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## Further Aspects of Optimal Unemployment Insurance

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Further Aspects of Optimal Unemployment Insurance

by

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## 1. Introduction

Moral hazard is defined to be a situation in which "one party to a transaction may undertake certain actions that (a) affect the other party's valuation of the transaction but that (b) the second party cannot monitor/enforce perfectly" (Kreps, p. 577). Unemployment insurance is a classic example of moral hazard -- the government would like to provide a social safety net for those who are currently jobless but seeking reemployment. Unfortunately, the government cannot monitor perfectly the effort put forth by the unemployed to find new jobs. Thus, there is a tradeoff -- if the government provides too much insurance, the unemployed will not work hard enough to find new jobs, but, if too little insurance is provided the unemployed will bear too much risk. In devising an optimal unemployment insurance program, the government must find a way to provide adequate insurance without substantially reducing the incentive to seek employment.

The current UI program in the U.S. provides a benefit equal to roughly 50% of the wage earned on the previous job for one-half of a year after a worker loses her job. There are at least four relevant lines of literature that have been devoted to assessing whether this program is structured correctly and whether the current level of generosity is adequate. The purpose of this paper is to offer a brief critical review these literatures and to extend our previous work (Davidson and Woodbury 1995) on this

issue. The paper divides into four additional sections. In section 2, we review three areas of the literature that deal explicitly with the issue of unemployment insurance. Section 3 provides a description of our model. Our previous results are reviewed and our new results are presented in Section 4. Finally, in section 5 we relate our results to the previous literature, compare them with insights that have been provided by the abstract literature on optimal insurance contracts, and discuss future extensions. We close the paper with a conjecture as to the structure of an optimal unemployment program that is radically different from the present system.

## 2. The Literature

There are at least four relevant strands of literature that have investigated aspects of an optimal insurance program in the presence of moral hazard. The first three -- labor economics, macroeconomics, and public economics -- use similar approaches. They all adopt search models of the labor market in which unemployed workers choose search effort to maximize expected utility. More generous unemployment insurance increases the insurance offered to the unemployed, but also lowers optimal search effort, thereby triggering an increase in unemployment. Although the approaches are similar, these literatures seem to have developed, for the most part, independently. Thus, it is not surprising that they differ in the questions that are addressed, the complexity of the models, and the assumptions that are used to

simplify the analysis. The purpose of this section is to provide a critical review of the contributions in each area.

In Section 5, we review work in a related area -- the abstract literature on optimal insurance contracts -- that does not directly deal with unemployment insurance. At that point, we discuss how the results from that related literature can be extended to provide insights concerning an optimal unemployment insurance program. We also combine the insights from the four literatures with own results to derive an unemployment insurance program that is fundamentally different from our current system, but which we believe makes more sense than the current one from an economic perspective.

#### A. Labor Economics

Perhaps the best known article on optimal unemployment insurance in the labor economics literature is Shavell and Weiss' 1979 paper in the Journal of Political Economy. This article addresses the following question -- given that the government is going to spend a fixed amount of money on unemployment compensation, how should the benefits be paid out to the unemployed? That is, how should benefits vary over the spell of unemployment? Note that this paper does not attempt to determine the optimal size of the program -- the generosity of the program is taken as given and fixed.

The authors consider a variety of models in order to indicate how different features of the model affect their results. Their

basic approach is similar to that described above in that they use a search model of the labor market. However, in some of the cases that they consider they do not allow agents to alter search effort. This allows them characterize the optimal benefit path when moral hazard is not an issue. When they do allow search effort to vary, they assume that unemployed workers choose search effort to maximize expected lifetime utility and that greater search effort, while costly, increases the probability of finding employment. In all of their models unemployed workers are assumed to be identical. In addition, labor demand is not modeled and the wage rate is exogenous and independent of the UI program adopted. Finally, in each case, the benefit path over the spell of unemployment is chosen to maximize the expected lifetime utility of a representative unemployed worker.

Shavell and Weiss derive several results, depending on the assumptions of their model. For our purposes, there are three results that are important. The first result concerns the optimal benefit path when workers (a) cannot save and (b) cannot alter search effort so that they cannot affect their probability of reemployment. Thus, workers cannot self-insure and there are no moral hazard concerns. In this case, it is optimal to offer the same benefit rate in each period of unemployment. The logic is simple. Risk averse agents wish to smooth consumption across time. If agents cannot save, the only way provide a smooth path of consumption across the spell of unemployment is to make the benefit independent of the number of weeks a worker has been unemployed.

And, if agents cannot affect the probability of finding employment, there are negative side effects of such a UI program.

The second result concerns the optimal benefit path when agents can save but cannot affect their probability of reemployment. Thus, self-insurance is possible, but there are still no moral hazard issues to deal with. In this case, the optimal benefit rate is lowest in the initial stages of unemployment and rises over the spell of unemployment. As the spell lengthens, the benefit rate approaches an upper bound asymptotically. Thus, benefits are offered indefinitely. The intuition for this result is straightforward. If agents can save while employed, then during the initial stages of unemployment they can smooth consumption by dissaving. However, as the spell of unemployment lengthens, savings are depleted, and the only way to maintain consumption is for the government to increase the benefit level. As before, if agents cannot affect their reemployment probabilities, then there are no negative side effects from this program.

Shavell and Weiss' last result describes the optimal benefit path when agents can affect their probability of reemployment but are unable to self-insure against employment risk. They show that due to moral hazard concerns, benefits should decline over the spell of unemployment. The reduction in benefits induces workers to put forth effort to become reemployed. In the limit, the benefit converges to zero.

Unfortunately, Shavell and Weiss are unable to characterize

the optimal benefit path when agents can save and can also affect their reemployment probabilities. However, the three results discussed above can be used to form a conjecture as to the optimal benefit path in this case. With savings, agents can maintain consumption in the early stages of unemployment without receiving benefits. Thus, providing high benefits in the early stages of unemployment would not be wise, since doing so would only serve to lower search effort and increase unemployment. As the spell lengthens and savings are depleted, the government must start to increase benefits in order to allow the unemployed to smooth consumption. However, increasing benefits too much or providing them for too long would have an adverse effect on search effort and unemployment. Thus, eventually the benefit rate must fall and converge to zero (a typical benefit path of this nature is depicted in Figure 1). It is important to emphasize that Shavell and Weiss' analysis provides no insight as to the optimal level of benefits or the point at which benefits should be cut-off, they are only concerned with the shape of the benefit path.

Several years after the publication of Shavell and Weiss, Hausman (1984) argued that it was possible to improve upon the type of UI program that they had advocated. He argued that by offering a large up front payment to newly unemployed workers followed by low (or zero) benefits during the spell of unemployment, the system would operate more efficiently. The reasoning behind this scheme is that the up front payment would provide the unemployed the funds necessary to smooth consumption while the low benefit payments



during the spell of unemployment would provide a strong incentive to seek and accept reemployment. As in Shavell and Weiss, Hausman makes no attempt to determine the optimal size of the initial payment nor the optimal potential duration of benefits.

Both the Shavell and Weiss and Hausman analyses were largely theoretical. There have also been two important recent empirical investigations of the current U.S. program in the labor economics literature. In 1994 O'Leary used a consumer theory approach to estimate the optimal benefit path. His basic finding was that with the current U.S. program short spells of unemployment are over-compensated while long spells are under-compensated. Note that this result is similar to what one might conclude by comparing the current system with Figure 1.

In an even more recent paper, Hamermesh and Slesnick (1995) compare the well-being of UI recipients with their counterparts who do not receive benefits. They conclude that since their welfare levels are similar, the current system provides the right level of insurance.

With the exception of O'Leary (1994), all of these papers attempt to analyze the UI system by focusing on its impact on the typical unemployed UI recipient. While this may seem reasonable at first, it ignores the costs of the program. If a more generous program increases the unemployment rate, it increases the tax burden on the employed for two reasons. First, it costs more to fund a more generous program. Second, with higher unemployment there are fewer employed workers to share the tax burden. Thus, it

is important to investigate the impact of different programs on the unemployment rate -- which is something that these papers do not attempt to do. In short, these papers focus on the insurance aspects of unemployment insurance without paying adequate attention to the costs of the program.

## B. Macroeconomics

Over the past five years it has become fashionable in macroeconomics to blame a large part of society's economic ills on unemployment insurance. It is argued that the disincentive effect of UI are so strong that they have led to a significant increase in the unemployment rate throughout Europe (see, for example, Layard, Nickell and Jackman 1991). There have also been claims that the current U.S. unemployment insurance program generates a large welfare loss for the U.S. economy (see, for example, Mortensen 1994).

In a recent book, Layard, Nickell and Jackman (1991) trace much of the recent European experience with unemployment to changes in UI programs in the European countries. They argue that the gradual increase in the "natural rate" of unemployment in several European countries can be explained by the increased generosity of their UI programs. In addition, they argue that much of the cross-country differences in unemployment can be attributed to differences in their UI programs. In fact, they estimate that approximately 91% of the variation in the 1983-88 unemployment rate averages across the major OECD industrial countries can be

explained by nothing more than the variation in the generosity of labor market policies and the extent of collective bargaining coverage.

Based on their results, Layard et al suggest a variety of reforms to combat Europe's dual problems of high unemployment and long average duration of unemployment. For example, with respect to the U.K. they suggest reducing the unemployment benefit period, discarding policies that impose firing costs on firms, and instituting subsidies to offset recruiting and training costs incurred by firms.

The purpose of the Layard, Nickell and Jackman book is to provide estimates of the impact of various labor market policies on unemployment and to suggest reforms. However, the authors make no attempt to link the employment effects that they estimate to measures of economic welfare. Thus, it is difficult to assess whether or not European UI programs are welfare enhancing or debilitating. In addition, their analysis provides no guidance as to how the reforms they suggest would improve matters when compared to the present programs.

In two recent papers, Mortensen (1994) and Millard and Mortensen (1994) attempt to improve on the Layard et al approach by estimating the welfare effects of a variety of labor market policies including unemployment insurance. As opposed to the labor economics literature, they use a general equilibrium search model to carry out their analysis so as to capture the cost of UI through its impact on the aggregate unemployment rate. There are two

primary reasons that UI generates economic costs (in addition to the tax burden it creates). First, as we have already discussed, more generous UI lowers the opportunity cost of unemployment resulting in lower search effort by the jobless. This increases the equilibrium rate of unemployment and reduces output. Second, since more generous UI makes the unemployed less likely to accept new jobs, the wage that firms must offer rises, making production less profitable. This decreases the total number of jobs available in the economy. This job destruction effect further lowers employment, production, and welfare. This latter effect is absent from all of the labor literature discussed in sub-section A since the authors do not employ equilibrium models nor do they model firm behavior.

For our purposes, the most important results from these papers concern the UI programs in the U.S. and the U.K.. To estimate the impact of these programs, the authors calibrate their model using data on labor market flows in the U.S. during the period covering 1983-1992 and estimates of key parameters that are obtained from the labor economics and macroeconomics literatures. Following Layard et al, they then recalibrate the model for the U.K. assuming that differences in the U.S. and U.K. unemployment experiences can be attributed to differences in their labor market policies and union coverage rates.

In both papers welfare is measured by aggregate income net of search, recruiting and training costs. With this measure, Mortensen (1994) estimates that a 50% reduction in the U.S.

replacement rate would reduce the equilibrium rate of unemployment by 1.48 percentage points and increase net output by slightly less than one percentage point. He also estimates that a 50% reduction in the potential duration of benefits would decrease the equilibrium rate of unemployment by .78 percentage points while increasing welfare by about .5 percentage points.

As for the U.K., Millard and Mortensen estimate that the welfare cost imposed on the U.K. by its current UI program is roughly equal to 1.7% of net output, a fairly large measure for dead weight loss. They also estimate that by limiting the benefit period to 2 quarters (as in the U.S.), the U.K. could increase welfare by more than one percentage point (and lower unemployment by over 2 percentage points). Moreover, if the firing costs currently imposed by the government were also eliminated (as suggested by Layard et al), Mortensen and Millard estimate that welfare in the U.K. would rise by as much as 3.5%.

It is easy to infer from these results that the current UI programs in the U.S. and the U.K. impose significant welfare burdens on their economies. However, there is at least one serious drawback to these analyses. By using aggregate net income as their measure of welfare, the authors implicitly assume risk neutrality on the part of workers so that there is no need or desire for insurance of any kind. It follows that the positive aspects of UI -- the fact that it provides desired insurance against employment risk -- are given no weight in the welfare calculations. In contrast to the labor literature which focused on the insurance

aspects of UI without measuring the economic costs of the program, these two papers focus on the costs of the program while ignoring the benefits it provides.

A recent paper by Wang and Williamson (1995) improves upon the Mortensen and Millard and Mortensen analyses by explicitly incorporating risk aversion into a general equilibrium model. In that paper, welfare is measured by summing the utilities of all the agents in the economy. Since each agent is risk averse, there is a desire for employment insurance, and, since a general equilibrium model is used, the authors are able to measure the impact of UI programs on aggregate unemployment. Thus, Wang and Williamson use an approach that measures both the benefits and costs of different UI programs. It is important to note, however, that this is not the only difference between the Millard/Mortensen and Wang/Williamson papers -- Wang and Williamson do not adopt a search framework, choosing to work instead in an abstract framework in which the process by which jobs are created and destroyed are not modelled. We discuss the importance of this difference in approach in Section 5.

The purpose of the Wang and Williamson paper is to derive the optimal unemployment insurance program assuming that the replacement rate can vary over the spell of unemployment and that the government can tax and/or subsidize transitions into various labor market states. Thus, they allow for extremely complex programs. In fact, the program that they find to be optimal is so complex that it is hard to imagine any government actually trying

to implement it. In brief, they find that the replacement rate should vary non-monotonically with the spell of unemployment -- starting low and then rising before falling off eventually to zero. Thus, their optimal benefit path is similar to what we conjectured the optimal path would look like in the Shavell and Weiss analysis when agents can save and affect their reemployment probabilities (see Figure 1). In addition, they find that the government should subsidize transitions into employment (with, for example, a reemployment bonus).

Although Wang and Williamson use an approach that is quite different from ours (since they do not use a search model and do not include firms in their analysis) and although their optimal UI program is far more complex than any program that we allow the government to consider, their results share many of the important features of our optimal program. Therefore, in Section 5 we describe their results in greater detail and compare them with ours.

### C. Public Economics

The two most heavily cited papers on optimal unemployment insurance appeared in the same 1978 issue of the Journal of Public Economics. These papers were written by Martin N. Baily and J.S. Flemming and were so similar in approach and conclusions that they were given almost identical titles. Both authors use a search model of the labor market in which unemployed agents choose search effort to maximize expected lifetime utility. Agents are risk

averse, so that insurance is desired, and an equilibrium model is used in order to capture the impact of UI on unemployment. However, neither author explicitly models firm behavior so that neither paper is able to capture the job destruction effects of UI. This implies that all of the increase in unemployment from UI is due to its impact on search effort.

The papers differ in the time horizon that is considered (Baily uses a two-period model while Flemming uses an infinite horizon approach), the manner in which the capital market (and thus, savings) is handled, and the utility function that is used. Nevertheless, as we discuss below, they derive remarkably similar results.

Both authors have the same goal -- to determine the optimal replacement rate assuming that the rate remains constant over the spell of unemployment. The results are then compared to replacement rates offered in the U.S. and the U.K. in order to determine whether or not current UI programs are too generous. Briefly, Baily and Flemming both find that if agents cannot save then the optimal replacement rate lies in the 60%-70% range. This result is fairly robust, since it does not depend on the time horizon or the manner in which the authors calibrate their models. There is one exception -- this result does depend on the degree of risk aversion that is assumed. Baily assumes that the Arrow-Pratt measure of relative risk aversion is constant and equal to one, while Flemming assumes that the Arrow-Pratt measure of absolute risk aversion is constant and equal to one. For lower measures of



risk aversion, they find lower optimal replacement rates.

When agents can save but capital markets are imperfect (so that workers can only partially self-insure), Baily and Flemming find that the optimal replacement rate falls by about 25-30 percentage points. Thus, they conclude that the optimal replacement rate is below 50% and that the current U.S. unemployment insurance program is too generous. Similar conclusions have been reached by Gruber (1994) who recently used Baily's framework to estimate the optimal replacement rate for the U.S..

In our earlier work, Davidson and Woodbury (1995b), we criticized Baily and Flemming for two of the assumptions that they used in their analysis -- both authors assume that all unemployed agents are eligible for UI benefits and that they receive such benefits for as long as they remain unemployed. In reality, less than 50% of the unemployed are eligible for UI benefits in the U.S. (Blank and Card 1991) while in the U.K. roughly 70% of the unemployed are eligible (Layard et al 1991). In addition, benefits are offered for only 26 weeks in the U.S. and are limited in almost every other country. In section 4, we review our earlier results which indicate that the conclusions reached by Bailey and Flemming are extremely fragile with respect to these two assumptions. We then go on to extend the Baily and Flemming analysis even further by explicitly modelling firm behavior and making the wage rate and the number of active firms endogenous. This allows us to capture the job destruction effects of UI and see exactly how this alters

our results.

### 3. Our Model

In this section we provide a description of the model that we use to derive the optimal UI program. As we describe our model, we also point out the elements that are missing from each of the analyses described in Section 2. This should help clarify some of our criticisms of the earlier literature.

We follow the tradition in this literature by employing a search model of the labor market. In order to focus on the benefits and costs of UI we model the behavior of a representative unemployed worker who is searching for employment and desires employment insurance. This worker earns a wage of  $w$  while employed and collects UI benefits of  $x$  while unemployed provided that she has not exhausted her benefits. Benefits are provided by the government to jobless workers who have been unemployed for no more than  $T$  periods. Thus, at the outset we assume that all newly unemployed workers are eligible for UI. In the next section, we describe how the model is modified to take into account the fact that the actual UI take-up rate is below 100%.

In our model, UI is funded by taxing all employed workers' incomes at a constant rate  $\tau$ . This assumption, common in the optimal UI literature, is used to capture the notion that in a competitive economy the incidence of a UI tax is likely to be borne by workers.

We assume that unemployed workers choose search effort ( $p$ ) to

maximize expected lifetime income and that all workers are infinitely lived. As for firms, we assume that each firm hires at most one worker and that new firms enter the labor market until the expected profit from creating a vacancy is zero. Once a firm with a vacancy and an unemployed worker meet, they negotiate the wage. Following a well-established tradition in the search literature, we assume that the negotiated wage splits the surplus created by the job evenly (this will be made precise below). Total labor demand ( $F$ ) and search effort together determine equilibrium steady-state unemployment ( $U$ ).

The government's goal is to choose  $x$  and  $T$  to maximize aggregate expected lifetime income. Increases in  $x$  and/or  $T$  provide unemployed workers with additional insurance but these increases also lower optimal search effort. In addition, since a more generous UI program reduces the opportunity cost of unemployment, it increases the wage rate and makes creating a vacancy less profitable. The reduction in search effort coupled with the destruction of job opportunities leads to an increase in equilibrium unemployment. The optimal government policy must balance these costs and benefits.

In terms of the literature reviewed above, our approach is very similar to that of Mortensen (1994) and Millard and Mortensen (1994), except that we assume risk aversion on the part of workers. Alternatively, our work could be viewed as an extension of Baily (1978) and Flemming (1978) in which we (a) make the potential duration of benefits variable, (b) take into account the fact that

the UI take-up rate is below 100%, and (c) model labor demand so that the job destruction effects of UI are taken into account.

We describe the model in three steps. First, we show how to determine expected lifetime utility for all agents in the economy and use these measures to define welfare. We also show how these measures may be used to determine optimal search effort for unemployed workers. Second, we show how total labor demand and search effort can be combined to determine equilibrium unemployment. Finally, we introduce our model of firm behavior and show how total labor demand and the equilibrium wage are determined.

Before we begin, a few words about our notation are in order. Throughout the analysis we define variables such as search effort, expected lifetime utility, reemployment probabilities, et cetera that depend upon the employment status of the worker. In each case, we use sub-scripts on the variables to denote the employment status with  $w$  representing employed workers,  $t$  denoting unemployed workers in their  $t^{\text{th}}$  period of search, and  $x$  denoting unemployed workers who have exhausted their benefits. Thus, for example, if we use  $m$  to denote the reemployment probability,  $m_t$  would represent the reemployment probability for an unemployed workers in the  $t^{\text{th}}$  period of search while  $m_x$  would represent the reemployment probability for an unemployed worker who has exhausted her benefits.

#### A. Expetected Lifetime Utility, Search Effort, and Welfare

We use  $V_j$  to denote expected lifetime utility for a worker in employment state  $j$  ( $j = w$  if employed,  $t$  if unemployed for  $t$  periods, and  $x$  if unemployed and benefits have been exhausted). In addition, we use  $u(\cdot)$  to represent the agents' common utility function. We assume that per period utility takes the form  $u(C) - c(p)$  with  $C$  denoting consumption,  $c(p)$  denoting the cost of search, and  $p$  denoting search effort (if unemployed). We assume that  $c(p)$  is a convex function and that  $c(0) = 0$ . We begin by assuming that agents cannot save so that in any given period consumption equals income. In Section 4 we discuss how relaxing this assumption affects our results.

For employed workers, current income consists of two components -- labor income, which is equal to the wage net of taxes,  $w(1 - \tau)$ , and non-labor income, which is equal to their share of the aggregate profits earned by the firms,  $\theta_w$ . Thus, current utility is given by  $u[w(1 - \tau) + \theta]$ . Obviously, employed agents incur no search costs. To determine expected lifetime utility, we must also consider the worker's future prospects. Let  $s$  denote the probability that in any given period the worker will lose her job. Then, with probability  $(1 - s)$  the worker's expected future lifetime utility will continue to be  $V_w$  (since she remains employed). With the remaining probability of  $s$  the worker loses her job and her expected future lifetime utility falls to  $V_t$ . It follows that,

$$(1) \quad V_w = u[w(1-\tau)+\theta_w] + [sV_t+(1-s)V_w]/(1+r).$$

Note that future utility is discounted at rate  $(1+r)$  with  $r$  denoting the interest rate.

Turn next to the unemployed. For them, current income is equal to the sum of unemployment insurance (if benefits have not yet been exhausted) and profits. We use  $\theta_u$  to denote a typical unemployed worker's share of aggregate profits. Future income depends on future employment status. We use  $m$  to denote reemployment probabilities so that with probability  $m_t$  the worker finds a job and can expect to earn  $V_w$  in the future, while with the remaining probability she remains unemployed and can expect to earn  $V_{t+1}$  in the future. Thus,

$$(2) \quad V_t = u[x + \theta_u] - c(p_t) + [m_t V_w + (1 - m_t) V_{t+1}] / (1 + r) \quad \text{for } t = 1, \dots, T.$$

$$(3) \quad V_x = u[\theta_u] - c(p_x) + [m_x V_w + (1 - m_x) V_x] / (1 + r).$$

We are now in a position to define welfare ( $W$ ). Let  $U_t$  represent the number of workers who have been unemployed for  $t$  periods and define  $U_x$  analogously for UI-exhaustees. Then, if we define  $J$  to be the total number of jobs held in the steady-state equilibrium and aggregate expected lifetime utility across all agents, we obtain

$$(4) \quad W = J V_w + U_x V_x + \sum_t U_t V_t.$$

Finally, since unemployed workers choose search effort ( $p$ ) to

maximize expected lifetime income (V) we have,

$$(5) \quad p_t = \arg \max V_t \quad \text{for } t = 1, \dots, T.$$

$$(6) \quad p_x = \arg \max V_x.$$

In maximizing expected lifetime utility, it is important to note that the reemployment probability ( $m$ ) is an increasing function of search effort ( $p$ ). We make the link between the two explicit in sub-section B below.

This completes the description of expected lifetime utility and the determination of search effort. At this point it is useful to note that if we were to stop here, we would have a model very similar to the one used by Shavell and Weiss (1979). In essence, their approach is to describe expected lifetime utility, assume that  $m$  is increasing in  $p$ , fix the total amount the government is going to spend on UI, and then choose a path of benefits ( $x_t$  for  $t = 1, 2, \dots$ ) to maximize  $V_1$ , the expected lifetime utility of a newly unemployed UI-eligible worker. As discussed above, this does not take into account the costs of the program nor does it tell us the optimal amount that the government should be spending on UI. In addition, it is not at all clear why Shavell and Weiss focus on the benefit path that maximizes  $V_1$ , since it seems clear that  $W$  is a more appropriate measure of welfare.

#### B. Determining Unemployment

In this sub-section we show how total labor demand ( $F$ ) and search effort ( $p$ ) can be combined to determine equilibrium unemployment. To do so, we first show how to determine steady-state unemployment once the reemployment probabilities have been determined. Second, we show how the reemployment probabilities vary with search effort, labor demand, and other features of the labor market.

Formally, we use  $L$  to denote total labor supply. Then, since every worker is either employed or unemployed, we have

$$(7) \quad L = J + U.$$

In addition, given our definitions of  $U_t$  and  $U_x$  we can write total unemployment as

$$(8) \quad U = \sum_t U_t + U_x.$$

Turn next to the firms. For simplicity, we assume that each firm provides only one job opportunity.<sup>1</sup> Thus,  $F$  denotes both the total number of firms and the total number of jobs available at any time. Each job is either filled or vacant. If we let  $V$  denote the number of vacancies in a steady-state equilibrium, it follows that

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<sup>1</sup> This assumption is commonly used in general equilibrium search models (see, for example, Diamond 1982 or Pissarides 1990). Alternatively, we could simply assume that each firm recruits for and fills each of its many vacancies separately.



$$(9) \quad F = J + V.$$

We are now in a position to describe the dynamics of the labor market and the conditions that must hold if we are in a steady-state equilibrium. These conditions guarantee that the unemployment rate and the composition of unemployment both remain constant over time. We begin by reminding the reader that  $s$  is defined to be the economy's separation rate -- that is,  $s$  denotes the probability that an employment relationship will dissolve in any given period. In addition, remember that reemployment probabilities are denoted by the  $m$  terms. Then, for any given worker, there are  $T + 2$  possible employment states --  $U_1, U_2, \dots, U_T, U_x$ , and  $J$ . If employed (i.e., if in state  $J$ ) the worker faces a probability  $s$  of losing her job and moving into state  $U_1$ . If unemployed for  $t$  periods (i.e., if in state  $U_t$ ), the worker faces a probability of  $m_t$  of finding a job and moving into state  $J$ . With the remaining probability of  $1 - m_t$  this worker remains unemployed and moves on to state  $U_{t+1}$ . Finally, UI-eligible exhaustees face a reemployment probability of  $m_x$ , in which case they move into state  $J$ . Otherwise, they remain in state  $U_x$ .

In a steady-state equilibrium the flows into and out of each state must be equal so that the unemployment rate and its composition do not change over time. Using the above notation, the flows into and out of state  $U_1$  are equal if

$$(10) \quad sJ = U_1.$$

The flows into and out of state  $U_t$  (for  $t = 2, \dots, T$ ) are equal if

$$(11) \quad (1-m_{t-1})U_{t-1} = U_t$$

Finally, the flows into and out of state  $U_x$  are equal if

$$(12) \quad (1-m_T)U_T = m_x U_x.$$

In each case, the flow into the state is given on the left-hand-side of the expression while the flow out of the state is given on the right-hand-side.

Equations (7)-(12) define the dynamics of the labor market given the reemployment probabilities and total labor demand. We must now explain how search effort translates into a reemployment probability for each unemployed worker. As described above, each unemployed worker chooses search effort ( $p$ ) to maximize expected lifetime utility. Search effort is best thought of as the number of firms a worker chooses to contact in each period of job search. For workers who contact fewer than one firm on average,  $p_i$  could also be thought of as the probability of contacting any firm. Once a worker contacts a firm, she files an application for employment if the firm has a vacancy. Since there are  $F$  firms and  $V$  of them have vacancies, the probability of contacting a firm with a vacancy is  $V/F$ . Finally, once all applications have been filed, each firm with a vacancy fills it by choosing randomly from its pool of applicants. Thus, if  $N$  other workers apply to the firm, the

probability of a given worker getting the job is  $1/(N+1)$ . Since each other worker either does or does not apply,  $N$  is a random variable with a Poisson distribution with parameter  $\lambda$  where  $\lambda$  is equal to the average number of applications filed at each firm. It is straightforward to show that this implies that the probability of getting a job offer conditional on having applied at a firm with a vacancy is  $(1/\lambda)[1 - e^{-\lambda}]$ . The employment probability for any given worker is then the product of these three terms -- the number of firms contacted, the probability that a given firm will have a vacancy, and the probability of getting the job conditional on having applied at a firm with a vacancy:

$$(13) \quad m_t = p_t(V/F)(1/\lambda)[1 - e^{-\lambda}] \quad \text{for } t = 1, \dots, T$$

$$(14) \quad m_x = p_x(V/F)(1/\lambda)[1 - e^{-\lambda}]$$

where

$$(15) \quad \lambda = \{\sum_t p_t U_t + p_x U_x\} / F.$$

These equations define the employment probabilities of workers as a function of search effort and the length of time that they have been unemployed. Note that for any given worker, the search effort of other workers affects that worker's employment probability through  $\lambda$ .

Given the levels of search effort and expected lifetime

utilities defined by (1)-(6), equations (7)-(15) can be solved for equilibrium unemployment ( $U$ ), its composition ( $U_t$  for  $t = 1, \dots, T$  and  $U_x$ ), and the reemployment probabilities ( $m_t$  for  $t = 1, \dots, T$  and  $m_x$ ). If we were to stop developing the model at this point, treating  $F$  and  $w$  as exogenous, we would have a model almost identical to the one used by Flemming (1978). In fact, there would be only two real substantive differences between the models -- Flemming allows workers to save while employed while we do not and Flemming assumes that UI is offered indefinitely while we assume that it is only offered for  $T$  periods. As we mentioned above, we add a third distinction in the next section when we add UI-ineligible workers to the model.

### C. Firms

To make the number of firms endogenous we assume that firms enter the market until the expected profit from doing so equals zero. When a firm enters the market, it creates a vacancy and starts to accept applications from unemployed workers to fill it. Once the vacancy is filled, the firm produces and sells output as long as its vacancy remains filled. If the firm loses its worker, it must restart the process of filling its vacancy.

We use  $\Pi_v$  to denote the expected lifetime profit for a firm that currently has a vacancy and use  $\Pi_f$  to represent the expected lifetime profit for a firm that has filled its vacancy. Thus, when a firm enters the market and creates a vacancy it can expect to earn  $\Pi_v$  in the future. Once it fills its vacancy, its expectations

about future profits rise to  $\Pi_j$ . Firms enter until

$$(16) \Pi_v = 0.$$

To calculate  $\Pi_v$  and  $\Pi_j$ , we follow the same procedure that was used to determine expected lifetime utilities -- we consider the current and future prospects of typical firms. Let  $q$  denote the probability of filling a vacancy, use  $R$  to denote the revenue earned by a firm that is producing, and let  $K$  represent the cost of maintaining a vacancy. Then, current profit for a firm with a vacancy is  $-K$  while current profit for a firm that is producing is  $R - w - K$ . Now consider their future prospects. A firm that has an opening fills it with probability  $q$ , in which case its expected lifetime profits rise to  $\Pi_j$ . With the remaining probability the vacancy remains open and the firm continues to expect to earn  $\Pi_v$ . Thus,

$$(17) \Pi_v = -K + [q\Pi_j + (1-q)\Pi_v]/(1+r).$$

A firm that has already hired a worker keeps that worker with probability  $(1-s)$  and continues to earn  $\Pi_j$ . With the remaining probability, it loses its worker and sees its expected profits fall to  $\Pi_v$ . Thus,

$$(18) \Pi_j = R - w - K + [s\Pi_v + (1-s)\Pi_j]/(1+r).$$

Note that, as before, future profits are discounted at rate  $(1+r)$ .

The probability of filling a vacancy,  $q$ , depends on the number of firms competing for the unemployed ( $V$ ), the number of unemployed workers ( $U$ ) and the search effort of workers. In any given period the number of unemployed workers who find new jobs is equal to  $\sum_i m_i U_i + m_x U_x$  while the number of vacancies that are filled is equal to  $qV$ . Since these values must be equal, we have

$$(19) \quad q = [\sum_i m_i U_i + m_x U_x] / V.$$

Note that the search effort of workers enters (19) through the reemployment probabilities.

The next step in developing our model is to use  $\Pi_v$  and  $\Pi_j$  to determine the profits that are distributed to workers in each period in the form of dividends ( $\theta_w$  for the employed and  $\theta_u$  for the unemployed). Since there are  $J$  jobs filled in equilibrium with each one generating  $\Pi_j$  in expected lifetime profits, aggregate expected lifetime profits are  $J\Pi_j$ . Thus, the aggregate per period profits are equal to  $rJ\Pi_j / (1+r)$ . These profits must be distributed to workers each period. We assume that these profits are distributed evenly to employed workers with the unemployed receiving nothing. It follows that  $\theta_w = rJ\Pi_j / (1+r)J = r\Pi_j / (1+r)$  and  $\theta_u = 0$ . We make this assumption for the following reason. Suppose that the government were to reduce the generosity of the UI program, resulting in an increase in aggregate profits. If the unemployed were to receive a share of these profits, this increase

in non-labor income could swamp the decrease in UI leaving the unemployed better-off. Since it is unlikely that the unemployed receive significant income from such non-labor sources, we assume that all profits go to the employed.

The final step in developing our model is to explain how the wage is determined. Following the general equilibrium search literature (see, for example, Diamond 1982 or Pissarides 1990), we assume that the firms and workers split the surplus created by the representative job evenly. For firms, when they fill a vacancy their expected profits rise from  $\Pi_v$  to  $\Pi_j$ . For an average worker, when they become employed their expected lifetime utility rises from  $V_u$  to  $V_w$  where  $V_u$  denotes the average expected lifetime utility for unemployed workers. That is,

$$(20) \quad V_u = [\sum_i U_i V_i + U_x V_x] / U.$$

It follows that the total surplus created by the average job when measured in dollars is  $\Pi_j - \Pi_v + (V_w - V_u)MU_1$  where  $MU_1$  represents the workers marginal utility of income and allows us to transform the workers gain,  $V_w - V_u$ , which is measured in utility, into an appropriate dollar value. This surplus is split evenly between the firm and its employee if the wage solves

$$(21) \quad \Pi_j - \Pi_v = (V_w - V_u)MU_1.$$

In summary, when we model firms the number of firms demanding

labor ( $F$ ) is determined by (16) while the equilibrium wage is determined by (21).

The government's problem is to choose  $x$  (the UI benefit level) and  $T$  (the potential duration of benefits) to maximize welfare ( $W$ , as given in eq. 4) subject to the constraint that its budget balances. Since there are  $J$  employed workers each earning a wage of  $w$ , total tax revenue is equal to  $Jwr$ . In equilibrium,  $U - U_x$  unemployed workers each receive benefits of  $x$  each period. Thus, the total cost of the program is  $(U - U_x)x$ . For the budget to balance it must be the case that

$$(22) \quad (U - U_x)x = Jwr.$$

As noted above an increase in  $x$  or  $T$  increases the level of insurance provided to unemployed workers, but both increase equilibrium unemployment and require that  $\tau$  increase in order to fund the expanded program.

This completes the description of our model. In structure it is very similar to that of Mortensen (1994) and Millard and Mortensen (1994). The major difference is in the manner in which welfare is measured -- while they use aggregate income net of search, recruiting, and training costs as their measure of welfare we use aggregate expected lifetime utility. These two measures are identical if agents are risk neutral. However, if the utility function is concave, so that agents are risk averse, the measures differ. As we argued above, we feel that it is important to assume



risk aversion since this implies that there are positive benefits from providing unemployment insurance.

#### D. Properties of Equilibrium

Before we turn to optimal policy, it is useful to first describe the structure of equilibrium and some of its comparative dynamic properties. It is straightforward to show that in a steady-state equilibrium that  $V_w > V_1 > V_2 > \dots > V_T > V_x$ . That is, expected lifetime income is highest for employed workers, lowest for unemployed workers who have exhausted their benefits, and decreasing in the number of weeks that a worker has been unemployed. Intuitively, workers in the early stages of a spell of unemployment have more weeks to find a job before they have to worry about losing their UI benefits. Because of this, workers who have recently become unemployed will not search as hard as those who have been unemployed for a longer period of time -- that is, optimal search effort will be increasing in the number of weeks of unsuccessful search ( $p_1 < p_2 < \dots < p_T < p_x$ ).

A decrease in UI benefits ( $x$ ) or the potential duration of benefits ( $T$ ) decreases the level of insurance offered unemployed workers and triggers an increase in search effort by all UI-eligible workers (and therefore lowers equilibrium unemployment). Either change results in a decrease in  $V_t$  for all  $t$ , but decreases in  $x$  and  $T$  have opposite effects on the probability of exhausting benefits. A decrease in  $x$  makes it less likely that a worker will exhaust her UI benefits before finding a job (since she searches

harder). But a decrease in  $T$  makes it more likely that benefits will be exhausted since the time horizon over which benefits are offered has been shortened (this is true in spite of the fact that search effort increases as a result of the decrease in  $T$ ). Of course, increases in  $x$  or  $T$  lead to the opposite effects.

Changes in the UI program also have important implications for firm behavior and labor demand. Since increases in either  $x$  or  $T$  reduce the cost of being unemployed, they make workers less willing to search for and/or accept jobs. This results in an increase in  $V_u$  and forces firms to increase the wage that they offer their new employees. This increase in the wage makes production less profitable and results in fewer firms and fewer job opportunities. This job destruction effect increases unemployment and lowers net output.

#### E. Calibration

In order to determine the optimal UI program we must choose values for the parameters of the model, solve for the equilibrium generated by each pair of policy parameters ( $x$  and  $T$ ), and compare the levels of welfare achieved in the different equilibria. Assuming that we choose realistic values for the parameters, this exercise should give us some idea as to the ranges in which the optimal level of benefits and the optimal potential duration of benefits lie.

The parameters of the model are the separation rate ( $s$ ), the interest rate ( $r$ ), the size of the labor force ( $L$ ), the search cost

function  $(c(p))$ , the revenue earned by producing firms  $(R)$ , the cost of maintaining a vacancy  $(K)$ , and the utility function,  $u(C)$ . Since we are interested in varying the degree of risk aversion, we calibrate the model separately for a variety of different utility functions and compare the optimal programs that result.

We calibrate the model in two steps. First, we treat the model introduced in sub-sections A and B as if it were self-contained -- that is, we treat the number of firms  $(F)$  and the wage  $(w)$  as if they were parameters of the model. To calibrate this portion of the model we rely on data collected to analyze the Illinois Reemployment Bonus Experiment. Since we have discussed this calibration exercise in detail elsewhere (see, for example, Davidson and Woodbury 1993, 1994), we provide only a brief description of how we obtain estimates of the parameters of this abbreviated model. Briefly, this portion of the model is calibrated so that its predictions concerning the impact of a reemployment bonus offered to unemployed workers matches what was observed in Illinois. By treating  $F$  and  $w$  as fixed, we are implicitly assuming that the Illinois experiment had no wage or job creation/job destruction effects. In fact, the data does indicate that there were no wage effects from the reemployment bonus (Woodbury and Speigelman 1987) and, given that the program was temporary and limited in scope, it seems reasonable to assume that there were no significant changes in the number of firms seeking workers as a result of the bonus. Thus, we consider this approach appropriate.

In the second step, we expand the model (by adding sub-section C) so that  $F$  and  $w$  become endogenous. This adds two new parameters to the model --  $R$  (the revenue earned by the firm when producing) and  $K$  (the cost of maintaining a vacancy). These values are then chosen so that the full model yields (a) a value for  $w$  that matches the data collected in Illinois, and (b) values for  $F$  that lie in the range predicted by the abbreviated model in the first stage of calibration.

Now, we begin with step one of the calibration. When considering the abbreviated model (as introduced in sub-sections A and B), the parameters of interest are the separation rate ( $s$ ), the interest rate ( $r$ ), the wage ( $w$ ), the number of firms ( $F$ ), the size of the labor force ( $L$ ), and the search cost function ( $c(p)$ ). We can obtain an estimate for  $s$  from the existing literature on labor market dynamics. Ehrenberg (1980) and Murphy and Topel (1987) both provide estimates of the number of jobs that break-up in each period. If we measure time in 2-week intervals, their work suggests that  $s$  lies in the range of .007 to .013. For the interest rate we set  $r = .008$  which translates into an annual discount rate of approximately 20%. Since our previous work (Davidson and Woodbury 1993) suggests that results from this model are not sensitive to changes in  $r$  over a fairly wide range, this is the only value for the interest rate that we consider.

For  $F$  and  $L$  we begin by noting that our model is homogeneous of degree zero in  $F$  and  $L$  so that we may set  $L = 100$  without loss of generality. If we then vary  $F$  holding all other parameters

fixed we can solve for the equilibrium unemployment and vacancy rates. Abraham's (1983) work suggests that the ratio of unemployment to vacancies ( $U/V$ ) varies between 1.5 and 3 over the business cycle. Although the actual values of  $U$  and  $V$  depend on the other parameters, we find that to obtain such values for  $U/V$  in our model with  $L = 100$ ,  $F$  must lie in range of 95 to 97.5. Thus, in the second stage of the calibration, we must choose values for  $R$  and  $K$  such that  $F$  lies in the range 95-97.5.

The remaining parameters in sub-sections A and B are the wage rate and the search cost function. For these values we turn to the data and results from the Illinois Reemployment Bonus Experiment. In the Illinois Reemployment Bonus Experiment a randomly selected group of new claimants for UI were offered a \$500 bonus for accepting a new job within 11 weeks of filing their initial claim. The average duration of unemployment for these bonus-offered workers was approximately .7 weeks less than the average unemployment duration of the randomly selected control group (Davidson and Woodbury 1991). In our previous work, we estimated the parameters of the search cost function that would be consistent with such behavioral results. That is, we assumed a specific functional form for  $c(p)$  and then solved for the parameters that would make the model's predictions match the outcome observed in the Illinois experiment. The functional form that we used was  $c(p) = cp^z$ , where  $z$  denotes the elasticity of search costs with respect to search effort. The values for  $c$  and  $z$  that make the model's predictions exactly match what occurred in Illinois depends upon the

utility function that is assumed. For example, if we assume that the utility function is linear in consumption, then our results indicated that for the average bi-weekly wage rate observed in Illinois (\$511), the values of  $c$  and  $z$  that are consistent with the Illinois experimental results are  $c = 338$  and  $z = 1.23$ . On the other hand, if the utility function takes on the form  $u(C) = \ln(C)$ , we find that the values of  $c$  and  $z$  that are consistent with the Illinois experimental results are  $c = 2.05$  and  $z = 1.38$ .

Finally, turn to the second stage of calibration. In order to make  $F$  and  $w$  endogenous, we add the equations in sub-section C to the model. This adds only two new parameters,  $R$  and  $K$ . From the Illinois data we know that the average bi-weekly wage should be \$511, and, from stage one of the calibration we know that  $F$  must lie in the range 95 to 97.5. Thus, we set  $x$  and  $T$  equal to their Illinois values --  $x$ , the average bi-weekly UI benefit in Illinois is set equal to \$242, and  $T$ , the potential duration of UI, in Illinois is set equal to 14 (since each period equals 2 weeks) -- and then we solve the model to determine what values of  $R$  and  $K$  would lead the model to predict that  $w = \$511$  and that  $F$  would fall in the range 95-97.5. Of course, the values of  $R$  and  $K$  depend upon the assumed functional form for the utility function. If the utility function is linear in consumption, then when  $R = 724$  and  $K = 2417$  the model predicts that  $w = 511$  and  $F = 96.25$ . On the other hand, if  $u(C) = \ln(c)$ , then when  $R = 1469$  and  $K = 10863$  the model predicts that  $w = \$511$  and  $F = 96.25$ .

Once the calibration is complete, we set the parameters at the

calibrated levels and solve for the welfare maximizing values of  $x$  and  $T$ . Once we have solved for the optimal values for  $x$  and  $T$  in one case, we vary the parameters over the ranges described above to test for the sensitivity of our results with respect to each parameter.

#### 4. Results

In this section we begin by reviewing results from our earlier work, Davidson and Woodbury (1995), in which we solved for the optimal UI program in the abbreviated model outlined in sections 3.A and 3.B. These results are best thought of extensions of Baily (1978) and Flemming's (1978) work to an environment in which (a) the potential duration of benefits can vary and be controlled by the government, and (b) not all unemployed workers are eligible for UI. Next, we present new results concerning optimal UI when firm behavior is explicitly added to the model as in section 3.C. This allows us to examine how our initial results must be modified when the job destruction effects of more generous UI programs are taken into account. Finally, we extend our model once more in order to allow for worker heterogeneity and show how including workers with different labor market experiences in the model alters our results.

##### A. Optimal Potential Duration of Benefits without Job Destruction

The most surprising result from our earlier analysis is that in the abbreviated model the optimal potential duration of benefits is infinite -- that is, the government should offer UI benefits

indefinitely to all unemployed UI eligible workers. Although there are some details omitted from the following reasoning<sup>2</sup>, the crux of the argument is as follows. Agents facing employment risk would prefer a program that allows them to smooth consumption as much as possible across spells of unemployment. Thus, if given the choice between two UI programs that provide the same level of total benefits to the unemployed, agents would choose the program that does the best job of consumption smoothing. With this in mind, consider the following two UI programs -- the first program offers a benefit level of  $x$  for  $T$  periods while the second program offers a benefit level of  $x'$  for  $T+1$  periods where  $x' < x$  and is chosen so that the two programs provide the same level of total benefits to the unemployed. Thus, the first program offers higher benefits but for a shorter period of time. The key to the argument is to note that the second program allows for greater consumption smoothing -- in moving from the first program to the second program benefits are lowered during the least adverse states of unemployment (i.e., the initial phase) and increased in one of the most adverse states (period  $T+1$  in which no benefits are offered in the first program) with total benefits provided remaining the same. In other words, by accepting slightly decreased benefits (and consumption) during the first  $T$  periods of unemployment, the unemployed can insure that benefits will not completely disappear for an additional period. Thus, all unemployed workers prefer the second program. Since this reasoning holds for all finite  $T$ , it follows that in an optimal UI

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<sup>2</sup> See Davidson and Woodbury (1995b) for details.



program T must equal infinity.

This result has important implications for some of the work reviewed in section 2. Most importantly, this result implies that the conclusions reached by Baily and Flemming are misleading. Since both authors use models in which it is assumed that benefits are offered indefinitely and since, in their models it is indeed optimal to provide benefits indefinitely, the optimal replacement rates that they derive are correct -- without savings, the optimal replacement rate is in the 60-70% range, and, with savings but imperfect capital markets, the optimal replacement rate is in the 40-50% range<sup>3</sup>. However, these rates are optimal only if they are offered indefinitely. Thus, the conclusion that Baily and Flemming reach, that the U.S.'s 50% replacement rate is probably too high, is misguided, since the U.S. offers this rate for only 26 weeks. In fact, if we solve for the optimal replacement rate with T set exogenously at 26 weeks, we find that the optimal replacement rate is 1! It follows that if one ignores the job destruction effect of UI, the current U.S. unemployment insurance program is not generous enough.

It is important, however, not to place too much emphasis on this result. That is, we must remember the setting in which it was derived -- it was derived in a model in which the job destruction effects of UI were ignored. In fact, as we show below, when the job destruction effects are taken into account, this result no

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<sup>3</sup> It is important to note that our abbreviated model yields almost identical predictions concerning optimal replacement rates.

longer holds. For this reason, we do not believe that an optimal UI program would indeed be characterized by an unlimited potential duration of benefits. However, what this result does indicate is that an optimal UI program is more likely to be characterized by low benefits and a long potential duration of benefits than a program with high benefits and a short potential duration of benefits (as in the U.S.). The intuition behind this result is clear -- programs with long potential durations of benefits lead to smoother consumption paths and therefore reduce the risk associated with unemployment more than programs with shorter potential durations.

#### B. Optimal Replacement Rates with UI-Ineligibles in the Model

Our second extension of the Baily and Flemming analyses was to explicitly take into account the fact that not all unemployed workers are eligible to collect UI. For example, for the U.S. Blank and Card (1991) report that over 50% of the unemployed are ineligible for UI and that of those who are eligible, only 75% bother to file for their benefits. Layard et al (1991) report that in the U.K. up to 30% of the unemployed are not eligible to collect UI benefits. This fact has important implications for the optimal replacement rate since more generous UI has positive spill-over effects on UI-ineligibles. The reasoning is as follows. If the government institutes a more generous UI program, UI-eligibles respond by searching less hard for employment. Assuming that UI-eligible and UI-ineligibles compete for some of the same jobs, this

reduces the competition that UI-ineligibles face for those jobs and increases their reemployment probabilities. The existence of these positive spill-over effects implies that models that ignore the fact that not all unemployed workers are eligible to collect UI will underestimate the optimal replacement rate. Thus, Baily and Flemming's estimates of the optimal replacement rate are biased downwards.

To determine the optimal replacement rate when these positive spill-over effects are present, we extended the abbreviated model of sections 3.A and 3.B to allow for UI-ineligibility. Briefly, UI-ineligibles were modelled in exactly the same manner as other workers except that they were not allowed to collect UI while unemployed. For example, an equation almost exactly identical to (2) and (3) was used to define the expected lifetime utility for an unemployed UI-ineligible worker, and an equation almost identical to (1) was used to define the expected lifetime utility for an employed UI-ineligible worker. To be precise, let  $V_i$  represent the expected lifetime utility for an unemployed UI-ineligible worker, let  $V_{wi}$  denote the expected lifetime utility for an employed UI-ineligible worker, and use the sub-script  $i$  on all other variables to denote UI-ineligibility. Then, we can apply the same logic used to derive (1)-(3) to obtain:

$$(23) \quad V_{wi} = u[w(1-\tau) + \theta_w] + [sV_i + (1-s)V_{wi}]/(1+r)$$

$$(24) \quad V_i = u[\theta_u] - c(p_i) + [m_i V_{wi} + (1-m_i)V_i]/(1+r).$$

Optimal search effort for UI-ineligibles is then the value of  $p_i$  that maximizes  $V_i$ :

$$(25) p_i = \arg \max V_i.$$

The remaining equations of the model can be modified in a similar fashion (interested readers are referred to Davidson and Woodbury 1995b for details) with only one new parameter added - the proportion of the unemployed who are ineligible for UI. Following Blank and Card (1991) we set this value equal to .6 for our basecase, and then vary it throughout the analysis from 0 to .6 to see how sensitive our results are to the value of the parameter.

We find, as expected, that including UI-ineligibles in the model does increase the optimal replacement rate. Depending upon the values of the other parameters (the interest rate, the separation rate, et cetera), we find that the positive spill-over effects of UI on UI-ineligibles increases the optimal replacement rate by 6 to 10 percentage points. Thus, if agents cannot save and the job destruction effects of UI are ignored, an optimal UI program offers a replacement rate in the 65-75% range indefinitely. If, on the other hand, agents can save but the job destruction effects of UI are ignored, then an optimal UI program entails the government offering replacement rates in the 45-55% range indefinitely.

This completes the description of our earlier results. Before moving on and discussing our new results, it is important to note

that all of our previous results were derived assuming that utility is linear in consumption. If we had also assumed that search costs were linear in effort, this would have been equivalent to assuming risk neutrality and there would have been no demand for employment insurance. However, since we assumed that search costs were convex in effort, each individual's optimization problem is concave in the choice variable and thus, each agent is risk averse.

To see how increasing the degree of risk aversion affects these results, we have recently recalibrated the model for two different utility functions, namely  $u[C] = \ln(C)$  and  $u[C] = \sqrt{C}$ , and rederived the optimal replacement rate in each case. The log utility function is characterized by constant Arrow-Pratt relative risk aversion equal to one and was chosen since it is identical to the one used by Baily (1978). The square root utility function is characterized by constant Arrow-Pratt relative risk aversion equal to  $1/2$  and was used since its measure of risk aversion falls midway between our other two extremes (the linear and log utility functions). Surprisingly, in this model without job destruction, we find that the degree of risk aversion does not make much difference -- optimal replacement rates rise by only about 5% when we go from the linear to the log utility function and only about 2% when we go from the linear to the square root utility function. The reason for this is that in recalibrating the model with the new utility functions, the values of the parameters change so that the model once again yields predictions that are consistent with the Illinois data. For example, as we make the agents in the model more

risk averse, the degree of convexity of the search cost function must also increase so that the model still yields the same predictions concerning a reemployment bonus. Since we recalibrate the model for each utility function so that the reemployment bonus impact is identical across the models, it is not surprising that the models yield similar predictions concerning UI.<sup>4</sup>

In summary, our earlier work focused on two shortcomings of the Baily and Flemming approaches -- the fact that they simply assumed that UI benefits would be offered indefinitely and the fact that they assumed that all agents are eligible for UI. We demonstrated that both of these assumptions bias their results in favor of less generous UI programs and led them to draw misleading conclusions. However, as we have emphasized above, these are not the only two shortcomings of the Baily and Flemming analyses -- they also ignored the impact of UI on firm behavior. In the next sub-section we discuss how extending the model to allow for the job destruction effects of UI forces us to further modify our conclusions concerning an optimal UI program.

### C. Job Destruction and Risk Aversion

When firm behavior is endogenized, there are several additional effects of UI. First, if a more generous UI program is

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<sup>4</sup> When we calibrate the model for the square root utility function we obtain the following values for the key parameters --  
c =      , z =      , R =      , K =      .

offered, the average expected lifetime income for the unemployed ( $V_u$ ) rises and this triggers an increase in the equilibrium wage. This higher wage lowers profit for producing firms ( $\Pi_f$ ) and lowers the expected lifetime profit for a firm creating a vacancy ( $\Pi_v$ ). This results in fewer firms ( $F$ ) and fewer job opportunities. In terms of welfare, per period income for the employed could rise or fall (since the wage is increasing while non-labor income from firms is falling) while unemployment unambiguously rises due to the job destruction effect. Thus, in a model with endogenous labor demand the optimal UI program is likely to be less generous than the optimal UI program in a model in which firm behavior is ignored, and the size of the job destruction effect determines just how much less generous it will be.

Our results indicate that, regardless of the degree of risk aversion, the job destruction effect is large enough to overturn the result that it is optimal to offer UI benefits indefinitely. To see why, return to our earlier argument concerning the potential duration of benefits. We argued that for any UI program in which  $T$  were finite there would exist another UI program with longer potential duration of benefits and lower benefits that would cost the same to finance and would be strictly preferred by all unemployed agents. Thus, it would always be possible to increase  $T$  and raise welfare. This argument no longer holds when labor demand is endogenous since increasing  $T$  in this manner reduces the number of job opportunities and increases unemployment. This negative effect of the decrease in job opportunities must be

weighed against the positive impact of smoothing consumption to determine if the increase in T raises welfare. We find that for all levels of risk aversion, the job destruction effect of increasing T eventually outweighs the consumption smoothing effect of increasing T so that benefits should eventually be cut-off.

The point at which the government should stop providing benefits depends heavily on the degree of risk aversion. We consider three cases. In the first, we assume that utility is linear in consumption so that the degree of risk aversion is extremely low (the reader is reminded that in this case risk aversion enters through the convexity of the search cost function). This makes our model and approach very similar to that of Mortensen (1994) and Millard and Mortensen (1994). In fact, in this case, our model yields predictions that are almost identical to those in Mortensen (1994) -- we find that the current UI program in the U.S. generates a dead weight loss of roughly 1.2% of welfare.

The fact that we obtain results that are so similar to Mortensen (1994) in spite of the fact that our models are calibrated in very different manners using different data is comforting. In addition, the reader is reminded that the abbreviated model of sub-sections 3.A-3.B yielded results remarkably similar to those found in Baily (1978) and Flemming (1978). Thus, our model seems to be able to reproduce the existing results in the literature once the assumptions are altered to match the models used by previous authors. This is true in spite of the fact that virtually all of the previous models were calibrated in



different ways using data from a wide variety of different sources.

Unlike Mortensen (1994), we go on to use our model to derive the optimal UI program when benefits are constant over the spell of unemployment. With this low level of risk aversion, we find that the optimal UI program entails no benefits at all! That is, when the degree of risk aversion is low, the job destruction effect of UI is large enough to outweigh the positive impact of even one unit of insurance. Clearly, this result depends upon the fact that when utility is linear in consumption the demand for employment insurance is relatively low.

In the second case that we consider we assume that  $U(C) = \ln(C)$  so that the Arrow-Pratt measure of relative risk aversion is constant and equal to one. This is the utility function used by Baily (1978) and is probably the utility function that is most often used in the literature on decision making under uncertainty. With these preferences, we obtain very different results. First, in stark contrast to the results obtained with linear utility, we find that the current U.S. unemployment insurance system increases welfare above the level that would be achieved without publically provided UI. Moreover, the welfare gains are far from trivial -- our estimate is that welfare rises by 1.2%.

Our second set of results concern the optimal UI program. As before, the job destruction effect overturns the result that benefits should be offered indefinitely. However, in this case, the optimal value of T remains quite large -- 90 weeks -- so that benefits should be offered for almost two full years. Thus, the

job destruction effect is not nearly as important when agents are reasonably risk averse. As for the optimal replacement rate, when agents cannot self-insure, the optimal replacement rate is 65%. With savings, this rate is likely to fall by roughly 20%. We conclude that with reasonable assumptions concerning risk aversion, the optimal UI program offers benefits slightly below 50% for almost two years. Our model predicts that instituting such a UI program would raise welfare above the level achieved with the current U.S. program by 5.5% of welfare -- a startlingly high measure for a potential welfare gain.

In the final case that we consider we assume that utility is equal to the square root of consumption. This utility function has a constant Arrow-Pratt measure of relative risk aversion equal to  $1/2$ , so that it falls mid-way between our other two utility functions. With this utility function we find that the current UI program in the US is just about right -- the optimal program involves offering a replacement rate of 61% for 26 weeks. We also find that this optimal program increases welfare above the levels that would be achieved without a UI program by about 2%.

The differences in our three sets of results indicate that the assumptions made concerning risk aversion are crucial. Thus, it is important to determine which utility function represents the most reasonable assumption concerning risk aversion. To answer this question, there are two contradictory strands of literature that we may consult. First, there is the empirical literature on consumption behavior that attempts to directly estimate agents'

degree of risk aversion (see, for example, Zeldes 1989). The work in this area seems to indicate that the best point estimate of the Arrow-Pratt measure of relative risk aversion is 2.

The other literature, which is theoretical, attempts to infer the degree of risk aversion from observed behavior. For example, we can observe how agents adjust their investment portfolios as their wealth changes and we can build models of investment under uncertainty to explain such behavior. Most work in this area finds that the theories of choice under uncertainty are consistent with observed behavior only if the Arrow-Pratt measure of relative risk aversion is less than one.

The fact that these two literatures contradict one another is troubling and leaves us in an uncomfortable position. Our work indicates that if the Arrow-Pratt measure of relative risk aversion is close to (or above) one, then the current UI program in the US is not nearly generous enough. However, if the Arrow-Pratt measure of relative risk aversion is close to  $1/2$ , then the current system is about right. If one chooses to believe the empirical literature on consumption (as we tend to do), then the former outcome is much more likely than the latter. Thus, we conclude that in the most general model with the most reasonable assumption concerning risk aversion, we find that the optimal UI program offers benefits that are close to the levels currently offered by most States in the U.S. but it offers those benefits for a considerably longer period of time -- almost two years. In other words, the current U.S. program does not offer sufficient employment insurance.

### C. Heterogeneity

All of the previous work on UI, including our own, relies on the assumption that all agents are alike. In reality, however, workers are subject to a wide variety of labor market experiences. Some workers are never unemployed, others find jobs quickly, and some always face long spells of unemployment upon losing a job. In addition, some agents may attempt to take advantage of the UI system while others would never even consider filing for benefits much less exploit the system. This implies that agents will have different preferences concerning employment insurance based on their labor market histories and expectations. Moreover, the number of workers that attempt to exploit the system may depend upon the generosity of the program.

In order to take worker heterogeneity into account, we extend our model to allow for three different classes of workers. The first class represents the bulk of the labor force and is described by the model introduced above. These workers face employment risk, losing their jobs with probability  $s$  in each period, and actively search for a new job once unemployed.

The second class consists of workers who are never unemployed. We refer to this group as "professionals" and use  $\phi$  to denote the proportion of the labor force that falls into this class. We also use  $L_p$  to denote the number of such workers and  $V_p$  to denote their expected lifetime utility. Since these workers are never unemployed, they earn  $w$  in each period of life, and thus,  $V_p = u(w)(1+r)/r$ . The total contribution of these workers to social

welfare is therefore  $L_p V_p$  and adding professionals to the model is accomplished by adding this term to  $W$  as defined in equation (4).

The last class of workers consists of agents who try to take advantage of the system. We refer to such workers as "slouchers." We assume that these agents work only to become eligible for UI and that they live off of the dole as much as possible. We use  $L_s$  to denote the number of slouchers and use  $V_s$  to represent their expected lifetime utility. Thus, their contribution to social welfare ( $W$ ) is equal to  $L_s V_s$ .

Presumably, the number of slouchers in the labor force will be a function of the generosity of the system -- a more generous UI program should result in more slouchers. To measure the generosity of the system, we introduce the following variable  $G$ :

$$G = \{u(x)/u(w)\} \{1 - (1/1+r)^{T+1}\}.$$

$G$  measures the ratio of utility received by simply collecting benefits as opposed to working for wage  $w$  during one spell of unemployment that lasts  $T$  periods (the potential duration of benefits). Note that if  $x = 0$  or  $T = 0$ , so that no UI is offered,  $G = 0$ . On the other hand, as the replacement rate approaches one and  $T$  approaches infinity,  $G$  approaches 1. Increases in  $G$  represent increases in the generosity of the UI program. We assume that  $\alpha$ , the proportion of the labor force that are slouchers, is positively related to  $G$ . In particular, we assume that  $\alpha = \eta G$ .

To complete the extended model, we must describe the determination of  $\eta$  and  $V_s$ . Consider  $V_s$  first. We assume that,

since these agents work as little as possible, they contribute less to social welfare than the average unemployed agent (who, after all, is at least seeking a job). Thus, since  $V_u$  is the average expected lifetime utility for unemployed workers, we set  $V_s = \Omega V_u$  with  $\Omega < 1$ . We then vary  $\Omega$  and see how this affects the optimal UI program.

For  $\eta$ , we solve the model under the assumption that the current US program is in effect (a 50% replacement rate offered for 26 weeks) and then vary  $\eta$  so that  $\alpha$  ranges from 0 to .05. Thus, we consider values for  $\eta$  that imply that currently anywhere from 0% to 5% of the labor force is exploiting the system.

Our results for the square-root utility function are summarized in Tables 1 and 2 where we report the optimal UI program for various values of  $\alpha$ ,  $\Omega$ , and  $\phi$ . In each cell, the optimal UI program is reported by first listing the optimal replacement rate and then listing the optimal potential duration of benefits. Table 1 shows how the optimal UI program varies with  $\alpha$  and  $\Omega$  when there are no professionals in the model (i.e.,  $\phi = 0$ ). If  $\alpha = 0$ , so that there are no slouchers in the model, the optimal program offers a 61% replacement rate for 26 weeks. As the number of slouchers increases, the generosity of the optimal program declines regardless of the value of  $\Omega$ . This is hardly surprising -- with more slouchers in the economy the government needs to make the program less generous in order to discourage the exploitation of the system.

Table 1 also indicates that the generosity of the optimal

program is decreasing in  $\Omega$ , the parameter that measures the amount that slouchers contribute to social welfare. As  $\Omega$  decreases, slouchers contribute less to social welfare and it becomes more important for the government to discourage slouching. Table 1 clearly indicates the importance of the actual values of  $\alpha$  and  $\Omega$ . If  $\alpha$  is low or if  $\Omega$  is close to one, then the optimal program is quite close to the optimal program in the model that ignores slouching. On the other hand, for large values of  $\alpha$  and low values of  $\Omega$  (e.g.,  $\alpha = .05$  and  $\Omega = .7$ ), the optimal program is considerably less generous.

Table 2 reports the optimal UI program when both slouchers and professionals are included in the model. These results are derived assuming that utility is equal to the square-root of consumption and that  $\Omega = .8$  (as in the middle row of Table 1). Table 2 indicates that as the number of professionals increases the optimal program becomes more generous. The reasoning is as follows. Adding professionals to the model spreads out the tax burden that the UI system places on the employed and allows the government to afford a more generous system. As in Table 1, knowing the true value of  $\phi$  is important -- for low values of  $\alpha$ , the optimal UI program varies quite a bit with  $\phi$ . For example, when  $\alpha = 0$  the optimal UI program when 10% of the work force is made up of professionals offers a replacement rate of 64% for 28 weeks. If, on the other hand, 30% of the work force are professionals, the optimal program offers a replacement rate slightly higher (68%) but for a much longer time (36 weeks).

## 5. Discussion

In this paper we have presented a general equilibrium search model of the labor market in order to determine the optimal UI program when (a) the government can control the optimal potential duration of benefits and (b) the replacement rate must remain constant over the spell of unemployment until benefits are exhausted. We believe that our approach is superior to those that have been used in the past for a number of reasons. First, with respect to the labor economics literature, we have used an equilibrium model that allows us to measure the costs of different UI programs through their impact on search effort, job creation and unemployment. With respect to the macroeconomics literature, we have assumed that workers are risk averse so that we can measure the welfare benefits of different UI programs through the insurance that they provide against employment risk. Finally, with respect to the literature in public economics, we have adopted their approach, but offered a richer model in that (a) we have allowed the potential duration of benefits to vary, (b) we have included UI-ineligibles in the model, and (c) we have modeled firm behavior so that we could measure the job destruction effects of UI.

Our basic finding is that current benefit levels offered by most States in the U.S. are about right, but that these benefits are not offered for a long enough period of time. Thus, we conclude that the current U.S. system is not generous enough.

Our finding that the optimal UI program is characterized by fairly a low replacement rate and a very long potential duration of



benefits stands in stark contrast to most of the previous literature. However, we argue below that our results should have been expected, since they are consistent with the vast abstract literature on optimal insurance contracts in the presence of moral hazard. In the next sub-section we offer a brief review of this literature for two purposes. First, reviewing this literature allows us to view the UI issue from a different perspective -- one that makes the economic sense behind our results seem almost transparent. Second, the results in this literature suggest that there may be another slightly more complex UI program that is radically different from the current program and possibly superior to the one that we have proposed.

#### . The Optimal Insurance Literature

There are three issues that have been addressed in the abstract literature on optimal insurance contracts that have important implications for the design of an optimal UI program. The first issue concerns the design of an optimal insurance contract when the insured agent's behavior can effect the probability of a loss occurring (i.e., moral hazard is present). To investigate this issue, it is assumed that the agent's behavior cannot be observed by the insurance provider so that the contract must be structured in a manner that makes putting forth effort optimal for the agent. The key issue then is how to provide adequate insurance without reducing the agent's incentive to avoid the loss. Shavell (1979) is perhaps the best known work in this

area.

The second issue concerns the optimal way to share risk between a risk neutral insurance provider and a risk averse agent when the total level of insurance coverage is fixed. Although the article actually addresses a host of other issues as well, Raviv (1979) provides the classic treatment of this issue.

The final issue concerns the design of insurance contracts in the presence of adverse selection -- a situation in which agents differ in a dimension that affects their need for insurance but is unobservable to the insurance providers. The main issue in this case is to devise insurance contracts that will lead agents to self-select into groups and therefore reveal their personal characteristics. The classic article in this area is Rothschild and Stiglitz (1976).

The remarkable thing about these three strands of literature is that in spite of the fact that they ask different questions, they all come up with the same answer -- in all three cases, the optimal insurance contract takes the form of a "deductible policy" in which coverage is not provided for losses below a certain level. The reasoning is as follows. When agents face uncertainty in income they would like to smooth income as much as possible by purchasing insurance. In fact, in the absence of moral hazard concerns, the optimal insurance contract in a competitive insurance market provides full coverage so that income is the same in all circumstances. However, when moral hazard is present, the market breaks down when full insurance is provided since, in that case, no

agent would have any incentive to take care in order to avoid large losses. With no one taking care, large losses would occur and insurance providers would go broke compensating the insured. Thus, given that full insurance will not be provided, what type of insurance is best? To answer this, note that agents are most concerned about avoiding catastrophes -- that is, extremely large losses. It follows that the outcomes that they are most concerned about being insured against are the most adverse outcomes, and any optimal insurance contract will have to provide coverage in such cases. The insurance contract must also provide incentives to take care to avoid losses, and this is provided by not covering small losses -- there is a deductible that the insured agent must cover any time that a loss occurs. In summary, a deductible contract forces agents to cover all small losses and provides coverage against large losses. It is optimal since it provides coverage in the cases that agents are most concerned about and includes incentives for agents to put forth effort to avoid losses.

What are the implications for unemployment insurance? For unemployed workers, large losses occur when they suffer long spells of unemployment. Thus, an optimal UI program should provide compensation to those who have a particularly difficult time finding reemployment. This is why we find that a long potential duration of benefits is optimal. As for the deductible, we have ruled them out by requiring the replacement rate to remain constant over the spell of unemployment until benefits are exhausted. Therefore, the only way to force agents to search for employment is

to keep the replacement rate relatively low. This explains why we find optimal replacement rates at or below the current rates offered in the U.S..

The results from the optimal insurance literature also imply that the current UI program in the U.S. is exactly the opposite of what it should be. By offering benefits for the first 26 weeks of unemployment, the government is covering all short spells of unemployment and thus, all small losses. In addition, by cutting off benefits after 26 weeks the government is not providing coverage in the most important cases -- ones in which agents suffer large losses due to long spells of unemployment.

Is there any way to design a UI program with a deductible? One simple way to do so would be to use a three stage program in which the government offers very low (or zero) benefits during the first stage of unemployment, followed by a higher replacement in the second stage that lasts for a considerable length of time, followed by no benefits in the final stage. For example, the replacement rate could be 25% for the first 26 weeks of unemployment, followed by 60% for weeks 27 through 90, followed by zero thereafter. Such a program would provide a strong incentive for unemployed workers to find rapid reemployment since they would be receiving very little from the government early on. However, in the unfortunate cases in which workers are unable to find new jobs quickly, the government would step in and provide help when it is most needed.

This type of program would also carry with it at least two

additional benefits. First, it would end the government subsidization of temporary layoffs by firms. For quite some time economists have argued that since UI is not completely experienced rated, firms have an incentive to exploit the system by temporarily laying off workers and then recalling them as their benefits expire. Some authors have estimated that as many as 25-50% of all layoffs in the U.S. can be explained in this manner (see, for example, Anderson and Meyer 1995 or Topel ). However, if laid-off workers receive little or no benefits during the initial stages of unemployment, they would have an incentive to move on and seek new jobs rather than wait for recall. And, if workers are unwilling to wait for the firm to recall them, then the firms will be less likely to lay them off initially.

The second benefit of such a program is that it would discourage those who attempt to exploit the system (slouchers). With a substantial waiting period before UI begins or low replacement rates during the initial stages of unemployment, agents who would like to live off of the dole would have to pay a substantial penalty in order to collect the higher replacement rates that would be offered to the long term unemployed. Therefore, such a program should substantially reduce the number of slouchers in the system.

At this point it is useful to emphasize that previous results have hinted that such a "deductible" program might be more efficient than current UI programs. Figure 1, which shows the conjectured optimal benefit path when agents can save and affect

their probability of reemployment has this flavor -- benefits are initially low to encourage search and then rise as savings are depleted in order to allow workers to smooth consumption. O'Leary's (1994) empirical results that short spells of unemployment are currently over compensated while long spells are under compensated is also consistent with this type of policy shift. Finally, Wang and Williamson (1995) have argued for a benefit path similar to the one depicted in Figure 1 along with reemployment bonuses as part of an optimal UI program.

The results of Wang and Williamson (1995) are especially worthy of review, given their similarity to ours. In their paper, they solve for the optimal benefit path and consumption stream when agents face randomness in employment. Thus, they allow the government to subsidize or tax movements into various labor market states (by choosing consumption) in addition to setting the benefit path. As noted above, they do not model firms and therefore do not capture the job destruction effects of UI. Nevertheless, their results have the same flavor as ours. Our Figures 2 and 3 are (slightly modified) reproductions of Figures 17 and 21 from their paper. Figure 2 shows the optimal benefit path as a function of the length of the spell of unemployment with one unit of time equally one quarter of a year. Note the non-monotonicity of the benefit path -- benefits are lower in the first quarter than the second quarter. In addition, note the generosity of the system -- the replacement rate remains above 50% for over 5 quarters!

Figure 3 shows consumption across the spell of employment. It

is important to note that consumption in the first period after reemployment is much higher than it is in all subsequent periods -- there is a reemployment bonus. This bonus provides workers with an extra incentive to seek reemployment in the early stages of unemployment by rewarding those who find new jobs. Without such a bonus, the deductible that workers would have to pay in the first period of unemployment (as represented by the low replacement rate in the first quarter of unemployment) would be higher (so that the replacement rate in the first quarter would be lower).

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Replacement  
Rate

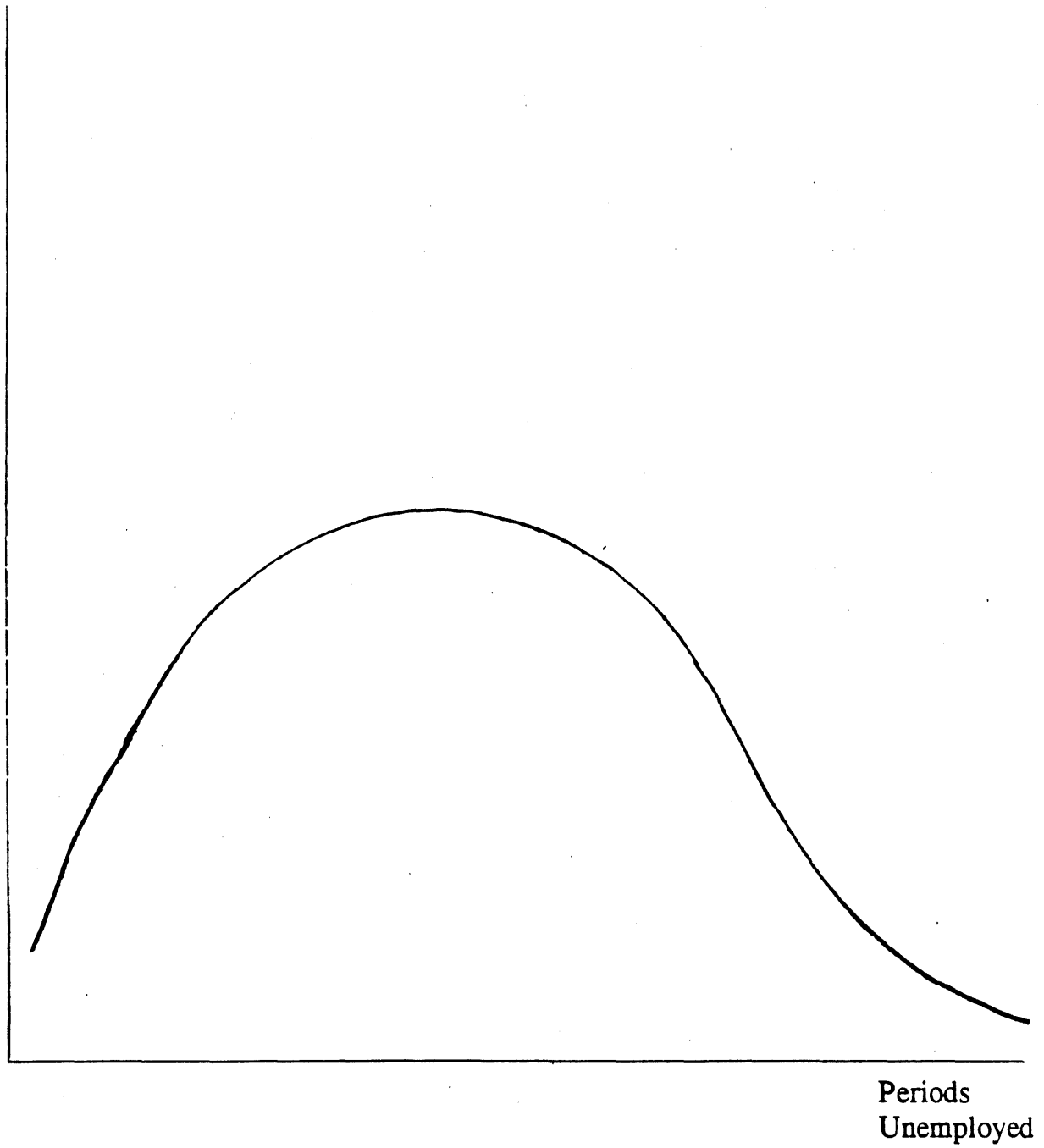


Figure 1

Replacement  
Rate

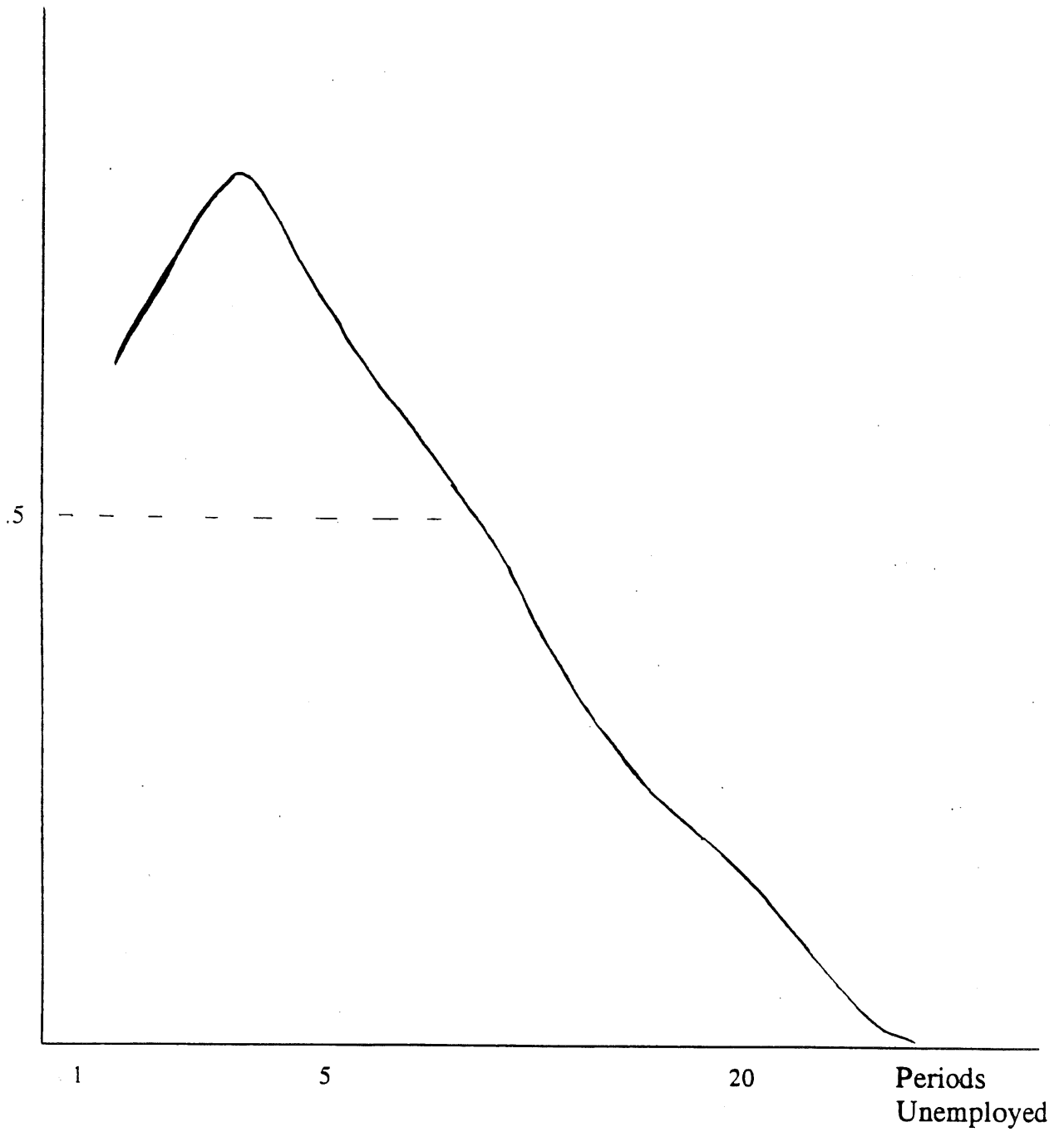


Figure 2

Consumption

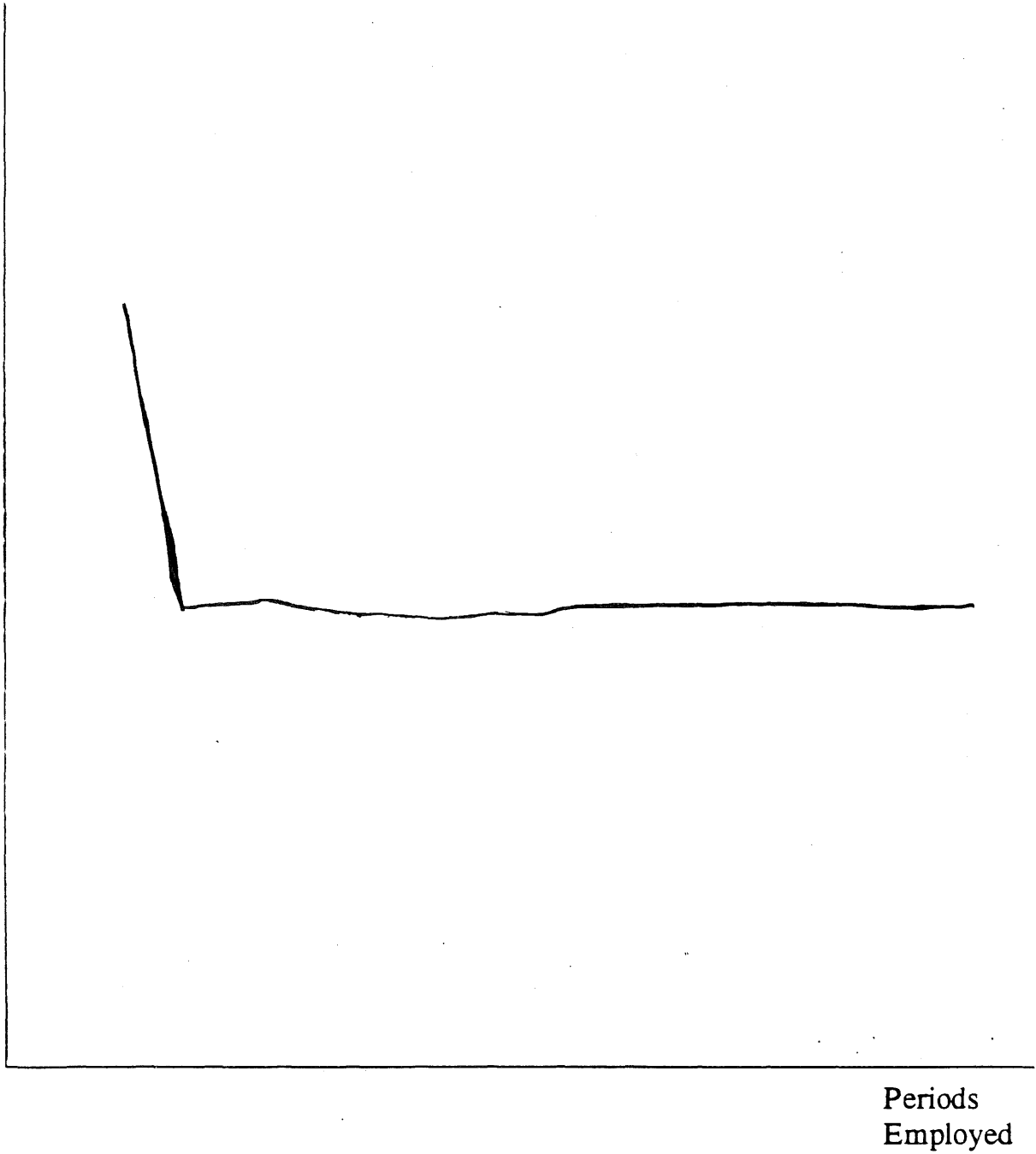


Figure 3

| $\alpha$ | 0         | .01       | .02       | .05       |
|----------|-----------|-----------|-----------|-----------|
| $\Omega$ |           |           |           |           |
| .9       | (61%, 26) | (59%, 24) | (56%, 22) | (48%, 16) |
| .8       | (61%, 26) | (60%, 22) | (55%, 20) | (42%, 14) |
| .7       | (61%, 26) | (58%, 22) | (54%, 18) | (36%, 12) |

Table 1  
 Optimal UI Programs with Slouchers but No Professionals  
 Square-root Utility

| $\alpha$ | 0         | .01       | .02       | .05       |
|----------|-----------|-----------|-----------|-----------|
| $\phi$   |           |           |           |           |
| 0        | (61%, 26) | (60%, 22) | (55%, 20) | (42%, 14) |
| .1       | (64%, 28) | (60%, 26) | (57%, 22) | (45%, 14) |
| .2       | (66%, 32) | (63%, 28) | (61%, 24) | (47%, 16) |
| .3       | (68%, 36) | (67%, 32) | (64%, 28) | (51%, 18) |

Table 2

Optimal UI Programs with Professionals and Slouchers

Square-root Utility

$\Omega = .8$  in all cells