

**THE ROLE OF UNEMPLOYMENT INSURANCE IN AN  
ECONOMY WITH LIQUIDITY CONSTRAINTS  
AND MORAL HAZARD**

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## Abstract

A dynamic general equilibrium economy is used to compute the potential welfare benefits that can be obtained from unemployment insurance, along with the optimal replacement ratio. In order to obtain an upper bound on these welfare benefits, we assume that agents face exogenous idiosyncratic employment shocks and are unable to borrow or insure themselves through private markets. In the absence of moral hazard, replacement ratios as high as .7 are optimal, and the welfare benefits of unemployment insurance are quite large. However, even under these extreme assumptions, if there is a moderate amount of moral hazard, the potential welfare benefits disappear.

## 1. Introduction

Over the postwar period, unemployment insurance (UI) programs in the U.S. have expanded quite dramatically. The fraction of employed individuals covered by these programs has increased from 58 percent in 1950 to over 90 percent during the 1980's.<sup>1</sup> In addition, it has been estimated that an unemployed worker receiving benefits will collect, on average, payments equal to two-thirds of his after tax income.<sup>2</sup> Not surprisingly, along with the expansion of UI programs, a large literature has appeared examining the effects of UI on the incidence and duration of unemployment.<sup>3</sup> What is surprising, however, is that relatively little effort has been devoted to studying the effect of UI programs on social welfare and determining how much UI, if any, is optimal. In this paper we focus on these issues by studying the role of UI in a particular dynamic equilibrium economy.

We have chosen to study an economy in which the potential benefits derived from UI are extreme. From a quantitative analysis of this model, we hope to obtain an upper bound on the welfare benefits that could possibly be obtained from UI programs in an actual economy. That is, we consider an

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<sup>1</sup> Economic Report of the President 1984 and 1988.

<sup>2</sup> See Clark and Summers (1982).

<sup>3</sup> Some examples are as follows: Hamermesh (1979) and Welch (1977) provide surveys of work that measures the extent to which UI increases the duration of unemployment. The theory motivating this work is the classic result from search theory that an increase in UI will cause workers to increase their reservation wages and search longer (standard references include Ehrenburg and Oaxaca (1976) and Mortensen (1977)). In addition, UI may make workers search less intensively. Feldstein (1978), Topel (1983) and Burdett and Wright (1989) examine the role of UI in increasing the rate of temporary layoff unemployment. This work is based on the argument that if UI is not fully experience rated (that is, firms are not fully liable for the UI paid to its workers), firms will be more likely to layoff workers during bad times.

economy where individuals, although subject to idiosyncratic employment shocks, do not have access to private insurance markets, are unable to borrow, and are only able to save using a non-interest bearing asset. Given these assumptions, it is not surprising that, as long as moral hazard problems are not severe, UI can significantly improve welfare. However, we find that when even a relatively small amount of moral hazard is introduced, the potential welfare benefits of UI disappear. That is, depending on the degree of risk aversion assumed, if a relatively small fraction (15 percent) of the individuals in our economy succeed in collecting UI after having rejected an employment opportunity (quitting a job or turning down a job offer), there is essentially no welfare improvement to be enjoyed by introducing UI. We find this conclusion quite surprising given the extreme assumptions underlying the model economy.

As mentioned above, there has been relatively little attention paid to the insurance aspects of UI and therefore most of the existing literature does not address the question of how much UI is optimal, or even whether UI is welfare improving at all. There are, however, some notable exceptions. Bailey (1977) presents a model of UI as insurance to workers and provides results concerning how much insurance should be provided, and in what form. Flemming (1978) studies how the optimal amount of UI is affected by the degree of completeness of capital markets. In addition, the extent to which UI programs are experience rated affects the optimal amount of UI, and this is studied in Mortensen (1983). Hamermesh (1982) presents empirical evidence on whether existing levels of UI are sufficient to enable individuals to overcome binding liquidity constraints when unemployed. Easley, Kiefer and Posson (1985) present a theoretical model designed to compare the potential welfare benefits from an UI program versus a negative income tax program. Finally,

Wright(1986) studies an economy with liquidity constrained workers, and derives the unemployment insurance system endogenously as a majority voting equilibrium policy.

The approach taken in this paper differs from most of these previous studies in that we employ a dynamic general equilibrium model to address these issues. This has the advantage of enabling us to simultaneously study the following effects of UI programs on equilibrium allocations and welfare: 1) the fact that UI helps agents to overcome liquidity constraints so that they can more effectively smooth consumption; 2) the fact that UI subsidizes leisure so that, in the presence of moral hazard, an agent's incentive to work is reduced; and 3) the fact that the taxes used to finance the UI program also distort allocations.

The model economy described in this paper, which is similar to the one studied in Imrohoroglu (1989b), consists of a continuum of infinitely lived agents with identical preferences defined over consumption and leisure. The agents are offered employment opportunities according to a known stochastic process. Agents who are offered the opportunity to work can choose to accept or reject the offer. Labor is assumed to be indivisible, so an agent who accepts an offer must work some exogenously given number of hours. An agent who rejects an offer will not work and, as long as there is no moral hazard, receives no UI. Consumption must be financed with savings in the form of a non-interest bearing asset. Thus, at a given point in time, agents will differ with respect to their asset holdings and employment status. We also assume a linear technology that is not subject to any stochastic shocks. Thus, the wage received by an employed worker does not change over time--the

employment opportunity is the only source of uncertainty in the model.<sup>4</sup> There is no aggregate uncertainty.

The welfare benefits that can be obtained from introducing UI in this economy without moral hazard turn out to be quite large. In fact, if agents are sufficiently risk averse, it is possible for UI to make them as well off as they would be given the Pareto Optimal allocation. In order to study how this result is affected by moral hazard, we allow for a positive probability that an agent can reject an employment opportunity and still collect UI. The agent knows at the time he makes his decision what this probability is, but he does not know whether he will personally receive UI or not. In this case, UI would provide an incentive for households to reject employment opportunities and less than the socially optimal amount of employment will result. By varying this probability, we are able to vary the degree of moral hazard in the economy.<sup>5</sup>

For different degrees of moral hazard, we analyze the effect UI has on the equilibrium employment rate, average consumption, the variability of consumption over time, average asset holdings and average utility. In particular, we analyze how moral hazard affects the optimal replacement ratio and the potential welfare benefits that can be obtained from UI.<sup>6</sup> We measure

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<sup>4</sup> We have deliberately abstracted from distortions present in search models in order to obtain an upper bound to the potential welfare benefits that can be obtained from UI. As explained in footnote 3, in search models UI may distort the decision of how intensively to search as well as the decision of when to stop searching and accept a job.

<sup>5</sup> This approach is an alternative to that taken by Mortensen (1983) who varies the level of moral hazard by changing the degree to which UI is experience rated. Our approach is analogous to adjusting the degree of enforcement of the requirement that someone must be available and actively seeking work in order to collect UI.

<sup>6</sup> The "replacement ratio" is the fraction of after tax labor income that is provided by UI when an agent is unemployed.

these welfare benefits by computing (in a way to be made precise in Section 4) how close UI can bring average utility to the level enjoyed under the optimal allocation that would be chosen by a social planner. In addition, we examine how these conclusions are affected by the degree of risk aversion assumed.

The paper is organized as follows: The second section is a description of the structure of the model and provides a definition of competitive equilibrium. The social planning problem that gives the optimal allocation is also described. The third section is an explanation of how the model is calibrated and how equilibrium allocations are obtained. We obtain equilibria using the same method as Imrohoroglu (1989a,b) by discretizing the state space and using numerical methods to calculate equilibrium decision rules. The statistical properties of the equilibrium stochastic process for each example are computed and examined. These results are presented in Section four and, in addition, we discuss the ways in which our particular assumptions might have biased the results. In Section 5, we provide concluding comments.

## 2. Structure of the Economy

The economy consists of a continuum of ex ante identical individuals who maximize:

$$(2.1) \quad E \sum_{t=0}^{\infty} \beta^t U(c_t, l_t)$$

where  $0 < \beta < 1$  is their subjective time discount factor,  $c_t$  is their consumption in period  $t$  and  $l_t$  is their leisure in period  $t$ . The utility function is assumed to have the following form:

$$(2.2) \quad U(c_t, l_t) = \frac{(c_t^{1-\sigma} l_t^{\sigma})^{1-\rho} - 1}{1-\rho}$$

Agents are endowed with one unit of time in each period that can be allocated to work or leisure. However, labor is assumed to be indivisible, which means that an agent can choose to work some given number of hours,  $0 < \hat{h} < 1$ , or not at all. An employed agent is assumed to produce  $y$  units of the consumption good. Thus, the technology is a linear function of the number of workers.

In addition, the employment decision is contingent upon an individual specific stochastic employment opportunity that an agent faces each period. The employment opportunities state,  $s$ , is assumed to follow a 2-state Markov chain. If  $s=e$ , the agent is given the opportunity to work and can choose to work either  $\hat{h}$  hours or not at all. If  $s=u$ , the agent is not given the opportunity to work and has to be unemployed. The transition function for the employment opportunities state is given by the 2x2 matrix  $\chi = [\chi_{ij}]$ ,  $i, j \in \{e, u\}$ , where, for example,  $\Pr\{s_{t+1}=e | s_t=u\} = \chi_{12}$  is the probability of being given the employment opportunity in  $t+1$  conditioned on not having been given the employment opportunity in period  $t$ .

The market structure in this economy is one in which individuals are unable to borrow and have no access to private insurance markets. They are able to accumulate a non-interest bearing asset, call it money, to help smooth consumption across time. Letting  $m_t$  be an agent's real money holdings at the beginning of period  $t$ , an individual's money holdings evolve through time according to:<sup>7</sup>

$$(2.3) \quad m_{t+1} = m_t + y_t^d(s_t, \ell_t, \mu_t) - c_t,$$

where  $y_t^d$  is disposable income in period  $t$ . An agent's disposable income is

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<sup>7</sup> The money supply in this economy is assumed to be constant and there are no aggregate shocks, so the price level is also constant.

affected by the variable  $\mu_t$ , which is equal to one when an agent receives UI and is equal to zero when an agent does not receive UI. Since borrowing is not allowed,  $m_{t+1}$  is required to be nonnegative.

In any given period, depending on their asset positions and employment opportunities, agents will divide themselves into three categories: those who are employed ( $s=e, l=1-\hat{h}$ ), those who do not have the employment opportunity ( $s=u, l=1$ ) and those who have the employment opportunity but choose to reject it ( $s=e, l=1$ ). In addition, unemployment insurance equal to  $\theta y$ , where  $\theta$  is the "replacement ratio," is received by all agents who are not offered an employment opportunity ( $s=u$ ). Hence the indicator  $\mu$  is equal to one for these agents. An employed agent receives no UI ( $\mu=0$ ), and an agent that rejects an employment opportunity receives UI with probability  $\pi$ . That is, after an agent rejects an employment opportunity, with probability  $\pi$  the indicator  $\mu$  will equal one and with probability  $(1-\pi)$  the indicator  $\mu$  will equal zero. The probability  $\pi$  determines the degree of moral hazard associated with a particular UI program.<sup>8</sup>

To finance this UI program, we assume the existence of a government that taxes income. In particular, the government chooses a tax rate,  $\tau$ , so that the government budget constraint is satisfied with equality. That is,  $\tau$  is set so that total tax revenue equals total UI payments. Under these assumptions, the amount of disposable income received by a given agent is the following:

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<sup>8</sup> This feature can be interpreted in the following way: Every individual that doesn't work, for whatever reason, applies for UI. However, the government audits a certain fraction of the applications and when it discovers a person who has rejected an employment opportunity, it rejects that person's application. However, since the government only audits a portion of the applications, a fraction  $\pi$  of the undeserving applicants successfully beat the system.

$$(2.4) \quad y_t^d(s, \ell, \mu) = \begin{cases} (1-\tau)y & \text{when } s = e \text{ and } \ell = 1 - \hat{h} \\ (1-\tau)\theta y & \text{when } s = u \\ (1-\tau)\theta y & \text{when } s = e, \ell = 1 \text{ and } \mu = 1 \\ 0 & \text{when } s = e, \ell = 1 \text{ and } \mu = 0 \end{cases}$$

Each period, given their current money holdings and employment opportunity  $(m, s)$ , the individuals in the economy first choose leisure. Second, the agents that reject an employment opportunity find out whether they receive UI (that is,  $\mu_t$  is revealed), and given this they choose money holdings (and consumption) subject to (2.3) and the non-negativity constraint on asset holdings. The remaining agents, those that accept employment opportunities or those who are not offered one, choose money holdings without having to wait for any uncertainty to be resolved. Therefore, the maximization problem faced by an agent at the beginning of a period is represented by the following dynamic programming problem:

$$(2.5) \quad V(m, s) = \begin{cases} \max_{m'} \left\{ U(m+(1-\tau)\theta y - m', 1) + \beta \sum_s \chi(u, s') V(m', s') \right\}, & s = u \\ \max_{\ell} \left\{ \max_{m'} \left\{ U(m+(1-\tau)y - m', 1 - \hat{h}) + \beta \sum_s \chi(e, s') V(m', s') \right\}, \right. \\ \quad \pi \left[ \max_{m'} \left\{ U(m+(1-\tau)\theta y - m', 1) + \beta \sum_s \chi(e, s') V(m', s') \right\} \right] \\ \quad \left. + (1-\pi) \left[ \max_{m'} \left\{ U(m - m', 1) + \beta \sum_s \chi(e, s') V(m', s') \right\} \right] \right\}, & s = e \end{cases}$$

subject to  $m' \geq 0$ .

A Stationary Competitive Equilibrium for this economy consists of a set of decision rules  $c(x)$ ,  $\ell(m, s)$ ,  $m'(x)$  (for consumption, leisure and next period money holdings), where  $x = (m, s, \mu)$ , an invariant distribution  $\lambda(x)$ , that is a measure of agents of type  $x$ , and a tax rate  $\tau$  such that:

- a) Given the tax rate  $\tau$ , the households' decision rules solves (2.5).

b) The goods market clears. That is,

$$(2.6) \quad \sum_x \lambda(x)c(x) = \sum_x \lambda(x)I_\ell(x)y \quad , \quad \text{where}$$

$$I_\ell(x) = \begin{cases} 1 & \text{if } \ell(x) = 1 - \hat{h} \\ 0 & \text{if } \ell(x) = 1 \end{cases}$$

c) The government budget constraint is satisfied. That is,

$$(2.7) \quad \sum_m \left[ (\lambda(m,e,1) + \lambda(m,u,1))(1-\tau)\theta y - \lambda(m,e,0)I_\ell(m,e,0)y \tau \right] = 0$$

## 2.1 Optimal Allocations

In this paper we are primarily interested in studying the competitive equilibrium of the above economy. However, for computing welfare costs, we also consider the optimal allocation that solves a social planner's problem. The welfare measure we use in Section 4 evaluates the gap between the equilibrium allocation and this optimal allocation. In particular, we measure how well, in terms of welfare, the government in the above economy is able to approximate the optimal allocation by choosing the level of UI.

The optimal allocation is given by the solution to the following optimization problem:

$$(2.8) \quad \text{Max} \quad \sum_{t=0}^{\infty} \beta^t \left\{ \eta_t U(c_{1t}, 1-\hat{h}) + (1-\eta_t) U(c_{2t}, 1) \right\}$$

subject to

$$\eta_t c_{1t} + (1-\eta_t)c_{2t} \leq \eta_t y$$

$$\eta_t \leq \bar{\eta}$$

In this problem,  $\eta_t$  is the employment rate in period  $t$ ,  $c_{1t}$  is the consumption of an employed agent and  $c_{2t}$  the consumption of an unemployed agent in period  $t$ . In addition,  $\bar{\eta}$  is the upper bound on the employment rate

implied by the transitions probabilities ( $\chi$ ) governing the employment opportunity state,  $s$ . Since there is no uncertainty or dynamic linkages in this problem, the solution turns out to be constant over time. In particular, the interior solution is

$$(2.9) \quad c_{2t}/c_{1t} = a \quad , \quad c_{1t} = \left[ (1-a)(1-((1-\rho)(1-\sigma))^{-1}) \right]^{-1}$$

$$\eta_t = (1-\rho)(1-\sigma)/(1-a^{-1}) \quad , \quad \text{where } a = (1-\hat{h})^{\sigma(1-\rho)/((1-\sigma)(1-\rho)-1)}$$

This allocation can be supported as a competitive equilibrium for an economy where agents trade employment lotteries rather than hours worked as in Rogerson (1988) and Hansen (1985).

### 3. Computation of the Equilibrium

In this section we specify the parameter values used for our experiments and describe the method used for obtaining an equilibrium. We calibrate the economy so that the time period is equal to six weeks and normalize the output produced by an employed agent to be one ( $y = 1$ ). Many of our parameter values are taken from Kydland and Prescott (1982). This leads us to set  $\beta = .995$  (which implies an annual discount rate of 4%) and  $\sigma = .67$ . We set  $\hat{h}$  by assuming that when people choose to be employed, they allocate 45 percent of their time to work ( $\hat{h} = .45$ ). As for the degree of risk aversion ( $\rho$ ), Mehra and Prescott (1985) cite various empirical studies that provide support for a value of  $\rho$  between one and two. Bailey (1977), who studies similar issues as in this paper, argues for setting  $\rho$  equal to one. We have chosen to set  $\rho$  equal to 1.5 as our standard case. However, we found that our results were quite sensitive to the degree of risk aversion, as one might expect when studying optimal insurance issues. Therefore, we also consider results

obtained with higher degrees of risk aversion ( $\rho$  equal to 3 and 5).

The transition probabilities,  $\chi_{ss'}$ , are chosen so that the employment opportunity is offered 92% of the time, and the average duration of not having the employment opportunity is equal to two periods (twelve weeks).<sup>9</sup> The first requirement implies that the upper bound on the employment rate,  $\bar{\eta}$ , is equal to .92. Both these requirements imply that the transition probabilities matrix for the employment opportunities state (s) is:

$$\chi = \begin{bmatrix} .9565 & .0435 \\ .5000 & .5000 \end{bmatrix}$$

The decision rules for these economies are computed by using numerical methods to solve the functional equation (2.5) (see Imrohorglu (1989a) for additional details). The first step is to discretize the state space and the control space. The maximum level of money holdings that an agent is permitted to hold is assumed to be 8, which is a little more than average annual per capita income if an agent is continuously employed for a year. It turns out that in equilibrium this constraint is not binding. Given this limit on money holdings, a grid of 301 points with increments of 0.027 are utilized. Since the employment opportunities state takes only two values, the total number of possible states is 301x2. At each point in time, the number of possible outcomes is also 301x2, the number of choices for money holdings times the number of choices for leisure.

The optimal value function and decision rules for this finite state

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<sup>9</sup> This assumption implies that the fraction of individuals not working is at least eight percent. This number is higher than the average unemployment rate reported by the BLS since, in our model, this includes both workers who are unemployed (as the BLS defines the term) as well as individuals who temporarily leave the labor force.

discounted dynamic programming problem are obtained by successive approximations. This very standard approach involves starting with an initial approximation,  $V_0(m,s)$ , and obtaining the next approximation by computing the right side of (2.5) using this initial approximation. This process is continued until the sequence of value functions so obtained converges.

Given the ergodicity of the state transition function implied by the equilibrium decision rules, there exists a unique invariant distribution,  $\lambda(x)$ , for the equilibrium Markov process.<sup>10</sup> For these economies, since there is no aggregate uncertainty, this invariant distribution is the distribution of people indexed by their money holdings, employment opportunities and whether or not they receive UI at a given point in time. This distribution also specifies the fraction of the time a particular individual is in these various states over an infinite lifetime.

To compute this invariant distribution, we begin with an initial guess,  $\lambda_0(x)$ , and iterate on the following mapping:

$$(3.1) \quad \lambda_{t+1}(m',s',\mu') = \begin{cases} 0 & \text{if } s'=u, \mu'=0 \\ \sum_s \sum_\mu \sum_{m \in \Omega(m',s,\mu)} \chi(s,s') \lambda_t(m,s,\mu) & \text{if } s'=u, \mu'=1 \\ \sum_s \sum_\mu \sum_{m \in \Omega} \chi(s,s') \lambda_t(x) (I_\rho(x) + (1-\pi)(1-I_\rho(x))) & \\ \sum_s \sum_\mu \sum_{m \in \Omega} \chi(s,s') \lambda_t(x) (1-I_\rho(x)) & \text{if } s'=e, \mu'=0 \\ \pi \sum_s \sum_\mu \sum_{m \in \Omega} \chi(s,s') \lambda_t(x) (1-I_\rho(x)) & \text{if } s'=e, \mu'=1 \end{cases}$$

$$\text{where } \Omega(m',s,\mu) = \{m : m' = m'(m,s,\mu)\}$$

The statistical properties of the economies studied are computed using this invariant distribution. Since the law of large numbers holds, the sample

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<sup>10</sup> For the experiments described in the next section, we have checked for ergodicity using a procedure similar to that described in the appendix to Imrohoroglu (1989a).

average of any function  $f(x)$ , converges to the expected value of  $f$  with respect to this invariant distribution. Thus we should obtain the same results by creating long time series using Monte Carlo methods. We check our results by computing the same statistics from simulated time series that consist of 500,000 periods. The time series we focus on are average utility, consumption, money holdings and employment.

In order to obtain an equilibrium for which the government budget constraint is satisfied, we follow the following steps: Given an unemployment insurance level, a value for the tax rate  $\tau$  is assumed and the dynamic programming problem is solved. After the decision rules are obtained, the statistical properties of the economy are examined, in particular, the government budget constraint is evaluated. If the government budget constraint is not satisfied a different tax rate is assumed. This procedure is followed until an equilibrium is obtained.

#### 4. Results

In this section we present results obtained from various experiments that differ according to the degree of moral hazard assumed. In addition, we also study how the results are affected by the degree of risk aversion. The section is organized as follows: Section 4.1 is a discussion of how the employment rate, average consumption, the tax rate, the variability of consumption over time, asset holdings, and average utility are affected by changing the amount of UI. In addition, optimal level of UI is computed assuming different degrees of moral hazard. Section 4.2 is a description of the potential welfare improvements that are possible through UI. Finally, section 4.3 provides a discussion of the ways in which our results may be biased by the particular assumption we have made.

#### 4.1 Moral Hazard and the Optimal Replacement Ratio

The major finding reported in this section is that the optimal replacement ratio is quite sensitive to the degree of moral hazard. When the degree of risk aversion,  $\rho$ , is set equal to 1.5, a high replacement ratio is optimal only when the degree of moral hazard is quite low (values of  $\pi$  below .1). However, if higher values of  $\rho$  are assumed, higher replacement ratios are justified.

In order to illustrate how the equilibrium of our economy is affected by moral hazard and risk aversion, we report in Tables 1 through 3 results obtained from the two polar cases: no moral hazard ( $\pi = 0$ ) and extreme moral hazard ( $\pi = 1$ ). In Table 1, results obtained under the assumption that  $\rho$  equals 1.5 are given. In this case, the upper bound on the employment rate ( $\bar{\eta}$ ) is never binding for any replacement ratio no matter what the degree of moral hazard. That is, there are always some individuals that choose to be unemployed. As the replacement ratio is increased from zero, the employment rate (which is the same as average consumption) falls. This occurs even with no moral hazard since the after tax wage falls with increases in the replacement ratio. In the no moral hazard case, an increase in the replacement ratio from zero to .25 decreases the employment rate by 1.9 percent. In the extreme moral hazard case this same policy change would decrease the employment rate by 45 percent! Under a more moderate degree of moral hazard, say  $\pi$  equal to .15, the employment rate would decrease by 6.5 percent. Clearly, these results are quite sensitive to the degree of moral hazard.

In addition, as one would expect, the standard deviation of consumption and average asset holdings fall as the replacement ratio is increased. As before, the magnitude of these changes are quite sensitive to the degree of

moral hazard. The tax rate required to finance a UI program with a replacement ratio of .25 is ten times larger with extreme moral hazard than with no moral hazard.

In Table 2 results are presented assuming a higher degree of risk aversion ( $\rho = 3$ ). One effect of higher risk aversion is that the upper bound on the employment rate ( $\bar{\eta}$ ) is sometimes binding. In particular, in the no moral hazard case, the employment rate is always equal to its upper bound unless the replacement ratio is set quite high, somewhere between .65 and .75. However, in the extreme moral hazard case, when the replacement ratio is increased from zero to .25, the employment rate still falls significantly (47 percent). In Table 3 we present results for  $\rho$  equal to 5. These results lead to the conclusion that higher degrees of risk aversion imply equilibria that are less sensitive to the replacement ratio.

The optimal replacement ratio is the replacement ratio that maximizes average utility. In Table 1, we see that the optimal replacement ratio is .7 with no moral hazard and zero with extreme moral hazard.<sup>11</sup> The optimal replacement ratios for a variety of values of  $\pi$ , under the assumption that  $\rho$  is equal to 1.5, are shown in Figure 1. Figure 1 reveals that the optimal replacement ratio falls drastically in the presence of even small amounts of moral hazard. For example, increasing  $\pi$  from .05 to .1 causes the optimal replacement ratio to fall from .6 to .2. For values of  $\pi$  above .25, the optimal level of UI is essentially zero.

Figures 2 and 3 illustrate how the optimal replacement ratio changes

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<sup>11</sup> In each of these tables, as well as in Figures 1 through 3, we report the optimal replacement ratio to the nearest .05. In the tables, we also report results for replacement ratios .05 above and below the optimal replacement ratio in order to illustrate the sensitivity of the results to small changes in the level of UI. In the tables, the optimal replacement ratio is indicated with and arrow ( $\rightarrow$ ).

with the degree of risk aversion. In contrast to the case described above, when  $\rho$  equals 3 the optimal replacement ratio is not sensitive to small amounts of moral hazard ( $\pi$  less than .1). However, when  $\pi$  is increased to .15, the optimal replacement ratio falls from .6 to .35. The optimal replacement ratio continues to fall with increases in the degree of moral hazard until it reaches five percent under extreme moral hazard. Figure 3 reveals that if  $\rho$  equals 5, the optimal replacement ratio is insensitive to moral hazard unless  $\pi$  is larger than .25. In this case, the optimal replacement ratio is ten percent even in the presence of extreme moral hazard.

From a policy perspective, if we assume that  $\rho$  is equal to 1.5, which we regard as a reasonable value given available empirical measurements, strict enforcement of the work test (the requirement that an individual must be available for and actively searching for work to qualify for UI benefits) is very important if high replacement ratios are to be justified. If larger values of  $\rho$  are assumed, less strict enforcement of the work test is required. Intuitively, this result follows from the fact that, when an agent is more risk averse, he is less attracted by a lottery that promises positive income with probability less than one in exchange for more leisure.

#### 4.2 The Welfare Benefits of UI

As expected based on the results described above, the potential welfare benefits from an UI program are sensitive to the degree of risk aversion and moral hazard. In fact, we find that if risk aversion is high enough, and moral hazard low enough, it is possible to attain the allocation that would be chosen by a social planner by implementing the appropriate UI program. However, for reasonable values for the risk aversion parameter and relatively low degrees of moral hazard, the welfare costs suffered by an economy with

optimal UI are no lower than those for an economy with no UI at all.

The welfare measure used in this section is based on the deviations from the social planner's allocation described in Section 2.1. Using the parameter values given in Section 3, and with  $\rho = 1.5$ , the optimal employment rate-- which is given by equation (2.9)--turns out to be .88. The consumption of employed agents ( $c_1$ ) turns out to be .90 and the consumption of unemployed agents ( $c_2$ ) is .76. The average utility level is -.4405. Alternatively, the competitive equilibrium allocation for the economy with liquidity constraints and no UI implies an employment rate equal to .851 and an average utility level of -.4435.

To measure the welfare cost of living in the liquidity constrained economy, we ask the following question: How much more productive would an employed agent in the liquidity constrained economy have to be (that is, how much would  $y$  have to increase) for that person to have the same average utility level as under the optimal allocation? The answer turns out to be .73% percent.

However, as the income of employed agents is increased, the decision of whether or not to accept an employment opportunity will be affected. Thus, total GNP (or average consumption) will not necessarily increase by the same amount as  $y$  is increased. Therefore, we also compute the percentage change in GNP that occurs as a result of the increase in  $y$  that makes people, on average, as well off as they would be under the optimal allocation. For the above example, this turns out to be .76 percent. This is the welfare measure that is reported in Figures 4 through 7.<sup>12</sup>

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<sup>12</sup> This welfare measure can be interpreted as measuring how much the total cost would be to a benefactor that wanted to make individuals (on average) as well off as they would be under the optimal allocation by subsidizing employment.

To determine to what extent the welfare costs can be reduced by introducing UI, we compute welfare costs for the liquidity constrained economy assuming the optimal level of UI. This can then be compared to the welfare costs given above to determine the potential welfare benefits of UI. In the no moral hazard case, where the optimal replacement ratio is .7, the welfare costs are reduced to .29 percent of GNP. This amounts to a 62 percent decrease in welfare costs. Of course, if there is moral hazard, the potential welfare benefits of UI are lower. In fact, as shown in Figure 4, the welfare costs of living with optimal UI are only slightly less than if there were no UI when  $\pi$  is equal to .15. However, if moral hazard is slightly less,  $\pi = .10$ , the welfare costs can be reduced from .76 to .33 percent of GNP by introducing UI.

For the higher risk aversion cases, the potential welfare benefits from introducing UI are greater. As shown in Figure 5, if  $\rho = 3$ , welfare costs can be reduced by 100% (that is, average consumption and average utility will be the same as under the social planner's allocation) if the degree of moral hazard is small. When  $\rho = 5$  this is possible for values of  $\pi$  up to .25, as shown in Figure 6. In both of these cases, there exist potential welfare benefits even if there is extreme moral hazard: Welfare costs can be reduced by ten percent when  $\rho$  equals 3 (from .68 percent of GNP to .61 percent) and by 26 percent when  $\rho$  equals 5 (from .61 percent of GNP to .45 percent).

For the results presented above, welfare costs (or benefits) of UI are computed assuming that the replacement ratio is set optimally. In Figure 7 we show the welfare costs for various degrees of moral hazard, arbitrarily setting the replacement ratio equal to .5. We have chosen this value because it represents a reasonable lower bound for estimates of the replacement ratio

in the U.S. economy.<sup>13</sup> This figure shows that for very low levels of moral hazard ( $\pi$  equal to 0 or .05), UI with a replacement ratio of .5 is better than having no UI at all. However, for values of  $\pi$  of .1 or higher, this amount of UI decreases welfare. In fact, as the value of  $\pi$  is increased, the welfare costs become enormous.

#### 4.3 Discussion

The surprising aspect of the above findings is how sensitive the size of these welfare benefits are to even small amounts of moral hazard. This may have important implications for the design of UI programs in actual economies. However, before applying the results of this analysis to the real world, it is important to understand how the assumptions made in this study may have influenced our results. For example, in our effort to obtain an upper bound on the potential benefits of UI, we have ignored the fact that most individuals have access to some credit and are not entirely liquidity constrained. In addition, some level of insurance is provided privately, particularly through families. Therefore, if individuals subject to employment risk have access to these alternative forms of insurance, we may have over estimated the potential welfare gains from UI.

In addition, if jobs differ according to some characteristic that matter to workers or that workers accumulate job specific human capital, we may have over estimated the effect of moral hazard on the social desirability of UI. That is, in our model workers are often willing to give up jobs if there is a chance of collecting UI. However, if there were some cost associated with

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<sup>13</sup> We have chosen a lower bound because in our model individuals are able to collect UI for as many periods they are unemployed while in the U.S. economy they can only collect for some specified number of weeks.

quitting a job--for example, the loss of job specific human capital--one may find that this type of moral hazard is less important.<sup>14</sup>

Finally, the work test requirement, common to essentially all UI programs in the U.S., is usually very poorly enforced (see Clark and Summers (1982)). Clark and Summers point out that fewer than 0.1 percent of UI claimants are disqualified for this type of reason. Instead, UI programs in the U.S. use eligibility requirements as an indirect method of reducing moral hazard. From 1977 to 1987, although over 90 percent of employed individuals are covered by UI, only 43 percent of unemployed workers are eligible to collect benefits (see Blank and Card (1988)).<sup>15</sup> Therefore, it would be useful to introduce these eligibility requirements into a model like this one in order to determine the extent to which these requirements attenuate the effects of moral hazard, which our theory suggests are quite large.

## 5. Conclusion

In this paper we have studied the role of unemployment insurance in an economy where agents are liquidity constrained and face stochastic employment opportunities. We find that, as long as the work test is strictly enforced, UI programs with replacement ratios above .5, as found in the U.S. economy,

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<sup>14</sup> This would especially affect the number of workers who turn down employment opportunities while currently employed. It is less clear how the number of individuals rejecting employment opportunities while currently unemployed would be affected.

<sup>15</sup> The most common reason for unemployed individuals to be ineligible for UI, according to Blank and Card, is that the individual was not employed for a minimum required number of weeks (and/or did not earn a required minimum amount) in the twelve month "base period" prior to becoming unemployed. This accounts for 52.1 percent of the ineligible unemployed during the period from 1977-1987. Other reasons for not receiving UI include that the individual quit his job (11.7%), the period for which the individual is allowed to receive benefits (usually 26 weeks) has expired (26.1%), or the period that one must be unemployed before receiving benefits (usually one week) has not yet expired (9.5%).

are justified in this artificial economy. How sensitive this conclusion is to the degree of moral hazard depends on the degree of risk aversion. If a coefficient of relative risk aversion of 1.5 is assumed, which we take to be a reasonable value, we find that this result is quite sensitive to the degree of moral hazard. For higher values of this parameter, moderate degrees of moral hazard become less important.

We also find that significant welfare gains are possible by introducing UI into this environment. Using the welfare measure described in the paper, we find that the welfare costs of living in this liquidity constrained economy can be reduced from .76 percent of GNP to .29 percent if the risk aversion parameter is equal to 1.5 and there is no moral hazard. If the risk aversion parameter is equal to three, the welfare costs can be reduced from .68 percent of GNP to zero. However, these results are significantly affected by the presence of moral hazard. For risk aversion equal to 1.5, the welfare benefits of UI disappear with relatively moderate amounts of moral hazard. We also find that in this case the welfare benefits of having UI with the replacement ratio arbitrarily set at .5, are significantly negative in the presence of moderate amounts of moral hazard.

In this paper, we have abstracted from many factors which may be relevant to determining how much UI is optimal or measuring the welfare benefits that can be obtained from UI. However, it does illustrate how a quantitative-theoretical analysis can be used to address these issues and provides tentative answers to these questions. More work needs to be done to assess the importance of the potential biases described in the previous section. In addition, there are other effects of UI that can be addressed using this methodology. One example is the impact of UI on temporary layoff unemployment. In particular, the effects of experience rating on the frequen-

cy of temporary layoff unemployment and the associated welfare costs can be studied.

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Table 1 -- Selected Results for  $\rho = 1.5$ <sup>16</sup>

(Optimal Allocation: Emp. Rate = 0.880, Avg. Utility = -0.44055)

A. No Moral Hazard ( $\pi = 0$ )

Replacement Ratio ( $\theta$ )	Tax Rate ( $\tau$ )	Employment Rate (Avg. Cons.)	Standard Deviation of Consumption	Average Money Holdings	Average Utility
0.00	0.000	0.851	0.0970	4.669	-0.44348
0.25	0.023	0.835	0.0874	1.242	-0.44264
0.50	0.046	0.818	0.0759	0.408	-0.44211
0.65	0.060	0.813	0.0614	0.320	-0.44174
→ 0.70	0.064	0.811	0.0571	0.325	-0.44173
0.75	0.069	0.806	0.0544	0.327	-0.44190
1.00	0.092	0.784	0.0567	0.350	-0.44283

B. Extreme Moral Hazard ( $\pi = 1$ )

Replacement Ratio ( $\theta$ )	Tax Rate ( $\tau$ )	Employment Rate (Avg. Cons.)	Standard Deviation of Consumption	Average Money Holdings	Average Utility
→ 0.00	0.000	0.851	0.0970	4.669	-0.44348
0.01	0.002	0.848	0.0965	2.801	-0.44362
0.05	0.012	0.808	0.0929	2.299	-0.44433
0.25	0.220	0.466	0.0513	0.555	-0.50101

<sup>16</sup> In these tables we indicate the optimal replacement ratio with an arrow (→). In addition, since we have assumed that the income of an employed agent,  $y$ , is equal to one, the employment rate is also equal to average consumption.

Table 2 -- Selected Results for  $\rho = 3.0$

(Optimal Allocation: Emp. Rate = .920, Avg. Utility = -0.61777)

A. No Moral Hazard ( $\pi = 0$ )

Replacement Ratio ( $\theta$ )	Tax Rate ( $\tau$ )	Employment Rate (Avg. Cons.)	Standard Deviation of Consumption	Average Money Holdings	Average Utility
0.00	0.000	0.920	0.1372	4.561	-0.62277
0.25	0.021	0.920	0.1294	0.957	-0.62032
0.50	0.042	0.920	0.1173	0.094	-0.61837
0.55	0.045	0.920	0.1126	0.025	-0.61804
→ 0.60	0.049	0.920	0.1030	0.000	-0.61780
0.65	0.053	0.920	0.0969	0.005	-0.61782
0.75	0.061	0.918	0.0955	0.039	-0.61795
1.00	0.082	0.891	0.1048	0.095	-0.62029

B. Extreme Moral Hazard ( $\pi = 1$ )

Replacement Ratio ( $\theta$ )	Tax Rate ( $\tau$ )	Employment Rate (Avg. Cons.)	Standard Deviation of Consumption	Average Money Holdings	Average Utility
0.00	0.000	0.920	0.1372	4.561	-0.62277
→ 0.05	0.004	0.920	0.1356	2.354	-0.62224
0.10	0.015	0.866	0.1431	1.789	-0.62592
0.25	0.205	0.491	0.1184	0.461	-0.74416

Table 3 -- Selected Results for  $\rho = 5.0$

(Optimal Allocation: Emp. Rate = .920, Avg. Utility = -1.01043)

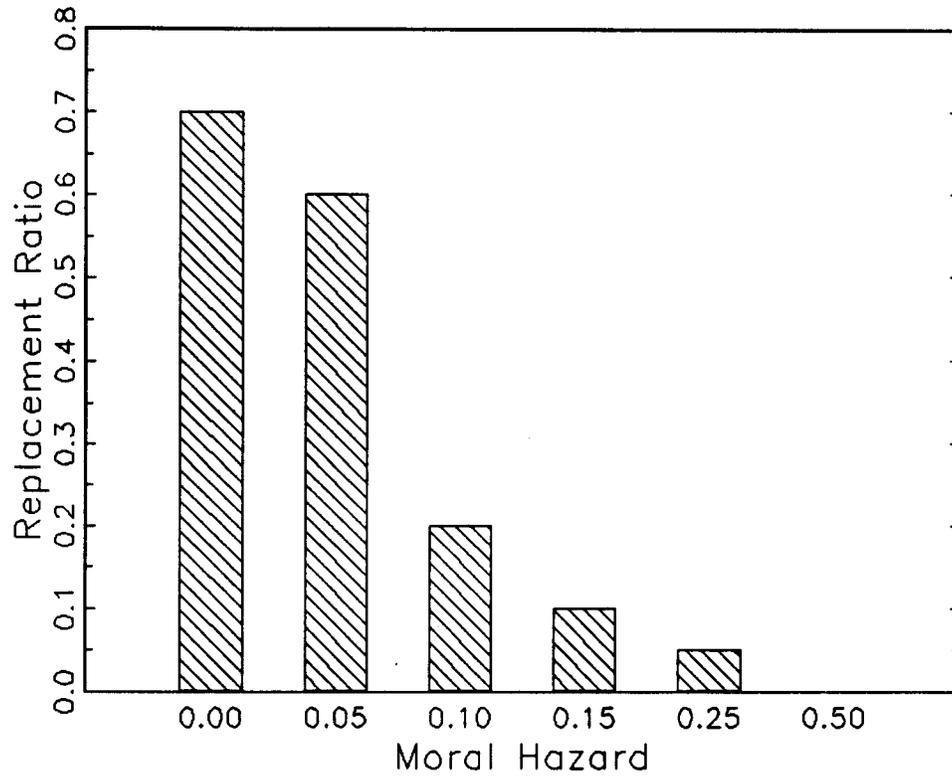
A. No Moral Hazard ( $\pi = 0$ )

Replacement Ratio ( $\theta$ )	Tax Rate ( $\tau$ )	Employment Rate (Avg. Cons.)	Standard Deviation of Consumption	Average Money Holdings	Average Utility
0.00	0.000	0.920	0.1534	4.509	-1.02068
0.25	0.021	0.920	0.1491	0.711	-1.01461
0.45	0.038	0.920	0.1396	2.454	-1.01103
→ 0.50	0.042	0.920	0.1298	0.000	-1.01044
0.55	0.045	0.920	0.1244	0.007	-1.01066
0.75	0.061	0.920	0.1253	0.061	-1.01173
1.00	0.080	0.918	0.1265	0.383	-1.01423

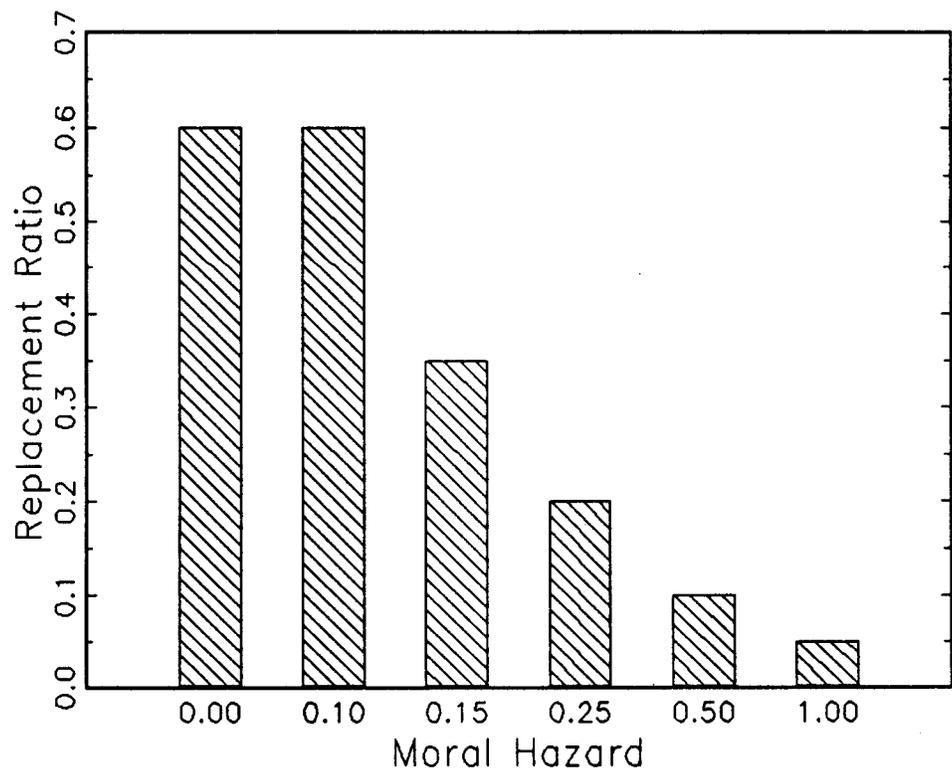
B. Extreme Moral Hazard ( $\pi = 1$ )

Replacement Ratio ( $\theta$ )	Tax Rate ( $\tau$ )	Employment Rate (Avg. Cons.)	Standard Deviation of Consumption	Average Money Holdings	Average Utility
0.00	0.000	0.920	0.1534	4.509	-1.02068
0.05	0.004	0.920	0.1521	2.287	-1.01904
→ 0.10	0.009	0.920	0.1514	1.763	-1.01788
0.15	0.018	0.889	0.1646	1.311	-1.02574
0.25	0.166	0.554	0.1761	0.404	-1.26067

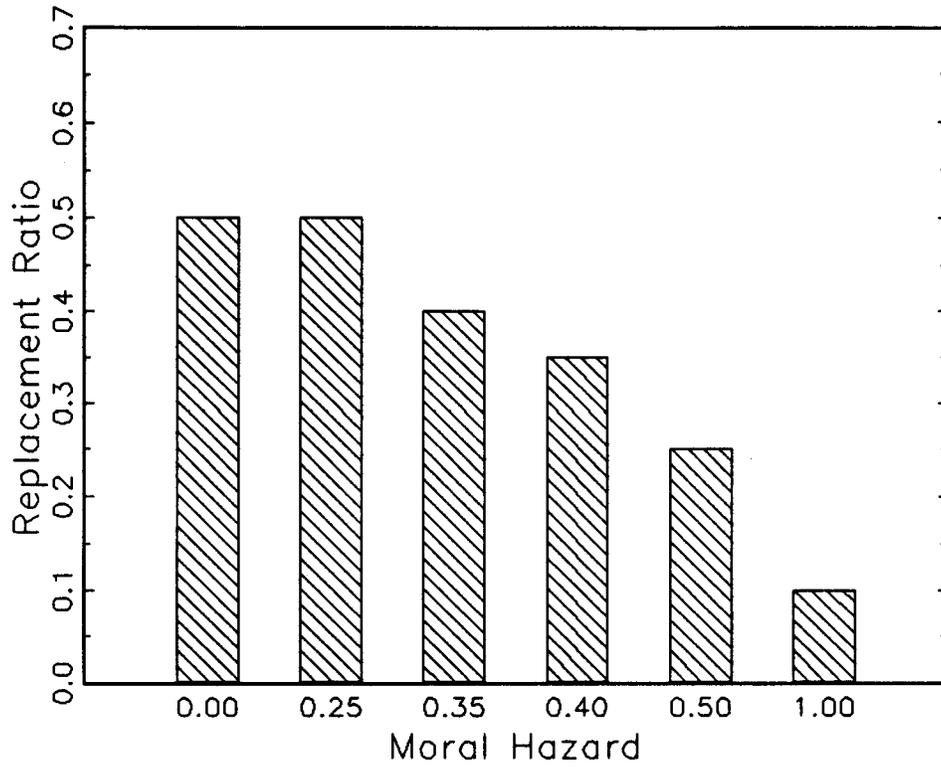
**Figure 1 Optimal Unemployment Insurance for  $\rho = 1.5$ .**



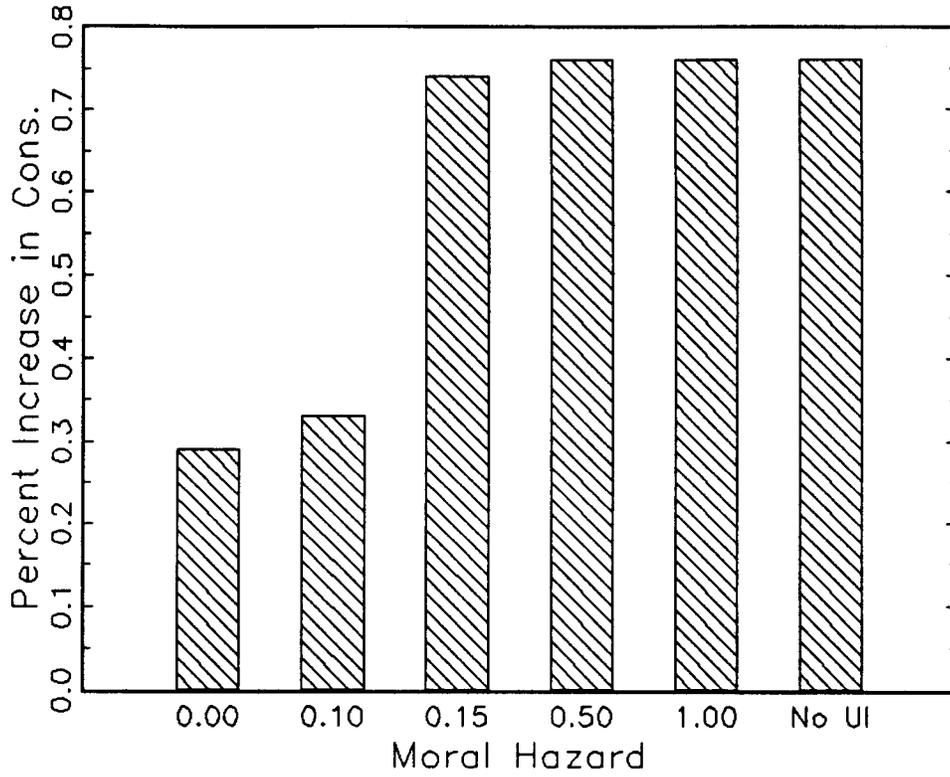
**Figure 2 Optimal Unemployment Insurance for  $\rho = 3.0$ .**



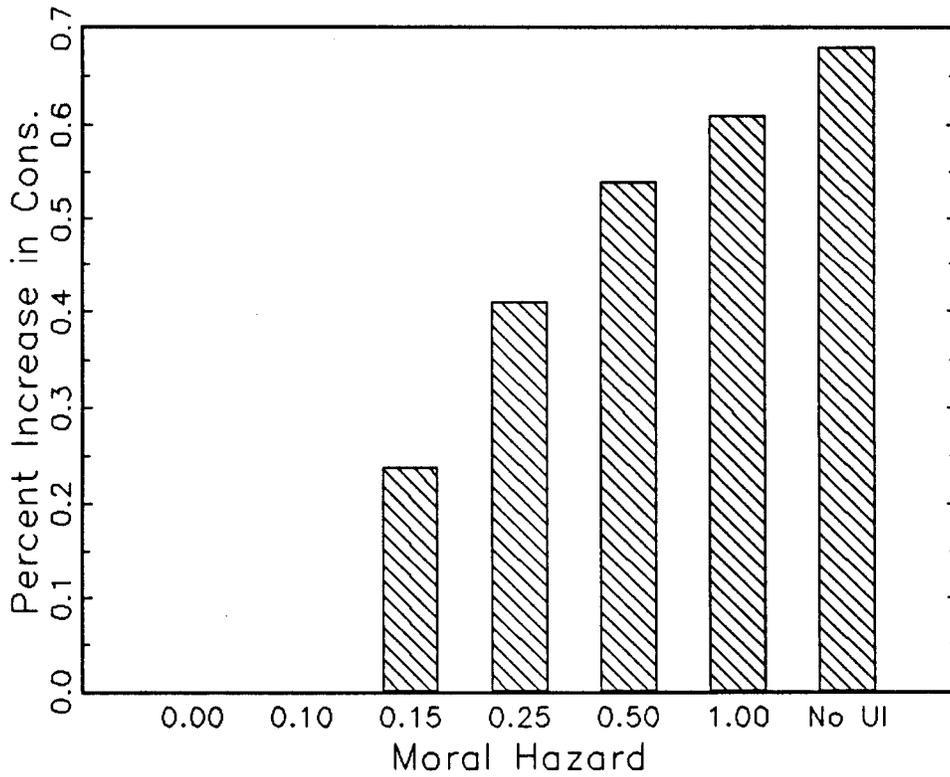
**Figure 3 Optimal Unemployment Insurance for  $\rho = 5.0$ .**



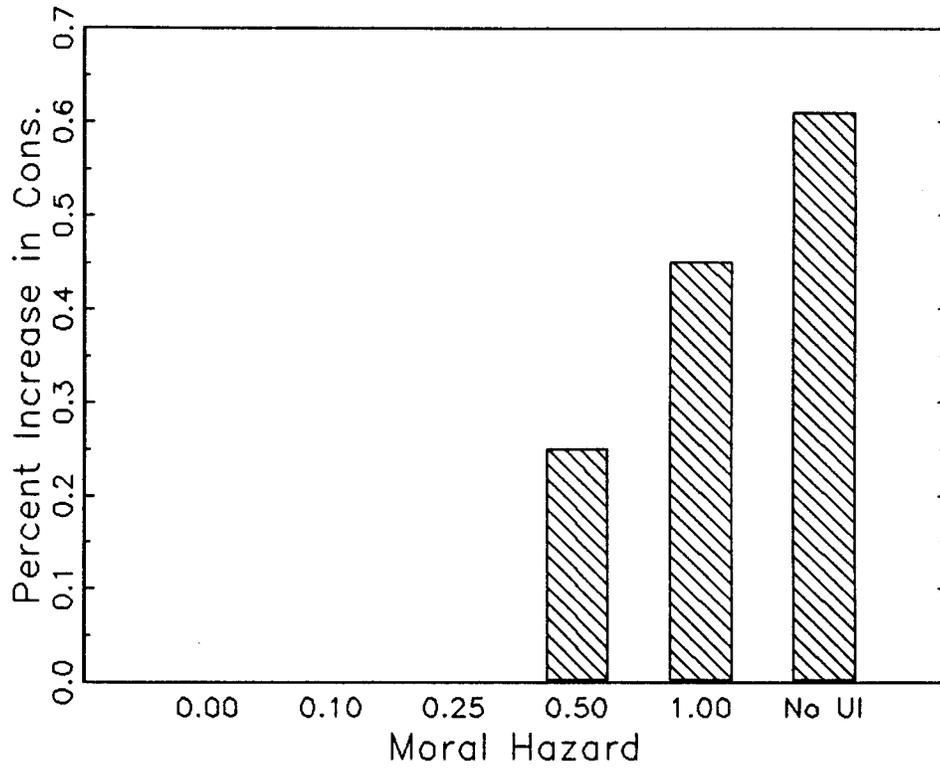
**Figure 4 Welfare Costs for Rho = 1.5.**



**Figure 5 Welfare Costs for Rho = 3.0.**



**Figure 6 Welfare Costs for Rho = 5.0.**



**Figure 7 Welfare Costs for Replacement Ratio = 0.5, Rho = 1.5.**

