A CRITIQUE OF EULER EQUATION METHODS.
- 8421C Barro, Robert J. THE BEHAVIOR OF U.S. DEFICITS.
- 8422C Persson, Torsten and Lars E.O. Svensson. INTERNATIONAL BORROWING AND TIME-CONSISTENT FISCAL POLICY..
- 8423C Obstfeld Maurice. CAPITAL CONTROLS, THE DUAL EXCHANGE RATE, AND DEVALUATION.
- 8424C Kuhn, Peter. UNION PRODUCTIVITY EFFECTS AND ECONOMIC EFFICIENCY.
- 8425C Hamilton, Bob and John Whalley. TAX TREATMENT OF HOUSING IN A DYNAMIC SEQUENCED GENERAL EQUILIBRIUM MODEL.
- 8426C Hamilton, Bob, Sharif Mohammad, and John Whalley. RENT SEEKING AND THE NORTH-SOUTH TERMS OF TRADE.
- 8427C Adams, Charles and Jeremy Greenwood. DUAL EXCHANGE RATE SYSTEMS AND CAPITAL CONTROLS: AN INVESTIGATION.
- 8428 Loh, Choon Cheong and Michael R. Veall. A NOTE ON SOCIAL SECURITY AND PRIVATE SAVINGS IN SINGAPORE.
- 8429 Whalley, John. REGRESSION OR PROGRESSION: THE TAXING QUESTION OF INCIDENCE ANALYSIS.
- 8430 Kuhn, Peter. WAGES, EFFORT, AND INCENTIVE-COMPATIBILITY IN LIFE-CYCLE EMPLOYMENT CONTRACTS.