

## **Abstract**

This paper derives optimal employment contracts when workers are risk averse and there are employment and unemployment risks. Without income insurance, consumption rises during employment and falls during unemployment. Optimal employment contracts offer severance compensation to smooth consumption during employment without causing moral hazard. A pre-announced delay in dismissal when the job becomes unproductive provides further insurance but because of moral hazard it does not fully smooth consumption. During the delay consumption falls and the worker searches for another job. No delays in dismissals are optimal if exogenous unemployment compensation is sufficiently generous.

Keywords: employment risk, unemployment risk, severance compensation, notice of dismissal  
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# **Consumption and Savings with Unemployment Risk: Implications for Optimal Employment Contracts**

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# Consumption and Savings with Unemployment Risk: Implications for Optimal Employment Contracts

Christopher A. Pissarides

Employment contracts often contain provisions for the payment of severance compensation to dismissed employees, or for delays in dismissals. The most common procedure that delays dismissal is the requirement to give a notice of fixed duration before dismissal. There are, however, other procedures. In many countries, minimum levels of severance compensation and dismissal delays are written in employment laws but private contracts contain similar, if not more, stringent requirements. The OECD (1999) reports that on average in its member countries employers are required to give minimum advance notice of dismissal of 1.6 months to employees of four years standing and

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to pay severance compensation of four weeks' wages.<sup>1</sup> The purpose of this paper is to investigate the theoretical foundations for the existence of such provisions in optimal employment contracts.

I study a situation in which a principal, the firm, chooses the employment contract that minimizes the cost of its job offer, which has to be acceptable to an agent, the worker. I do not attempt to justify the inclusion of severance compensation or dismissal delays in legislation but investigate whether they can be a part of an optimal employment contract. The main result of the paper is that if workers cannot insure against the risk of becoming unemployed and the risk associated with an uncertain duration of the subsequent search for another job, severance compensation and dismissal delays provide second-best alternatives that avoid the moral hazard of first-best insurance. The payment of severance compensation is a perfect substitute for insurance against the risk associated with an uncertain duration of employment (I refer to this as the *employment risk*). Giving advance notice before dismissal provides additional insurance against the uncertain duration of unemployment (the *unemployment risk*). Optimal dismissal delays, however, do not fully insure against the unemployment risk because the failure of the firm to monitor the search strategy of its workers introduces moral hazard.

A dismissal delay has insurance value over and above that provided by severance compensation for the following reason. Suppose news arrives that a job has become unproductive. If the worker is dismissed into unemployment without delay her income falls and she searches for another job. Search is an uncertain activity so she wants to buy insurance contingent on its outcome, but the absence of private insurance markets does not make this possible. Instead, the worker can be made better off if the firm lets her stay employed without a pay cut but she agrees to search on the job and quit when she finds another job. The total wage payments actually received by the worker are then contingent on the outcome of search, and if the firm is risk neutral it is indifferent between paying the value of marginal product and dismissing without delay, or choosing

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<sup>1</sup>Provisions are more stringent in Europe than elsewhere but even in the United States, where legal provisions are virtually non-existent, similar arrangements are found in private contracts. For example, the OECD reports that in a survey conducted in 1992, it was found that between 15 and 35 percent of employees in the United States were covered by company severance plans, depending on company size. Civil rights laws and other legislation are also said to be contributing to delays in dismissals. See OECD (1999, p. 58).

a flat wage rate and indefinite delay subject to expected total payments not exceeding expected marginal product.

This contract is not feasible, however, when the firm cannot monitor the search strategy of its workers, because of moral hazard. The worker whose job has become unproductive will have no incentive to search if her income does not fall. As a second-best alternative, the firm can reduce moral hazard by structuring its compensation package so as to give incentives to the worker to search on the job and quit. I show that the firm can again achieve the contingency of payments when it delays dismissal but in a more subtle way. The optimal compensation package with moral hazard requires that when the job becomes unproductive the worker's utility of remaining employed should fall, and become progressively worse as the duration of employment increases. Delaying dismissal still has insurance value because by keeping the worker employed the firm can effectively monitor the outcome of search. If the firm pays employees on notice of dismissal more than the level of exogenous unemployment compensation, it knows that if the employee quits it is to take another job. Therefore, wage payments are still contingent on unsuccessful search. Workers are given incentives to search by the payment of compensation to quitting workers, which is effectively a reward for successful search.

The cost of delaying dismissal is that the worker on delayed dismissal is foregoing unemployment insurance, which is subsidized by the state (and the firm may incur costs when it keeps an unproductive job open). If exogenous unemployment insurance is sufficiently high, delaying dismissal is not optimal but for low unemployment compensation it is optimal.

With unlimited borrowing and lending (a maintained assumption in this paper) there is a number of ways that the firm can implement the contract. One compensation package that has the required properties holds the wage rate constant for a finite length of delay time and offers severance compensation to quitting workers. The worker is fired if she is still employed at the end of the "notice" period. This is the most common structure found in employment contracts that include dismissal delays. But other compensation packages give equivalent results. One such other package is to allow wages to fall monotonically with time employed after the job becomes unproductive. I discuss the implementation of the contract only briefly in the concluding section of the paper, my main focus in this paper being the derivation and description of the optimal contract.

My results on the optimal compensation package during a delay in dismissal are similar to the results derived for the optimal time structure of unemployment compensation, especially those by Shavell and Weiss (1979), Sampson (1978) and Hopenhayn and Nicolini (1997), who show that optimal unemployment compensation declines with search duration.<sup>2</sup> Although the model in this paper is deliberately simplified, and ignores the aggregate implications of the employment contracts, it can easily be extended to a model of labor market equilibrium with unemployment when workers have concave utility functions and can borrow and lend.<sup>3</sup>

The features of the optimal employment contract that I derive are often collectively described in the empirical literature as “employment protection.” There is a large literature on employment protection legislation, which studies partial or equilibrium models with risk neutrality in order to quantify the effect of various policy measures on employment and wages. Special emphasis is given to compulsory severance compensation and dismissal frictions.<sup>4</sup> The general conclusion reached in this literature is that employment protection measures do not have a significant impact on steady-state employment, but are likely to influence the dynamics of employment and wages. The main implication of the analysis of this paper for this literature is that a proper evaluation of employment protection measures should take into account the fact that they may be optimal responses to missing markets. This should influence the impact that they have on equilibrium but a proper evaluation of the empirical literature requires a model that implies

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<sup>2</sup>Their results, however, are usually derived for a more restrictive set of assumptions than in this paper. Although Shavell and Weiss (1979) allow the possibility of borrowing and lending in an extension of their model, they are unable to derive any results in this case when there is moral hazard, and their famous result holds only in the case where consumption is identically equal to income. Sampson (1978) who, like Shavell and Weiss, studies the optimal structure of unemployment compensation and reaches similar conclusions, also assumes away both borrowing and lending. Hopenhayn and Nicolini (1997) make a similar assumption and the absence of borrowing and lending also appears to be critical for some of their results (e.g. the result that the optimal insurance package should tax the post-unemployment wage according to the worker’s unemployment history rather than cut unemployment compensation).

<sup>3</sup>Other papers on optimal unemployment insurance with concave utility functions address different sets of issues. For example, Hansen and Imrohoroglu (1992), Andolfatto and Gomme (1996), Costain (1995), Valdivia (1995) and Wang and Williamson (1996) study computational models to derive the implications of unemployment insurance for welfare, aggregate economic activity and the optimal level of UI benefits in calibrated economies. Acemoglu and Shimer (1999) study a model with constant absolute risk aversion to derive results on the efficiency of unemployment insurance, given that risk-averse workers accept offers too quickly.

<sup>4</sup>See in particular Lazear (1990). For recent summaries see Nickell and Layard (1999) and Bertola (1999) and for more recent contributions see Ljungqvist and Sargent (1998), Mortensen and Pissarides (1999) and Blanchard and Wolfers (2000).

the optimality of legislation, an issue that I do not take up here.<sup>5</sup>

Also related to the model of this paper is another strand of the literature, which studies the behavior of wealth and the unemployment hazard during search when there is risk aversion. Danforth (1979) shows that with decreasing absolute risk aversion reservation wages fall and so the probability of leaving unemployment rises. A similar result is derived by Lenz and Tranaes (2001) for a more general model of job search, with both an employment and an unemployment risk and borrowing and lending.

It is important for the results of this paper that the firm should be better able to insure against fluctuations in income than workers are. This property, the asymmetric access to insurance markets by firms and workers, is the key assumption behind the static implicit contract theory, and this paper can be viewed as an application of the ideas first developed in that theory to dynamic search equilibrium (see Baily, 1974, Azariadis, 1975 and Gordon, 1974).

Section 1 outlines the framework used to study the implications of non-linear utility for consumption and job search. Section 2 studies the optimal consumption and search strategies when workers are paid their marginal product, and section 3 studies the other extreme, choices made under a full set of insurance contracts. Section 4 forms the core of the paper and studies first, the insurance implications of severance compensation and second the insurance implications of delayed dismissal. Section 4.3 shows that whereas it is always optimal to include severance compensation in employment contracts, whether dismissal delays are part of a contract or not depends on the subsidy received by unemployed workers and on their risk aversion. Section 5 shows with numerical computations that dismissal delays can be optimal for sufficiently low unemployment compensation. The concluding section 6 briefly summarizes the main findings and discusses issues in the implementation of the optimal contract. All proofs are collected in the Appendix.

## 1 Preliminaries

The model is a partial one and focuses on the relation between a risk-neutral firm that owns a job and a risk-averse worker who owns a time endowment. Time is discrete

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<sup>5</sup>Bertola (2001) studied the role of arbitrary legislated severance compensation in a model with risk averse workers. He shows that it can increase welfare but he does not allow agents to write optimal contracts, which could undo the effects of the legislation. See also Pissarides (2001) for more discussion of the policy issues and their implications for labor market equilibrium.

and information unfolds sequentially. The results that I derive do not depend on any particular horizon length but they are more transparent in a model that has the shortest horizon length that admits variable dismissal delays. This horizon length is  $T = 3$ , which allows me to include both the employment and unemployment risks and dismissal delays of either one or two periods.

The worker's time endowment yields no utility but it enables her to hold a job. Utility is derived only from consumption, at the rate  $u(c)$  per period, with  $u'(c) > 0$ ,  $u''(c) \leq 0$  and  $u'(0) = \infty$ , although there are also lump-sum disutilities associated with changing jobs, which are specified later. There is unlimited borrowing and lending at a safe rate of interest  $r$ , which accrues during the period, and which is also used to discount future utility. I define the discount factor  $\beta = 1/(1 + r)$ . The utility function, discount rates and capital structure are chosen such that under a full set of insurance markets the consumption profile is flat in all states of nature, irrespective of the income profile. This makes it easier to describe the implications of risk and optimal employment contracts. It is assumed that there are no exits from the labor force before the end of the horizon.

My objective is to describe the features of an employment contract offered by the firm to a new employee, when there is a positive probability that the job will end before the end of the agent's horizon and when the date of arrival of a new job (if this one ends) is uncertain. I make use of the following simplified framework (see footnote 7 for one possible rationalization of this framework).

In period  $t = 1$  a worker is born into a new job which produces output  $p > 0$ , but which may end at the end of the period. She has zero initial assets (an inconsequential assumption with unlimited borrowing and lending) which is known by her firm, and both firm and worker know that the probability that the job will end at the end of the period is a fixed  $q \in (0, 1)$ . If the job does not end at the end of the period it becomes an absorbing state, producing  $p$  per period. If the job ends, no more production takes place: the worker may be dismissed immediately, with or without severance compensation, or the contract may specify a delay before dismissal, during which the worker produces nothing but is paid a wage. I refer to this state as being *on delayed dismissal* or *on notice of dismissal*. In the three-horizon model the delay may be one or two periods.

Workers search on the job in period 1, because of the risk that the job will end, and may also search on the job during a period of notice. If a job is found during search the worker moves to it at the beginning of the next period. Unemployed workers also search

for a job and receive subsidy  $b < p$  in each period of unemployment. All jobs found after period 1 are absorbing states, i.e. the worker stays in them until the end of the horizon, producing output  $p$  per period.<sup>6</sup>

There are no search costs but before accepting an offer the worker has to pay a moving cost  $x \geq 0$ , which differs across jobs. The cumulative distribution of  $x$  for the best job offer available to the worker each period is denoted by  $G(x)$  and has support in the positive quadrant. The mobility cost is measured in utility units and it is strongly separable from the utility of consumption. Job acceptance is governed by a reservation rule on  $x$ , such that workers accept a job at the beginning of period  $t$  if the realized acceptance cost is  $x \leq R_t$ . The probability that a job searcher moves to a job at the beginning of period  $t$  is therefore  $G(R_t)$ .

Of course, a worker on notice of dismissal can quit at any time into unemployment and receive the subsidy  $b$ , but once she quits she cannot be rehired by the same firm. The circumstances that lead an agent to make decisions among the alternative states, the factors that influence their decisions, and whether contracts specify severance compensation or delayed dismissal, are the subject of analysis in this paper.

There are two income risks in this model, which are insurable with a full set of insurance markets. First, the risk that productive employment in the first job lasts either one period, or until the end of the worker's horizon. Second, conditional on the termination of employment in period 1, the risk that non-production (i.e., either unemployment or employment on notice of dismissal) lasts for one or two periods. The first risk is the *employment risk* and the second the *unemployment risk*, as each is associated with an uncertain duration of employment or unemployment (more precisely, job search).

The firm offers the worker an employment contract in period 1 which minimizes the cost of providing a pre-specified level of lifetime utility. I assume that the firm can monitor the worker's assets for the duration of the contract. It cannot, however, monitor the worker's search effort. Therefore, the firm can act as if it can choose a consumption profile for the worker, for the duration of the contract, subject to incentive-compatibility constraints on search effort. This is a typical principal-agent problem with moral hazard,

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<sup>6</sup>Employment is an absorbing state in all periods in Danforth (1979), Hopenhayn and Nicolini (1997) and Acemoglu and Shimer (1999) but not in Lentz and Tranaes (2001), who derive the effects of unemployment risk on savings (without employment contracts) in a more general environment.

with the firm acting as the principal who minimizes the cost of providing a consumption level to the worker.

It is convenient to set up the problem as if the contract ends either at the beginning of period 2 if the first job becomes an absorbing state, or in either period 2 or 3 if it does not. In the latter case, the contract ends either when the worker quits or when she is dismissed. For the duration of the contract the firm provides the worker with consumption. When the contract ends the firm makes a transfer of assets to the worker who then chooses her own consumption levels. There is no loss of generality if I assume that the contract ends at the beginning of period 2 if the job survives, because there is no uncertainty attached to lifetime earnings in the first job beyond period 1.<sup>7</sup>

## 2 Non-contingent contracts

I derive first the lifetime consumption profile in the absence of insurance and contingent transfers from the firm to the worker. Workers receive their marginal product  $p$  when employed, and subsidy  $b < p$  when unemployed. They do not receive any income if they are on notice of dismissal, making this option sub-optimal.

An equilibrium is a consumption sequence  $\{c_t^s\}$  for each state and period and an acceptance rule for each period of search. The states of nature are employment ( $s = j$ ) or unemployment ( $s = u$ ), and  $t = 1, 2, 3$ . Agents are always employed in  $t = 1$  but employed or unemployed in subsequent periods. The agent maximizes expected utility subject to a sequence of budget constraints and a value for initial assets, which is assumed to be zero, and subject to correct expectations about  $p, b$ , the distribution of costs  $G(x)$

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<sup>7</sup>The following rationalization, based on Jovanovic (1979) and Wilde (1979), can be used for the assumptions about jobs and their survival made in this paper. Suppose there are two or more differentiated types of agents and jobs and the match between a worker and a job is good if they are of the same type and bad if they are of different types. Net output is  $p$  per period in all matches, irrespective of type, but mismatched workers forego a lump-sum utility cost in order to produce this output. Workers who are matched to a job of their type do not forego any utility to produce; they stay in it for ever and earn their marginal product  $p$  per period. Workers, however, do not initially know how to recognize their job type without experiencing the job. They enter a randomly-selected job and spend the first period of their life in productive employment, learning also about their job type, and how to inspect and recognize future job types. The utility cost of a mismatch is sufficiently high that unemployment dominates production in a job of the wrong type. But the disutility is sufficiently low that all agents prefer to produce in period 1, and run the risk of mismatch, from taking leisure for ever and never learn about job types. The probability that the first job is not of the worker's type is a fixed  $q \in (0, 1)$ . Turnover and employment risk are higher for young individuals and at short tenures because of learning about job types and skill attributes.

and the termination probability of the first job,  $q$ . Income and consumption flows arrive at the end of the period whereas asset values are calculated at the beginning.

I derive the optimal policy starting from the end of the horizon. A person who is unemployed in period 2 starts period 3 with initial assets  $A_2$  and exits at the end of period 3 with zero assets. It follows that if the agent takes a job in period 3 consumption is

$$c_3^j = p + \beta^{-1}A_2. \quad (1)$$

If the agent remains unemployed she has no incentive to search, because she will exit the market at the end of the period, so she receives the subsidy  $b$  and consumes

$$c_3^u = b + \beta^{-1}A_2. \quad (2)$$

Suppose now the agent's initial assets in period 2 are  $A_1$ . If the agent is employed in period 2, either in the job that she was employed in period 1 or in a new job, income in periods 2 and 3 is  $p$  and both incomes and utilities are discounted at the common factor  $\beta$ . Therefore consumption in periods 2 and 3 is flat, and denoted by  $c_2^j$  :

$$c_2^j = p + \frac{1}{\beta(1 + \beta)}A_1. \quad (3)$$

If the agent is unemployed in period 2 she is also searching for another job. Job offers arrive and she can move to one at the beginning of period 3 by bearing a one-off utility cost  $x$ , which has distribution  $G(x)$ . By the separability of the mobility cost and the full information on  $G(x)$ , job acceptance satisfies the reservation property: the individual accepts a job at the beginning of period  $t$  if the realized mobility cost  $x \in [0, R_t]$ , where  $R_t$  is a reservation value. I denote by  $\bar{x}_t$  the expected acceptance cost conditional on the reservation  $R_t$ , i.e.  $\bar{x}_t = E(x|x \leq R_t)$ . It follows that the utility function in the event of unemployment in  $t = 2$  satisfies the Bellman equation

$$U^u(A_1) = \beta \max_{c_2^u, R_3, A_2} \{u(c_2^u) + G(R_3) (U^j(A_2) - \bar{x}_3) + (1 - G(R_3))U^u(A_2)\}, \quad (4)$$

where  $U^j(A_2)$  is lifetime utility when the worker moves to a job at the beginning of period 3, given by  $\beta u(c_3^j)$ , and  $U^u(A_2)$  lifetime utility when the worker is unemployed in period 3, given by  $\beta u(c_3^u)$ . The end-of-period budget constraint in period 2 is

$$A_1 + \beta(b - c_2^u - A_2) \geq 0. \quad (5)$$

The first order maximization conditions yield, after application of the envelope theorem,

$$u'(c_2^u) = G(R_3)u'(c_3^j) + (1 - G(R_3))u'(c_3^u), \quad (6)$$

and

$$R_3 = U^j(A_2) - U^u(A_2). \quad (7)$$

In period 1 the job is not an absorbing state because there is a probability  $q$  that it will end at the end of the period. The individual searches in period 1 and a job arrives at the beginning of period 2, which she can either accept or reject and join unemployment. The Bellman equation satisfied by lifetime utility at birth is

$$U = \beta \max_{c_1, R_2, A_1} \{u(c_1) + (1 - q)U^j(A_1) + q\bar{U}(A_1)\}, \quad (8)$$

where  $c_1$  is consumption in period 1,  $U^j(A_1)$  lifetime utility when the worker is in a job at the beginning of period 2 (given in this case by  $\beta(1 + \beta)u(c_2^j)$ ) and  $\bar{U}(A_1)$  is the expected lifetime utility when the job in period 1 terminates. In this event the agent either moves to another job, with (conditional) probability  $G(R_2)$ , or becomes unemployed. Therefore

$$\bar{U}(A_1) = G(R_2)(U^j(A_1) - \bar{x}_2) + (1 - G(R_2))U^u(A_1). \quad (9)$$

The budget constraint in period 1, given zero initial assets, is

$$p - c_1 - A_1 \geq 0. \quad (10)$$

The necessary and sufficient maximization conditions satisfy

$$u'(c_1) = (1 - q + qG(R_2))u'(c_2^j) + q(1 - G(R_2))u'(c_2^u). \quad (11)$$

$$R_2 = U^j(A_1) - U^u(A_1). \quad (12)$$

It follows from (6) and (11) that both the unemployment and the employment risk give rise to a lifetime consumption profile that is not flat. I now show (see the Appendix for proof)

**Proposition 1** *The employment risk causes a rising consumption profile and the unemployment risk a falling consumption profile.*

The optimal policy is one where the agent consumes  $c_1$  in the first period and increases her consumption permanently to a higher level if the job survives, or if she moves to another job (which is necessarily an absorbing state). If the job terminates in period 2 she reduces her consumption. During unsuccessful search consumption falls and when a job is found it rises to a permanently higher level.

The result that the employment risk yields a rise in consumption implies  $A_1 > 0$  and the result that the unemployment risk yields a fall in consumption implies  $A_1 > A_2$ . The latter restriction also implies  $c_2^j > c_3^j$ , i.e., the individual is better off if she finds a job in the first period of search than in the second.<sup>8</sup>

### 3 Full insurance

When workers have access to actuarially fair insurance against all income risks their consumption profile becomes flat and independent of state of nature. This result emerges readily from the assumptions of constant and equal rate of interest and rate of time preference and the existence of unlimited borrowing and lending at a safe interest rate, and will not be demonstrated in full. As an illustration, consider a one-period insurance contract for workers in period 1. With a full set of insurance contracts the worker can insure against the employment risk by buying insurance that will pay her  $I_1$  at the beginning of period 2 if she becomes unemployed. The risk of this is  $q(1 - G(R_2))$ , and so actuarial fairness implies that the budget constraint for period 1 changes from (10) to

$$p - c_1 - A_1 - q(1 - G(R_2))I_1 = 0. \quad (13)$$

At the end of period 2 initial assets (if the agent is in a job) are worth  $\beta^{-1}A$  as before, and in the event of unemployment they are worth  $\beta^{-1}(A_1 + I_1)$ . Because  $I_1$  is a choice variable, the agent can use it to transfer wealth between the states of employment and

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<sup>8</sup>The property that assets fall during unsuccessful search generalizes to an infinite horizon, provided that lifetime utility is a concave function of initial assets. This in turn also implies that the probability of leaving unemployment rises during unsuccessful search. With a shorter horizon the probability of leaving unemployment may fall because of the fixed utility cost of accepting jobs. Concavity of the utility function is not guaranteed because of the influence of wealth on reservation costs but almost certain to be satisfied. See Danforth (1979), Lentz and Tranaes (2001) and Hopenhayn and Nicolini (1997) for related discussion. Lentz and Tranaes (2001) introduce explicitly lotteries to avoid non-concavities. Hopenhayn and Nicolini (1997) derive results for the range of parameters that are consistent with concavity. Danforth (1979) restricts the utility function to decreasing absolute risk aversion. Where necessary I follow Hopenhayn and Nicolini and derive results for the range of parameters that guarantee concavity.

unemployment so as to maintain the same consumption level in each state. With a full set of insurance contracts the state does not influence the consumption level.

This result, however, is achieved for given transition probabilities. If the insurance company cannot monitor the search or quitting behavior of the worker, the flat consumption profile will give rise to moral hazard that will lead to the breakdown of insurance against both the employment and unemployment risks. Insurance against the unemployment risk gives rise to conventional moral hazard that prevents workers from accepting job offers, of the type commonly analyzed in the unemployment insurance literature. When there is insurance condition (12) changes to

$$R_2 = U^j(A_1) - U^u(A_1 + I_1). \quad (14)$$

With consumption equal in all states of nature both lifetime utilities are equal to  $\beta(1 + \beta)u(\bar{c})$ , where  $\bar{c}$  is the common consumption level, giving the solution  $R_2 = 0$ , and the same holds in all periods during which the agent searches for another job.

Insurance against the employment risk gives rise to a different type of moral hazard, temporary layoffs. Well-matched workers and firms can gain by colluding to separate temporarily, to enable the worker to collect the contingent claim from the insurance company. The loss to the pair from separating for one period is the marginal product  $p$  and the gain is the unemployment subsidy  $b$  and the insurance payment  $I_1$ . If  $b + \beta^{-1}I_1 > p$  this would be an optimal response to the contract, and if this is anticipated by the worker she might choose  $I_1$  such that this condition is satisfied.<sup>9</sup>

## 4 Optimal employment contracts

When workers have no access to insurance markets for income risk, employment contracts can make Pareto improvements by incorporating contingent transfers between risk-neutral firms and risk-averse workers. I derive the optimal contract under the following assumptions:

1. The firm can monitor the asset position of the worker, who can borrow and lend at a safe interest rate.

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<sup>9</sup>The moral hazard in this connection is closely related to the one discussed in the literature on temporary layoffs in the absence of perfect experience rating. Feldstein (1977) first showed how partial experience rating leads to excessive temporary layoffs, as firms and workers collude to maximize their revenue from the government subsidy to workers on layoff.

2. The firm cannot monitor the worker's search strategy.
3. The firm cannot make payments to unemployed workers but can make either positive or negative payments to employed workers.
4. The firm can monitor the productivity of the job (or the quality of the match).
5. The firm cannot monitor the destination of the worker after separation.

Assumptions 1 and 2 define the typical environment analyzed in the unemployment insurance literature, with the added generalization that the worker can borrow and lend. Assumption 3 implies that there is no private unemployment insurance. The implications of the other two assumptions will be stated shortly.

An employment contract is *optimal* if it yields at least some exogenous utility level  $\bar{U}$  to the worker at minimum cost to the firm. Employment contracts are written at the beginning of period 1. Assumptions 1-5 imply that an employment contract can in general be defined as: a consumption  $c_1$  for period 1, an asset transfer  $A_1$  from the firm to the worker in period 2 if the job survives, a period  $T \geq 1$ , at the end of which the worker is dismissed if the job does not survive, an asset transfer  $A_t^j$  for  $t < T$  if the worker quits before dismissal, an asset transfer at dismissal  $A_T^u$ , and consumption in periods 2 and 3 in the event of a delay in dismissal,  $c_t^n$  for  $t = 2, 3$ .

Assumption 4 ensures that the worker cannot falsely declare an unproductive job match, quit and collect  $A_1^j$  (or  $A_T^u$  if  $T = 1$ ). This removes a potential moral hazard problem in the payment of severance compensation to dismissed employees.<sup>10</sup> Assumption 5 implies that the asset transfer at separation,  $A_T^u$ , is not contingent on the destination of the worker.<sup>11</sup>

Let now  $V(U)$  be the minimum cost of the contract to the firm at the beginning of period 1.  $U$  is the lifetime utility that the contract yields to the worker. If the job survives the firm makes a transfer  $A_1$  to the worker at the beginning of period 2 and

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<sup>10</sup>Such conditions on the payment of severance compensation are sometimes found in practice, when the worker is paid compensation when she is fired but not when she quits against the firm's wishes.

<sup>11</sup>Even if the firm can monitor the worker's destination and makes transfers contingent on destination, if the transfer to workers entering unemployment is higher than the one to workers who have accepted another job, workers who find a new job can collude with the new employer to delay hiring. The worker enters in the meantime unemployment, in order to collect the severance payment. This moral hazard problem is similar to the one that gives rise to temporary layoffs and does not allow third-party insurance contracts against the employment risk.

the contract ends, because there is no more income uncertainty. The transfer yields the worker lifetime utility  $U^j(A_1)$ . Because now initial assets when the worker stays in the same job in period 2 and when she quits to take another job are allowed to differ, I need to distinguish consumption in periods 2 and 3 in a new job that starts in period 2, denoted as before by  $c_2^j$ , from consumption in periods 2 and 3 when the first job survives. I denote the latter by  $c_1^j$ . If the job proves unproductive the firm may offer to keep the worker but give notice of dismissal at the end of either period 2 or 3, denoted by  $T$ . Let  $U_t^n$  ( $t \leq T$ ), be the lifetime utility of the worker at the beginning of period  $t$  when the job becomes unproductive but the worker is employed on notice of dismissal. The minimum cost of the contract to the firm at the beginning of period  $t$  is denoted  $V(U_t^n)$ .

I first characterize the optimal contracts for any arbitrary duration  $T \geq 1$ , starting with  $T = 1$ , before fully characterizing the optimal duration of the contract.

#### 4.1 Severance compensation

Contracts of duration  $T = 1$  dismiss the worker without notice at the end of period 1 if the job turns out to be unproductive. The transfer made to dismissed workers is denoted by  $A_1^u$  and the transfer made to workers who remain with the firm is  $A_1$ . The contract therefore pays severance compensation if  $A_1^u > A_1$ . If  $A_1^u = A_1$  the employment contract contains no insurance provision. The worker could be paid a wage rate in period 1 and replicate this situation through the capital market, by borrowing or lending so as to start period 2 with non-contingent assets  $A_1$ . The assumption that the firm can verify whether the job is good or not implies that the severance compensation acts as insurance against the risk that the job is revealed to be unproductive, but not as insurance against the risk attached to the destination of the worker.

The cost of the contract to the firm,  $V(U)$ , satisfies the simple equation

$$V(U) = \beta \min_{c_1, A_1, A_1^u} \{c_1 + (1 - q)A_1 + qA_1^u\}. \quad (15)$$

The contract is acceptable to the worker if it is worth at least  $\bar{U}$ , constraining the firm to offer

$$\bar{U} \leq U. \quad (16)$$

The utility derived by the worker from this contract satisfies the Bellman equations

$$U = \beta (u(c_1) + (1 - q)U^j(A_1) + q\bar{U}(A_1^u)) \quad (17)$$

$$\bar{U}(A_1^u) = G(R_2)(U^j(A_1^u) - \bar{x}_2) + (1 - G(R_2))U^u(A_1^u). \quad (18)$$

The fact that there is search on the job in period 1 and the firm cannot monitor the search strategy of the worker introduces an incentive-compatibility constraint, derived from the unconditional maximization of lifetime utility with respect to the reservation  $R_2$ . Maximization of (18) with respect to  $R_2$  yields

$$R_2 = U^j(A_1^u) - U^u(A_1^u). \quad (19)$$

The optimal contract satisfies minimization conditions for (15) subject to (17), (18) and (19).

It is easy to see that in this case the incentive-compatibility constraint is not binding, due to the fact that the firm dismisses the worker at the end of period 1 if the job is unproductive, whatever the worker's search strategy. The appendix shows that the shadow price of (19) at the optimum is  $\lambda = 0$ , so the optimal contract satisfies

$$u'(c_1) = U^{j'}(A_1) = G(R_2)U^{j'}(A_1^u) + (1 - G(R_2))U^{u'}(A_1^u). \quad (20)$$

Application of the envelope theorem to lifetime utilities and substitution into (20) yields

$$u'(c_1) = u'(c_1^j) = G(R_2)u'(c_2^j) + (1 - G(R_2))u'(c_2^u). \quad (21)$$

The solution is illustrated in figure 1. The fact that the incentive-compatibility constraint is not binding in this case makes severance payments a first-best insurance against the risk of the termination of the job (the employment risk). In the absence of contingent transfers, proposition 1 demonstrated that the employment risk increases consumption in a good job. (21) shows that consumption in a good job is now flat: the consumption chosen in period 1,  $c_1$ , is at the level of consumption in all future periods in a good job,  $c_1^j$ .

But the failure of the firm to monitor the destination of the worker, or make payments to her after entry into unemployment, implies that severance compensation does not insure against the unemployment risk. In the event of separation at the end of period 1, the agent's maximization problem in periods 2 and 3 is identical to the one studied

in proposition 1, with initial assets  $A_1^u$ . Consumption increases when the worker goes to another job and falls when she joins unemployment. Equation (21) and proposition 1 yield:

$$c_2^j > c_1^j = c_1 > c_2^u. \quad (22)$$

Similarly, the optimal consumption profile in the event of a second period of unemployment also satisfies proposition 1. When the agent finds a job consumption increases permanently to a higher level but during unsuccessful search it decreases.<sup>12</sup>

It is straightforward to show that severance compensation is positive in this environment. Consumption from period 2 onward in the event of a productive match and consumption in another job accepted in period 2 both satisfy (3), with initial assets  $A_1^j$  and  $A_1^u$  respectively. The first inequality in (22) then yields  $A_1^u > A_1^j$ .

**Proposition 2** *The consumption profile is flat in all periods if the first-period job survives to the end of the horizon. If the job ceases to be productive and workers separate without delay, the firm pays positive severance compensation. Consumption falls in period 2 if the worker joins unemployment, or rises if she moves immediately to another job.*

## 4.2 Delayed dismissal

Partial insurance against the unemployment risk can be offered by delaying dismissal in the event of an unproductive job. Delaying dismissal has insurance value because the firm can make payments contingent on the worker's state after the end of the productive relationship. The worker searches on the job during the delay period and so there is a positive probability that she will move to another job without entering unemployment. During this period the firm can effectively monitor the worker's destination, because if the worker quits, it will be to take another job. It can therefore make payments conditional on destination and so increase the insurance value of its contract. It can easily be shown that if the firm can monitor search effort the additional insurance possibilities offered by delaying dismissal can fully insure the worker against the unemployment risk but with moral hazard the insurance is second-best.

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<sup>12</sup>The only qualitative difference between the results of proposition 1 and the policy shown in figure 1 is that in the case of proposition 1  $c_1^j$  jumps up to the level of  $c_2^j$ .

The disadvantage of delaying dismissal is that the worker cannot claim the unemployment subsidy during delay. One other potential cost and one other benefit of delayed dismissal are ignored in the analysis that follows, without loss of essential generality. If the job is costly to maintain the firm suffers losses by delaying dismissal, which can be avoided if the worker is fired. Against this, a firm may move the worker elsewhere during the delay to perform tasks that have some value to the firm.

#### 4.2.1 One-period delay

For  $T = 2$ , the firm pays  $A_1$  to workers in productive jobs at the beginning of period 2,  $A_1^j$  to workers in unproductive jobs who quit at the beginning of period 2, and guarantees utility  $U_2^n$  to workers in unproductive jobs who stay for one more period. The cost of this contract satisfies the Bellman equations

$$V(U) = \beta \min_{c_1, A_1, A_1^j, U_2^n} \{c_1 + (1 - q)A_1 + q(G(R_2)A_1^j + (1 - G(R_2))V(U_2^n))\} \quad (23)$$

$$V(U_2^n) = \beta \min_{c_2^n, A_2^u} \{c_2^n + A_2^u\}, \quad (24)$$

where  $c_2^n$  is the consumption level of those who remain in unproductive jobs and  $A_2^u$  the transfer to those workers at the end of the period, when by assumption they have to leave the job.

This contract yields utility

$$U = \beta (u(c_1) + (1 - q)U^j(A_1) + q\bar{U}_1) \quad (25)$$

$$\bar{U}_1 = G(R_2) (U^j(A_1^j) - \bar{x}_2) + (1 - G(R_2))U_2^n, \quad (26)$$

$$U_2^n = \beta (u(c_2^n) + G(R_3) (U^j(A_2^u) - \bar{x}_3) + (1 - G(R_3))U^u(A_2^u)), \quad (27)$$

The following incentive-compatibility constraint also needs to be satisfied

$$R_2 = U^j(A_1^j) - U_2^n. \quad (28)$$

The incentive-compatibility constraint for search in period 2, i.e., the choice of  $R_3$ , is not binding, for the same reasons that the choice of  $R_2$  did not bind in the case of no delay.

The optimal contract satisfies minimization conditions for (23)-(24) subject to (16) and (25)-(28). As already noted (see footnote 8), the constraint set defined by these

conditions may not be convex. I will again ignore the fact that with non-convexities a market for lotteries may open up and focus instead on the case where the parameters make the constraint set convex.

The important result derived in the preceding section for  $T = 1$ , that severance compensation fully insures the worker against the employment risk, also holds for the case of delay in dismissal, because the firm can differentiate between the asset transfer to workers in productive jobs and the asset transfer to those in unproductive jobs. In addition, because the incentive-compatibility constraint for the last period of the contract is not binding, condition (21) also holds for the last period of the contract:

$$u'(c_2^n) = G(R_3)u'(c_3^j) + (1 - G(R_3))u'(c_3^u). \quad (29)$$

As before,  $c_3^j = p + A_2^u/\beta$  and  $c_3^u = b + A_2^u/\beta$ , and so (29) implies

$$c_3^j > c_2^n > c_3^u. \quad (30)$$

With convexity, the following optimality conditions also hold for this contract:

$$\beta q(1 - G(R_2))(u'(c_1) - u'(c_2^n)) = -\lambda_1 u'(c_1)u'(c_2^n) \quad (31)$$

$$\beta qG(R_2)(u'(c_1) - u'(c_2^j)) = \lambda_1 u'(c_1)u'(c_2^j) \quad (32)$$

$$\beta qg(R_2)(A_1^j - V(U_2^n)) + \lambda_1 = 0 \quad (33)$$

where  $\lambda_1$  is the shadow price of the incentive-compatibility constraint (28).

A result that emerges readily from (31)-(33) is that if the incentive-compatibility constraints are not binding, which in this case requires monitoring of the worker's search effort,  $\lambda_1 = 0$  and consumption is equalized in all states of nature. With perfect monitoring of search effort the firm can offer first-best insurance against the unemployment risk to its employees on notice of dismissal. The Appendix shows (in the proof of proposition 3) that without monitoring of search  $\lambda_1 > 0$ , and so, by the concavity of the utility function, (31) and (32) imply

$$c_2^j > c_1 > c_2^n. \quad (34)$$

Condition (33) implies also that  $V(U_2^n) > A_1^j$ , i.e., if the firm pays compensation to quitting employees at the beginning of period 2, this compensation is not worth as much as the compensation that it pays to those who are unsuccessful in their search.

The reason that the firm pays compensation to quitting employees is the incentive-compatibility constraint. The compensation induces more search effort, and the firm pays it despite the fact that quitting employees leave to join another firm that pays them their marginal product, which cannot be less than their current wage.

Conditions (31) and (32) also imply

$$\frac{1}{u'(c_1)} = G(R_2) \frac{1}{u'(c_2^j)} + (1 - G(R_2)) \frac{1}{u'(c_2^u)} \quad (35)$$

which can be contrasted with (21), when there is no delay.

#### 4.2.2 Two-period delay

For  $T = 3$ ,  $V(U)$  satisfies the Bellman equations

$$V(U) = \beta \min_{c_1, A_1, A_1^j, U_2^n} \{c_1 + (1 - q)A_1 + q(G(R_2)A_1^j + (1 - G(R_2))V(U_2^n))\} \quad (36)$$

$$V(U_2^n) = \beta \min_{c_2^n, A_2^j, U_3^n} \{c_2^n + G(R_3)A_2^j + (1 - G(R_3))V(U_3^n)\}, \quad (37)$$

$$V(U_3^n) = \beta \min_{c_3^n} c_3^n. \quad (38)$$

The utility level derived from the contract satisfies:

$$U = \beta (u(c_1) + (1 - q)U^j(A_1) + q\bar{U}_1) \quad (39)$$

$$\bar{U}_1 = G(R_2) (U^j(A_1^j) - \bar{x}_2) + (1 - G(R_2))U_2^n, \quad (40)$$

$$U_2^n = \beta (u(c_2^n) + G(R_3) (U^j(A_2^j) - \bar{x}_3) + (1 - G(R_3))U_3^n), \quad (41)$$

$$U_3^n = \beta u(c_3^n). \quad (42)$$

There are now two incentive-compatibility constraints, one for search in period 1 and one for search in period 2. In period 3 there is no search. The constraints are:

$$R_{t+1} = U^j(A_t^j) - U_{t+1}^n, \quad t = 1, 2. \quad (43)$$

Implicit in the specification of the minimization program is the assumption that the worker will never want to quit into unemployment during the delay in dismissal, i.e. that  $U_{t+1}^n \geq U^u(A_t^j)$  is not binding for the duration of the contract. This follows trivially from the fact that if it were, the firm would dismiss the worker into unemployment than keep her employed, because this would reduce its costs in future periods (the financing of consumption if the worker were to remain employed).

The results for a two-period delay are natural generalizations of the results for the one-period delay. The optimality conditions yield again  $c_1 = c_1^j$  and satisfy (31)-(33). In addition they satisfy:

$$\beta(1 - G(R_3))(u'(c_2^n) - u'(c_3^n)) = -\lambda_2 u'(c_2^n) u'(c_3^n) \quad (44)$$

$$\beta G(R_3)(u'(c_2^n) - u'(c_3^j)) = \lambda_2 u'(c_2^n) u'(c_3^j) \quad (45)$$

$$\beta g(R_3)(A_2^j - V(U_3^n)) + \lambda_2 = 0. \quad (46)$$

where  $\lambda_2$  is the shadow price of (43) for  $t = 2$ . Once again it can be proved that without monitoring of search  $\lambda_2 > 0$  and so

$$c_1 > c_2^n > c_3^n. \quad (47)$$

Consumption falls during unsuccessful search on the job. Condition (35) also holds and a similar condition in the inverted marginal utilities holds also for period 3, in place of (29).<sup>13</sup> Qualitatively, the consumption path for contracts with delay is similar to the one shown in figure 1:

**Proposition 3** *If the value function is a concave function of beginning-of-period assets and workers in unproductive jobs are given notice before dismissal, consumption is flat in all states of nature if the firm can monitor its workers' search effort. If it cannot monitor search effort consumption falls during unsuccessful search on the job, or when the worker is dismissed into unemployment, but rises if the worker is successful in her search and quits to take another job.*

The result on the declining consumption profile during unsuccessful search parallels the result first derived by Shavell and Weiss (1979) for unemployment insurance. However, whereas in their case, because of the absence of a capital market, the result required a declining level of unemployment compensation, when there is unlimited borrowing and lending it can be achieved in a variety of ways, which I discuss briefly in section 6. The key property of the optimal contract is that the lifetime utility of the worker who remains employed in an unproductive job falls over time.

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<sup>13</sup>Conditions (44)-(46) hold in all periods of notice of dismissal in longer horizon models, and a condition like (35) always replaces one like (29), whenever a period of delay with on-the-job search replaces a period of unemployment with off-the-job search.

**Proposition 4** *If the firm's cost function is convex, in the case where search on the job cannot be monitored by the firm the lifetime utility of workers on notice of dismissal falls with the duration of employment.*

### 4.3 Optimal contract length

A contract of the type studied in section (4.1) dominates noncontingent wage offers because severance compensation insures against the risk of an early termination of the job, without causing moral hazard or increasing the firm's costs. The question I investigate here is whether the optimal  $T$  can be greater than 1. The optimal  $T$  is defined as the  $T$  that yields the smallest contract cost for given lifetime utility  $\bar{U}$ , or by its dual, the contract that yields highest lifetime utility for given cost  $V(U)$ . It is convenient in this section and the next to discuss the optimality of dismissal delays with reference to the dual, under the assumption of a given contract cost (I later assume that competition drives the cost of the contract to the expected marginal product of the worker).

A delay in dismissal ( $T > 1$ ) may or may not be optimal, partly because of the cost of foregone unemployment compensation and partly because of moral hazard. Consider again the problem studied in section 4.2.1 for  $T = 2$ . Inspection of the minimization problem shows that if the worker fails to find another job at the end of period 1, the minimization problem from period 2 onward is the dual of the utility maximization problem of a worker with lifetime utility defined by  $U_2^n$ , initial assets  $V(U_2^n)$  and zero income. Therefore, if unemployment income is zero, ex post the worker who fails to find a job in period 1 is indifferent between unproductive employment for one more period and unemployment with initial assets  $V(U_2^n)$ . But ex ante the worker who is offered one more period of employment is better off. The firm's failure to monitor the worker's destination after separation implies that if it were to dismiss the worker at the end of period 1, it would have to make the same transfer  $V(U_2^n)$  to workers who found jobs at the end of period 1 and workers who did not and joined unemployment instead. The firm that gives notice to the worker and keeps her employed can differentiate between the payment to each worker, being  $A_1^j$  to those who quit and  $V(U_2^n)$  to those who stay. I have shown that with risk aversion and moral hazard the firm chooses  $V(U_2^n) > A_1^j$ , although it could choose, if it wanted,  $V(U_2^n) = A_1^j$ . It follows that delaying dismissal always dominates immediate firing when  $b = 0$ .

This is a general property of the optimization problem in the last period of the contract. The tradeoff faced by the firm in the last period of the contract is that it can either set  $A_{T-1}^j = V(U_T^n)$  and dismiss the worker so she can receive subsidy  $b$  in the event of failure in search, or keep the worker for zero return and partially insure her against the risk of the outcome of search by differentiating between the transfers  $A_{T-1}^j$  and  $V(U_T^n)$ . The following result immediately follows:

**Proposition 5** *If unemployment income is zero (and there are no other costs of unproductive employment), it is never optimal to dismiss the worker.*

Suppose now that instead of zero income, the unemployed enjoy an income which is arbitrarily close to  $p$ , their marginal product. Then, trivially (and more formally by an extension of the argument used to prove proposition 1), the worker will never prefer a delay in dismissal over unemployment. Consumption is smoothed completely when the worker can move between employment and unemployment without suffering income loss. By the continuity and monotonicity of value functions with respect to the exogenous income flow during unemployment, it follows that:

**Proposition 6** *There is a unique value of unemployment income  $b^* \in [0, p]$  such that for  $b < b^*$  the optimal contract offers a dismissal delay but for values of  $b \geq b^*$  no delay is offered.*

(The proof is trivial and omitted.) Intuitively, by offering a delay in dismissal the firm partially insures the worker against the unemployment risk. If government insures workers instead, through the subsidy  $b$ , the firm does not need to offer the insurance. It would appear from this intuition that there should be a “well behaved” relation between the subsidy  $b$  and the length of delay offered by the firm, in the sense that as  $b$  is increased from a low value, the delay in dismissal falls from two periods to one and to zero. It has not been possible to prove this as a general result, and computations confirm that for some range of the parameters the “well behaved” relation holds but there are feasible parameter ranges that imply that the optimal contract offers either a two-period delay at low  $b$  or no delay at high  $b$  but never a one-period delay.

## 5 Computations

The model is too stylized to serve as a framework for the calibration of optimal contracts in real situations. In the computations that follow I give reasonable values to the parameters and compute the solutions to demonstrate the optimality of dismissal delays in some ranges of the parameters. As far as possible, I choose the parameters of the model to match known results in consumption and job search decisions.

I choose the value of output  $p$  as the normalizing constant, and set it at  $p = 1$ . The utility function has constant relative risk aversion with coefficient (in the benchmark case)  $\sigma = 2$ . The calibration studies cited in footnote 3 use mostly a coefficient between 1 and 2 but since this is one of the key parameters of the model, I will compute the solution for a number of different values. The period of analysis in this model is defined by the rate of discount and by the probability of success in job search. Given the short horizon, the value of the rate of discount turns out not to be important in the solution. But the value of the probability of success is important. In the CPS the fraction of unemployed workers with unemployment duration less than five weeks is about 0.4. In my model this fraction is an unknown but it is influenced by the parameters of the distribution of acceptance costs  $G(x)$ . I assume that this distribution is exponential, which has only one parameter, and choose the value of the parameter such that in the benchmark case the probability that those who become unemployed exit after one period is approximately 0.4. This parameter value is  $\mu = 0.4$ . The discount factor is set at  $\beta = 0.995$ , implying an annual discount rate of approximately 6 percent (but results are virtually identical for a large range of the discount factor).

The probability that the first job ends,  $q$ , is arbitrarily set at 0.5. It turns out that the value of this probability is not important for the results of interest, given the way that the remaining unknowns of the model are computed. Results for other values are also reported. In addition, I report results for the case where job offers in period 1 arrive with a lower probability than they do when the worker is unemployed or on notice of dismissal, to capture the idea that the worker searches with lower intensity in period 1 because she does not know with certainty that the job will end.

The choice of parameter for the distribution  $G(x)$  makes the period of analysis one month. A problem faced with such a short horizon is that the wealth effects from changes in a single period's income become important. For example, in the case where unem-

ployment income is  $b = 0$ , a person who experiences one period of unemployment has only two thirds the lifetime income of someone who does not experience unemployment. In practice unemployment durations are too short to have such a big impact on lifetime wealth, although evidence shows that at least for the unemployed, the impact of current income on consumption is more than the impact implied by a permanent-income model (Hansen and Imrohoroglu, 1992; Gruber, 1997). In some computations that I did with the infinite horizon version of this model (not reported), the impact of unemployment on consumption with the assumed capital market structure was negligible. Gruber (1997) reports that in the PSID, when a worker who is not entitled to unemployment compensation becomes unemployed, consumption drops by 22 to 25 percent and that if the replacement rate (the ratio of unemployment income to the wage rate) is increased by ten percentage points the drop falls by about 3 percent.

Because the impact of unemployment income on consumption is crucial for the results of this paper, I attempted to match the facts reported by Gruber in the benchmark case. There are two ways in which the facts can be matched. The horizon can be extended or shortened until the wealth effect from becoming unemployed is sufficiently big to give the required fall in consumption. Or, the value of  $b$  can be given a more general interpretation as the sum of non-market income and unemployment compensation and a value for it chosen such that in the three-period horizon case the drop of consumption in the benchmark case is in the range 22-25 percent. This value of  $b$  can then be interpreted as the one corresponding to zero unemployment compensation.<sup>14</sup>

I have experimented with both methods and the results for the key questions of the model, the optimality of dismissal delays, turned out to be virtually identical. I report only results for the three-period horizon and various values of  $b$ , but take  $b = 0.2$  as the benchmark case because of its implications for the drop in consumption in the first month of unemployment. It also turns out in this case that the marginal effect of increasing  $b$  reduces this drop by an amount of the order of magnitude reported by Gruber.

The computations were carried out under the assumption that competition ensures that the expected discounted value of earnings is equal to the expected discounted value

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<sup>14</sup>Note that I have chosen the normalization  $p = 1$  but the assumptions that initial assets and total income in the absence of unemployment insurance are both zero are also normalizations. The argument made in this paragraph is that to match Gruber's facts one of these normalizations has to be relaxed.

of marginal product. Table 1 gives some results for different parameter values. I give the percentage consumption drop in period 2 in the event of unemployment, the probability that the worker becomes unemployed when the first job is unproductive (i.e., the product  $q(1 - G(R_2))$ ), and the unemployment hazard after one period of unemployment,  $G(R_3)$ , for the case where only severance compensation is offered by the contract. The benchmark case of  $\sigma = 2$  and  $b = 0.2$  is one that implies that either a contract with severance compensation only or one that also includes a one period delay before dismissal give virtually identical lifetime utilities (see below) and very similar results. The numbers in brackets in the table are for the optimal contract when this is not one with severance compensation and no delay in dismissal.

The results are as expected. More risk averse individuals take action that reduces their consumption drop in the event of unemployment, and are more prepared to move in order to reduce both the probability of entering unemployment and the duration of unemployment. Unemployment income has a big impact on the drop in consumption, because of income effects, and also a big impact on unemployment experience, because of moral hazard. A higher probability that the first job becomes unproductive in the second period (higher  $q$ ) increases the consumption drop because the higher  $q$  reduces the expected lifetime contribution of the worker to the firm, and so the firm offers less insurance in the form of severance compensation. Not surprisingly, the higher  $q$  also increases the probability that the worker will enter unemployment, so the worker will want to save more to finance consumption in the event of unemployment. The lower expected income, however, dominates these two conflicting influences. To check that this is the reason for the larger consumption drop, I also computed the solution for the case  $q = 0.5$  but with a lower probability of moving directly to another job if the first job turns out to be unproductive in period 2. This effect was obtained by multiplying the probability of moving to another job,  $G(R_2)$ , by a constant  $a$ , and computing the solution for  $a = 0.5$ . It can be justified by the assumption that on-the-job search is less efficient than off-the-job search. The result shows a much smaller drop in consumption than in the benchmark. The firm increases the severance compensation in this case because of the higher probability of entering unemployment.

Finally, the results show that a more efficient search, in the form of lower mobility costs (higher  $\mu$  in the table), increases the consumption drop in the event of unemployment because of lower probability of entering unemployment and lower probability of

remaining unemployed.

The numerical solutions were next used to illustrate the paper's main results, that dismissal delays are more likely to be offered to more risk averse workers who do not have access to sufficient income during unemployment. Figure 2 plots the value of each contract type to the worker for the benchmark case of  $\sigma = 2$  against unemployment income. The value of the contract with no severance and no dismissal delay is not shown because it is always dominated. The figure confirms the results of propositions 5 and 6, that at  $b = 0$  the contract with the longest delay is optimal, and at sufficiently high  $b$  no delay in dismissal is optimal. Of course, the contract with a two-period delay is independent of unemployment income, because the worker never enters unemployment, whereas the contract with no delay shows the strongest dependence on unemployment income because there is a positive probability that the worker will experience up to two periods of unemployment. The figure also shows the intuitive result that could not be proved, that at intermediate values of unemployment income, a delay of one period is optimal. This result, however, is reversed at some parameter values; i.e., it is possible to find feasible ranges of the parameters which imply that the line for the one-period delay contract is entirely below the other two lines (for example, at large values of  $\mu$ , when the efficiency of search is high).

Figure 3 plots the regions in a space of risk-aversion against unemployment-income for which each contract type is optimal. The results conform with intuition and with the propositions proved in this paper: more risk averse workers are offered dismissal delays and the delay is less when exogenous unemployment income is higher. In addition to the influence of risk aversion and unemployment income, the results in brackets in table 1 also show that a delay is optimal when the period 1 job is more likely to prove a success and when the probability of success in job search is higher. The intuition for these results is also clear. In the first case, the worker is more likely to be productive in periods 2 and 3, so the firm can afford to offer more insurance in the form of longer dismissal delays in the event of a mismatch. In the second case the worker is more likely to quit if she is unproductive, so the delay is less expensive to the firm. The results in the table also show that the search disincentive effects of the contract are stronger when a delay is offered than when the worker is dismissed with severance compensation only. The probability of leaving unemployment (last row of table 1) is always higher in the case of severance compensation only than in the bracketed terms of delayed dismissals.

## 6 Conclusion

This paper has established that in the absence of insurance against income risk, a firm that cannot monitor the search strategy of its workers will offer employment contracts that include severance payments to dismissed employees and, under certain conditions, also delays in dismissal. For these results to hold the firm has to be risk neutral and unemployment insurance has to be less than perfect. An important result is that a delay in dismissal is less likely to be offered the more generous is the compensation to unemployed workers offered by an exogenous unemployment insurance system. Another important result is that the firm offers incentives to employees in unproductive jobs, whose dismissal is delayed for insurance reasons, to search on the job and quit. These incentives take the form of severance compensation in the event of a quit and falling consumption during unsuccessful search. For the firm to achieve the falling consumption profile it has to know the asset position of its workers, a maintained assumption in this paper.

The paper did not examine why severance compensation and dismissal delays should be in legislation and not in private contracts, if optimal. The firm will have an incentive to renege on the contract once the job proves to be unproductive, because it is required to make payments to employees who are quitting. But the conditions under which this incentive can give rise to legislated “employment protection” have not been examined. Nevertheless, if the assumption is made that the observed legislated measures reflect the extent to which private contracts call for them, the model says that there should be an inverse relation across countries between employment protection measures and the generosity of unemployment compensation. A correlation of this kind was found by Boeri et al. (2001) for a sample of OECD countries.

The method used to derive the results is that of a principal, the firm, minimizing the cost of offering a contract worth a pre-determined utility level to an agent, the worker. The implementation of the optimal contract was not discussed but it is straightforward to describe some of its main features. The key to the results is twofold. First the worker should be made progressively worse off during unsuccessful on-the-job search. Second, the contract should be able to differentiate between the asset transfer to workers who quit and the asset transfer to those who stay with the firm.

Two features of labor contracts, commonly found in practice, have these implications.

The first, is the “up or out” feature. The firm pays a worker initially a wage which is less than marginal product and if the job proves to be productive it raises the wage in subsequent periods. If the match is unproductive it dismisses the worker, with or without notice, but with some severance compensation. The “promotion” implied by the pay rise makes those who fail to get it worse off than their expectation when starting a job, giving incentives for search on the job. The severance compensation paid to those who leave differentiates the asset transfer of those who leave from those who stay.

Numerical computations confirm that more risk averse workers and workers with less entitlement to unemployment compensation are more likely to be offered contracts with dismissal delays. More efficient search increases this likelihood, despite the fact that in all cases there are more disincentives to search during a delay in dismissal than during unemployment.

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## 7 Appendix

### 7.1 Proofs of Propositions

**Proof of Proposition 1.** It follows immediately from (1), (2) and the restriction  $b < p$  that  $c_3^j > c_3^u$ . Therefore, by the concavity of the utility function and (6),  $c_3^j > c_2^u > c_3^u$ .

Suppose  $c_2^u > c_2^j$ . Then from (3) and (5) I obtain

$$A_2 - \frac{1}{1+\beta}A_1 + p - b < 0. \quad (48)$$

But  $c_2^u > c_2^j$  implies  $c_3^j > c_2^j$  because  $c_3^j > c_2^j$ , and so (3) and (1) yield

$$A_2 - \frac{1}{1+\beta}A_1 > 0, \quad (49)$$

which contradicts (48). Therefore,  $c_2^j > c_2^u$  and by the concavity of the utility function and (11),  $c_2^j > c_1 > c_2^u$ .

**Proof of Proposition 2.** Let  $\mu > 0$  be the Lagrangian multiplier associated with the constraint in (16), given the definition of  $U$  in (17), and  $\lambda_1$  the one for (19). The condition that minimizes (15) with respect to  $R_2$  subject to (16) and (19) is

$$\mu qg(R_2)[U^j(A_1^u) - R_2 - U^u(A_1^u)] + \lambda_1 = 0,$$

which, in view of (19) immediately yields  $\lambda_1 = 0$ . The conditions that minimize (15) with respect to  $c_1, A_1$  and  $A_1^u$  are

$$1 - \mu u'(c_1) = 0 \quad (50)$$

$$1 - \mu U^{j'}(A_1) = 0 \quad (51)$$

$$1 - \mu[G(R_2)U^{j'}(A_1^u) + (1 - G(R_2))U^{u'}(A_1^u)] = 0. \quad (52)$$

Application of the envelope theorem to (51)-(52) proves the proposition. Equality between  $c_1$  and  $c_1^j$  follows immediately and the other results follow from proposition 1.

**Proof of Proposition 3.** Consider the firm's choice problem for  $T = 2$ , that for  $T = 3$  following immediately. The firm minimizes (23) subject to (16) and (25)-(28). Let  $\bar{U}_2^n$  be the inherited (state) value of the contract to the worker at the beginning of period 2, given the choices made by the firm in period 1. Let  $\mu$  as before be the shadow price of (16),  $\mu_2$  the shadow price of the constraint  $\bar{U}_2^n \leq U_2^n$  and  $\lambda_1$  the Lagrangian for the constraint in (28). As before, minimization with respect to the controls  $c_1$  and  $A_1$  yield (50) and (51), so  $c_1 = c_1^j$ . Minimization with respect to  $c_2^n, U_2^n$  and  $A_1^j$  yields

$$1 - \mu_2 u'(c_2^n) = 0 \quad (53)$$

$$\beta q(1 - G(R_2))(V'(U_2^n) - \mu) + \lambda_1 = 0 \quad (54)$$

$$\beta G(R_2)(1 - \mu U^{j'}(A_1^j)) - \lambda_1 U^{j'}(A_1^j) = 0. \quad (55)$$

The envelope theorem gives  $V'(U_2^n) = 1/u'(c_2^n)$  and  $U^{j'}(A_1^j) = u'(c_2^j)$ , which, upon substitution into (54)-(55) yields (31)-(32). Minimization with respect to  $A_2^u$  yields

$$1 - \mu_2[G(R_3)U^{j'}(A_2^u) + (1 - G(R_3))U^{u'}(A_2^u)] = 0, \quad (56)$$

which can be used in conjunction with (53) and the envelope theorem to derive (29). Applying the results of proposition 1 gives (30). Finally, minimization with respect to  $R_2$  immediately yields (33).

If the firm can monitor search effort the incentive compatibility constraints are not binding and so  $\lambda_1 = 0$ . It then follows that  $c_2^j = c_2^n = c_1$ . If the firm cannot monitor search the proposition's result hinges on the sign of  $\lambda_1$ . I now show that if the incentive compatibility constraints are binding,  $\lambda_1 > 0$ .

Suppose  $\lambda_1 < 0$  and so by (33),  $A_1^j > V(U_2^n)$ . From (31) and (32),  $c_2^n > c_1 > c_2^j$  and so by (30)  $c_3^j > c_2^j$ . Given that  $c_3^j = p + A_2^u/\beta$  and  $c_2^j = p + A_1^j/\beta(1 + \beta)$ , it follows that  $A_2^u > A_1^j/(1 + \beta)$ . To get a contradiction, note that (24) and  $A_1^j > V(U_2^n)$ , derived from (33) when  $\lambda_1 < 1$ , yield

$$\begin{aligned} A_1^j &> \beta(c_2^n + A_2^u) \\ &> \beta(c_2^j + A_2^u) \\ &= \beta(p + A_1^j/\beta(1 + \beta) + A_2^u), \end{aligned}$$

which yields the contradiction  $A_2^u < A_1^j/(1 + \beta)$ . Therefore  $\lambda_1 > 0$ . By an analogous argument it can be shown that  $\lambda_2 > 0$  in the case  $T = 3$ .

**Proof of Proposition 4** From the optimization conditions (53)-(54), and given the envelope property  $V'(U) = 1/u'(c_1) = \mu$ ,

$$\beta q(1 - G(R_2))(V'(U_2^n) - V'(U)) = -\lambda_1 < 0.$$

Therefore, if  $V(\cdot)$  is convex,  $U > U_2^n$ . A similar property holds for  $T = 3$ , which yields  $U_2^n > U_3^n$ .

Table 1  
Numerical Solutions

	bench mark	$\sigma$		$b$		$q$		$a$	$\mu$	
		1	4	0	.5	.2	.7	.5	.2	.6
cons drop	.23	.26	(.17) .22	(.24) .35	.11	.17	(.29) .28	.09	.11	(.27) .37
prob enter unempl	.24	.26	(.22) .17	(.26) .17	.37	.12	(.36) .28	.27	.36	(.17) .11
prob exit unempl	.37	.32	(.57) .61	(.35) .57	.20	.27	(.43) .47	.31	.16	(.61) .82

*Notes.*

1. The solutions are for the contract with severance compensation but no delay in dismissal, except for the bracketed terms, which are for the optimal contract. When  $\sigma=4$  or  $b=0$  or  $\mu=.6$  the optimal contract has a two-period delay and when  $q=.7$  it has a one-period delay.
2. The benchmark case is  $\sigma=2$ ,  $b=.2$ ,  $q=.5$ ,  $a=1$ ,  $\mu=.4$ ,  $p=1$ .
3. The consumption drop is the percentage drop in consumption from period 1 to period 2 when the job is revealed to be unproductive. The probability of entering unemployment is the product  $q(1-G(R_2))$ , which gives the probability of entering unemployment (or a period of delayed dismissal) when the job in period 1 turns out to be unproductive. The probability of exiting unemployment is  $G(R_3)$ , the probability of becoming employed again in a productive job in period 3.

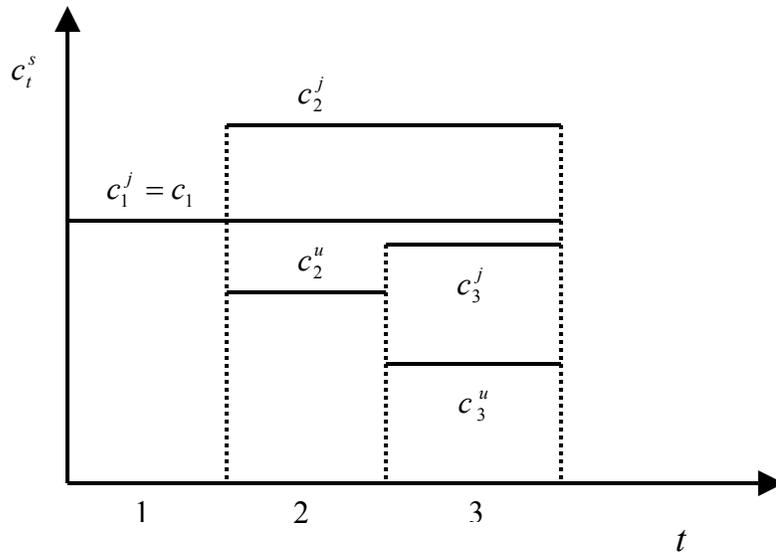


Figure 1  
The consumption profile with severance compensation

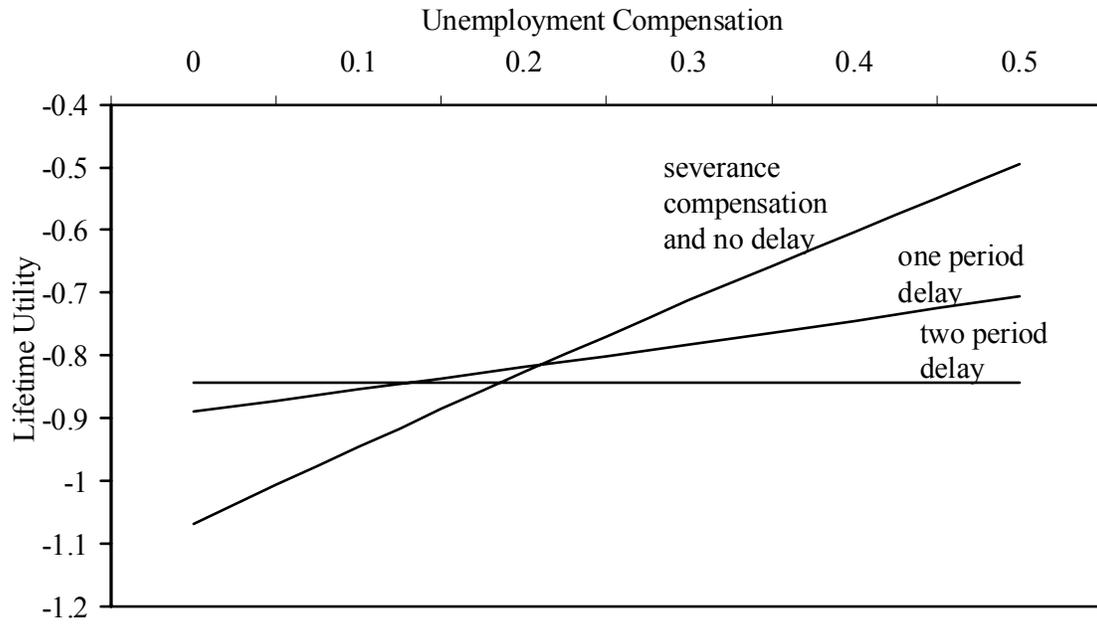


Figure 2  
 Unemployment compensation and the lifetime utility of  
 three contract types (risk aversion  $\sigma = 2$ )

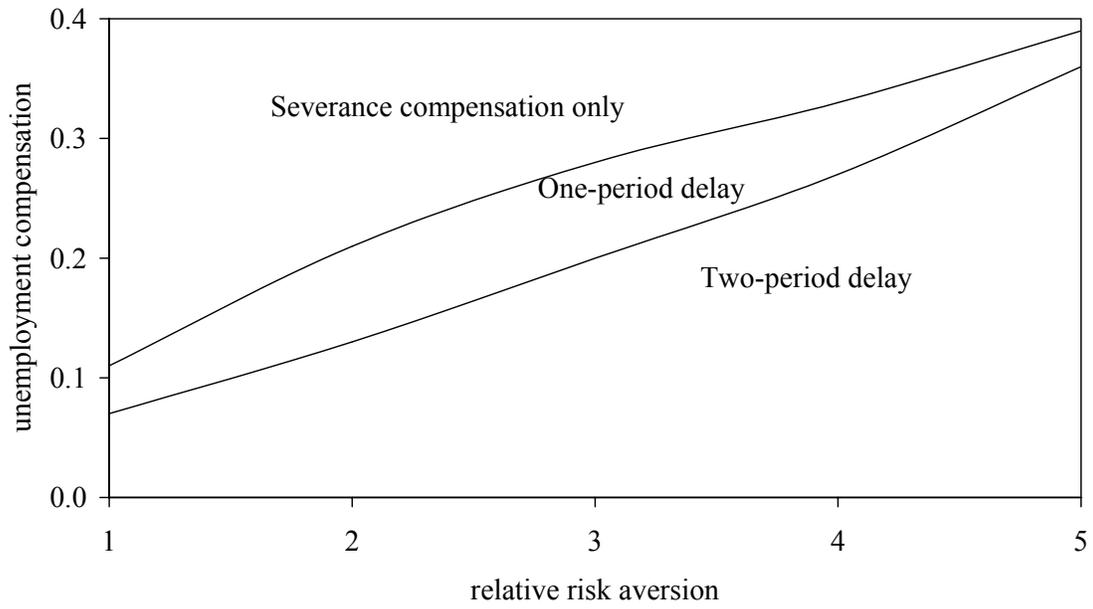


Figure 3  
Optimal contract regions: the influence of risk aversion and unemployment insurance

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