

# Should Unemployment Insurance Vary With The Local Unemployment Rate? Theory And Evidence

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## Abstract

We study theoretically and empirically how optimal Unemployment Insurance (UI) benefits vary with local labor market conditions. Theoretically, we show in a standard search model that the adverse incentive effect of UI varies with the unemployment rate. The model motivates our empirical strategy which tests whether the effect of UI benefits on unemployment durations varies with the local unemployment rate. In our preferred specification, we find that a one standard deviation increase in the local unemployment rate reduces the magnitude of the duration elasticity by 32%. Using our empirical estimates to calibrate the optimal level of UI benefits implied by our model, we find that a one standard deviation increase in the unemployment rate leads to a 13 percentage point increase in the optimal replacement rate. (JEL H5, J64, J65)

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# 1 Introduction

It is commonly accepted that higher unemployment benefits prolong unemployment durations (Hamermesh 1977, Moffitt 1985, Meyer 1990, Chetty 2008). Most of the evidence for this “moral hazard effect” comes from empirical studies that do not distinguish between changes in benefits when local labor market conditions are good and changes in benefits when local labor market conditions are poor.<sup>1</sup> If the moral hazard cost of Unemployment Insurance (UI) depends on local labor market conditions, this may imply that optimal UI benefits should respond to shifts in local labor demand. However, there exists little empirical evidence on measuring how local labor market conditions affect the moral hazard cost of UI, since many of the studies that conduct a welfare analysis of UI do not consider whether and to what extent UI benefits should vary with local labor market conditions (Baily 1978, Chetty 2006, Chetty 2008, Shimer and Werning 2007, Kroft 2008).<sup>2</sup> As Alan Krueger and Bruce Meyer (2002, p64-65) remark:

[F]or some programs, such as UI, it is quite likely that the adverse incentive effects vary over the business cycle. For example, there is probably less of an efficiency loss from reduced search effort by the unemployed during a recession than during a boom. As a consequence, it may be optimal to expand the generosity of UI during economic downturns ... Unfortunately, this is an area in which little empirical research is currently available to guide policymakers.

Similarly, the Congressional Budget Office writes that the availability of long-term unemployment benefits “could dampen people’s efforts to look for work, [but that concern] is less of a factor when employment opportunities are expected to be limited for some time.”<sup>3</sup>

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<sup>1</sup>Chetty (2008) shows that it is misleading to interpret the behavioral response to UI benefits as a pure moral hazard effect, as part of the observed response could be coming through liquidity effects. We discuss this in Section 3.2.1 where we investigate the importance of liquidity effects and how they affect our empirical findings. To preview our results in that section, we find no evidence that accounting for liquidity effects significantly alters our main results.

<sup>2</sup>Nicholson and Needels (2006) discuss how worsening labor market conditions in the U.S. in the 1970s and 1980s triggered large, policy-driven, increases in benefit payments.

<sup>3</sup>The CBO quote is available from the following URL: [http://www.washingtonpost.com/wp-dyn/content/article/2010/03/08/AR2010030804927\\_pf.html](http://www.washingtonpost.com/wp-dyn/content/article/2010/03/08/AR2010030804927_pf.html).

In this paper, we conduct both positive and normative economic analyses to investigate how the unemployment rate affects the moral hazard cost of UI. On the positive side, we consider a standard job search model and consider theoretically how the adverse incentive effect of UI varies with the unemployment rate. We first consider workers facing stochastic wages and an exogenous arrival rate of job offers. Workers set a reservation wage when searching for a job, accepting all wage offers above the reservation wage. We show that the elasticity of unemployment duration with respect to the UI benefit level varies with the unemployment rate in the steady state. Although we cannot sign this relationship analytically, we calibrate the model using a standard assumption on the wage offer distribution from the literature, and find that the duration elasticity is positively correlated with the unemployment rate for low levels of risk aversion ( $\gamma < 3$ ).

We then extend the search model to encapsulate the more realistic scenario where workers affect the job finding rate by increasing search effort and we allow shifts in labor demand to affect the returns to search effort. We derive an expression for the elasticity of unemployment duration that is the sum of the behavioral responses of (a) reservation wages and (b) search effort to UI benefits. Interestingly, how the search effort elasticity varies with the unemployment rate depends on how the job offer arrival rate interacts with search effort. For an arrival rate that is linear in search effort, the duration elasticity tends to covary positively with the unemployment rate, as in the reservation wage model. However, for an offer arrival rate that is log-linear in search effort, we find the opposite relationship. Therefore, we conclude that whether the duration elasticity rises or falls with the unemployment rate depends on the functional form of the offer arrival rate and on the relative importance of the search effort and reservation wage channels. We view the possibility that the moral hazard cost of UI can increase during times of high unemployment – contrary to the speculation of Krueger and Meyer (2002) above, as well as existing UI policy in the U.S. and many other developed countries – as an interesting prediction of the search model.

Our model and calibrations indicate that the relationship between the duration elasticity and the unemployment rate is ultimately an empirical question. Therefore, we estimate directly from the data how the duration elasticity varies with the unemployment rate. Specifically, we exploit variation in UI benefit levels within states over time and interact the effect

of UI benefit generosity with the state unemployment rate. Our findings indicate that the duration elasticity is significantly lower when the local unemployment rate is high. In our preferred specification, we find that the elasticity of unemployment duration with respect to unemployment benefits is 0.741 (s.e. 0.340) at the average unemployment rate. However, we find that a one standard deviation increase in the unemployment rate (an increase of 1.68 percentage points) reduces the magnitude of the duration elasticity by 0.239 to 0.502 (a decline in magnitude of 32.3%). We conduct a variety of robustness tests to address concerns that the interaction effect we estimate is driven by local labor supply shocks, compositional changes, endogenous UI benefits, unobserved trends, sample selection, and liquidity effects, and we find little evidence that any of these concerns are primarily responsible for our effect. The evidence indicates a negative association between the moral hazard of cost of UI and the local unemployment rate.

We next calibrate our model to match the estimated magnitude of the relationship between the duration elasticity and the local unemployment rate. The values of the structural parameters needed to match the empirical results are close to existing estimates of these parameters from the literature. This provides further evidence that the model used to interpret the empirical results is sensible and suitable for welfare analysis.

Finally, we show that when the duration elasticity depends on the unemployment rate, this has important implications for the welfare consequences of UI. We develop a simple formula for the marginal welfare gain of UI that takes into account how the behavioral response to UI benefits varies with the unemployment rate. The formula is stated in terms of our reduced-form parameter estimates and is thus in the spirit of the “sufficient statistics” approach to welfare analysis (Chetty 2009). The primary advantage of this method is that it can be implemented with relatively few parameter estimates. Furthermore, these parameters can often be empirically estimated using a credible quasi-experimental research design. One disadvantage of this approach is that it is not well-suited to out-of-sample counterfactual analysis because the sufficient statistics are only valid for relatively “local” changes in the policy-relevant parameters. Because we are primarily interested in computing optimal UI benefits within the range of local unemployment rates observed in our data, we prefer the sufficient statistics approach. Using our reduced form empirical estimates

to calibrate the optimal UI formula implied by our model, we find that a one standard deviation increase in the local unemployment rate leads to a 13 percentage point increase in the optimal replacement rate. To give a sense of the magnitude of this policy change, it is roughly equivalent to a one unit change in the coefficient of relative risk aversion in the model (e.g., from  $\gamma = 3$  to  $\gamma = 4$ ).

Several recent papers explore theoretically how UI benefits should vary with the unemployment rate (Kiley 2003, Costain and Reier 2005, Sanchez 2008 and Andersen and Svarer 2009). These papers differ in several respects. First, these papers take a structural approach to welfare analysis by imposing functional form assumptions characterizing how labor demand shocks affect search, while we take an approach in the spirit of the “sufficient statistics” literature, allowing us to use our reduced form estimates to calibrate our model. Second, our welfare analysis does not place any restrictions on the model primitives and is therefore valid for a wide range of underlying mechanisms which cause the duration elasticity to vary with the unemployment rate.<sup>4</sup> Third, these studies are primarily calibration analyses; they do not empirically estimate how the duration elasticity varies with the unemployment rate. Forth, since these papers are mostly based on search models with no reservation wage decision, they do not highlight the distinction between the reservation wage and search effort elasticities.

Lastly, this paper contributes to a large empirical literature on the behavioral responses to UI by providing empirical evidence on how the elasticity of duration with respect to the benefit level varies with the unemployment rate. There are several papers in this area that indirectly relate to our work (Moffitt 1985, Arulampalam and Stewart 1995, Jurajda and Tannery 2003, and Røed and Zhang 2005). Most recently, Schmieder, von Wachter and Bender (2009) attempt to shed light on how the behavioral responses to UI vary with the unemployment rate. Specifically, they implement a regression discontinuity design, using administrative data from Germany, to identify the elasticity of duration with respect to the potential benefit duration. Their research design allows them to estimate an elasticity for each year in their sample (1987-2004). They show that their annual elasticity estimate

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<sup>4</sup>In particular, our welfare analysis does not require assuming a specific functional form for how effort is translated into a job offer arrival rate.

does not correlate significantly with the annual unemployment rate over this time period. Our empirical analysis differs in several respects from this paper: first, we consider the US which is a different institutional setting than Germany; second, we consider variation in the benefit level rather than potential benefit duration; third, we focus on monthly variation in the unemployment rate within and between US states, which permits a more powerful test of whether the effect of benefits on duration depends on the unemployment rate.

The remainder of the paper proceeds as follows. The next section develops the search model and describes both the agent and planner problems. Section 3 presents our empirical analysis which estimates how the behavioral response to UI varies with the unemployment rate. Section 4 discusses the results from the calibration of the search model. Section 5 considers the welfare implications of our empirical findings. Section 6 concludes.

## 2 Theory

In this section, we describe the setup of a standard continuous-time, infinite-time horizon, job search model. The model closely follows Shimer and Werning (2007). We make a number of simplifying assumptions for tractability. First, we focus on benefit level, not potential benefit duration, although the latter is clearly also an important policy parameter.<sup>5</sup> Second, the model does not allow workers to save or borrow. Thus an unemployed worker's only way to smooth consumption across states is the unemployment insurance agency.<sup>6</sup> Third, we assume there is no value from leisure time during an unemployment spell. Forth, we assume that workers are homogeneous. Finally, we work in a partial equilibrium setting with no firms. We begin by considering a version of the model where the job offer arrival rate is exogenous. We then extend the model to allow for endogenous search effort. In both cases, we characterize the structural relationship between the moral hazard cost of UI and unemployment. We then exploit this relationship to show how the welfare gain of UI varies with unemployment.

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<sup>5</sup>Shimer and Werning (2008) find that socially optimal UI policy is infinite duration, constant benefits in both a hand-to-mouth model and one with free access to savings and lending.

<sup>6</sup>Since we assume that consumption during unemployment is equal to the UI benefit level and consumption during employment is equal to the net wage, there is full consumption-smoothing across time, within states.

## 2.1 The Agent and Planner's Problems

*Agent's Problem With Exogenous Arrival Rate.* Consider a single worker that who has flow utility given by  $U(c)$ , where  $U' > 0$ ,  $U'' < 0$ . The worker's subjective discount rate is given by  $\rho \geq 0$ . The worker maximizes the expected present value of utility from consumption

$$E \int_0^{\infty} e^{-\rho t} U(c(t)) dt \quad (1)$$

If the worker is unemployed, she samples wages exogenously at rate  $\lambda$  from a known distribution function,  $F(w)$ . Workers who accept a wage offer commence employment immediately. Employment is assumed to end exogenously with separation rate  $s$ .

If the worker is unemployed, she receives and consumes an unemployment benefit denoted by  $b$ . When the worker is employed, she earns a wage  $w$  and pays taxes  $\tau$  which are used to finance unemployment benefit payments. Thus, her consumption when employed is her net wage,  $w - \tau$ .<sup>7</sup> Finally, we assume that the model is stationary.<sup>8</sup>

*Worker Behavior.* We now characterize worker behavior subject to a particular policy  $(b, \tau)$ . Let  $V_u$  be the value function (maximal expected lifetime utility) of an unemployed individual and let  $V(w)$  denote the value function of a worker who accepts a wage offer of  $w$ . The worker solves the following:

$$\rho V_u = U(b) + \lambda \int_0^{\infty} \max\{V(w) - V_u, 0\} dF(w) \quad (2)$$

$$\rho V(w) = U(w - \tau) + s[V_u - V(w)] \quad (3)$$

where  $\rho V_u$  is the (per period) flow value of being unemployed, which is the consumption value plus the expected capital gain of getting an acceptable wage draw in the future (i.e., the "option value"). An employed worker earns  $w - \tau$  and then at rate  $s$  loses her job and

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<sup>7</sup>We do not model the worker's intensive labor supply decision. Since workers supply labor inelastically in our model, taxes are non-distortionary.

<sup>8</sup>This means that  $s$ ,  $F(w)$ ,  $b$ ,  $\tau$  and  $\rho$  are all assumed to be independent of time. The expressions that we derive in this paper depend on this assumption. For example, if there is duration dependence such that the reservation wage varies in response to the failure to find a job, then the expressions below will not be valid. Empirically, we do not find evidence of duration dependence in our data. Conceptually, we view  $\lambda$  as time-varying across spells, but time-invariant within spells.

changes states, which she values at  $V_u - V(w)$ . Rearranging equation (3) results in the following expression:

$$V(w) = \frac{U(w - \tau) + sV_u}{\rho + s}$$

The reservation wage,  $\bar{w}$ , satisfies  $V(\bar{w}) = V_u$ , implying that  $V(\bar{w}) = U(\bar{w} - \tau)/\rho$ .<sup>9</sup> Substitution yields the following expression:

$$U(\bar{w} - \tau) = U(b) + \frac{\lambda}{\rho + s} \int_{\bar{w}}^{\infty} [U(w - \tau) - U(\bar{w} - \tau)] dF(w) \quad (4)$$

Equation (4) is a standard expression in search models, which implicitly defines the reservation wage. The left-hand side of this equation represents the flow utility of accepting a wage offer of  $\bar{w}$ . The right-hand side is the flow utility of rejecting a wage offer of  $\bar{w}$  and waiting for a better wage draw. Note that  $1/(\rho + s)$  represents the expected present discounted value of a unit of income until a job ends. If there were no risk of job loss, this would be equal to  $1/\rho$  which is the value of a perpetuity with payment of \$1. Therefore, the risk of job loss effectively increases the discount rate.

The job finding rate is equal to the product of the job offer arrival rate and the probability of receiving an acceptable wage offer,  $\lambda(1 - F(\bar{w}))$ . The stationarity assumption implies that the job finding rate does not depend on how long the agent has been unemployed, meaning that we can express expected duration,  $D$ , as  $1/\lambda(1 - F(\bar{w}))$ . Finally, define  $u = \frac{s}{s + \lambda(1 - F(\bar{w}))}$  as the fraction of time a worker is unemployed, or the unemployment rate.

*Planner's Problem.* We consider a social planner whose objective is to maximize an unemployed worker's utility,  $V_u$ . We restrict the class of feasible policies to those where the unemployment benefit level,  $b$ , and the employment tax,  $\tau$ , are constant.<sup>10</sup> We assume that the worker receives UI benefits so long as she is unemployed. The planner's policy must satisfy a balanced-budget requirement which means that expected benefits paid out equals

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<sup>9</sup>Note that  $V(\bar{w}) = V_u \implies V(w) - V_u = \frac{U(w - \tau) - U(\bar{w} - \tau)}{\rho + s}$ . Also,  $V(\bar{w}) = \frac{U(\bar{w} - \tau) + sV_u}{\rho + s} = \frac{U(\bar{w} - \tau) + sV(\bar{w})}{\rho + s} = \frac{U(\bar{w} - \tau)}{\rho}$ .

<sup>10</sup>We assume that a lump-sum tax is available. As Chetty (2006) observes, in the US, UI benefits are financed by payroll tax which applies only to the first \$10,000 of income; as a consequence, the tax is inframarginal for most workers.



expected taxes collected. Denoting the interest rate by  $r$ , this can be stated as  $Db = \frac{\tau}{r+s}$ .<sup>11</sup> The right-hand side is roughly equal to the expected tax collected from the worker when she is employed. We solve the planner's problem in two steps: first, we show how the effect of UI on durations depends on the unemployment rate; second, we exploit this relationship to show that the optimal benefit level chosen by the planner depends on the unemployment rate. We will assume throughout that  $r = \rho$ .

## 2.2 Moral Hazard and Unemployment

In this reservation wage model, moral hazard depends on the duration elasticity, which in turn depends on the responsiveness of reservation wages to benefits.<sup>12</sup> The following is an expression for how the reservation wage responds to the benefit level

$$\frac{\partial \bar{w}}{\partial b} = \frac{U'(b)}{U'(\bar{w} - \tau)} \frac{\rho + s}{\rho + s + \lambda(1 - F(\bar{w}))} \quad (5)$$

This result is easily obtained by differentiating equation (4) with respect to the benefit level, holding taxes fixed, and applying Leibniz's rule for differentiation under an integral sign. There are several points worth making about expression (5). First, the responsiveness of reservation wages depends on risk aversion through the ratio of marginal utilities. Intuitively, a risk-averse agent values a guaranteed stream of unemployment benefits more than a risk-neutral agent and so is more sensitive to variations in her certain income. Second, the expression depends on the labor market parameters  $\lambda$ ,  $s$ , and  $F(w)$ . It is instructive to consider a special case of the model. If  $U'' \approx 0$  and  $\rho \approx 0$ ,

$$\frac{\partial \bar{w}}{\partial b} \approx u \quad (6)$$

Interestingly, expression (6) implies that, in a stationary environment, we can measure

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<sup>11</sup>One may wonder why taxes are discounted, but unemployment benefits are not. This is because the government must pay benefits currently to a worker who is unemployed and receives taxes later, when the worker becomes employed. Note that if  $r = 0$ , the budget constraint collapses to  $ub = (1 - u)\tau$ .

<sup>12</sup>Shimer & Werning (2007) show that, *conditional on the duration elasticity*,  $\frac{d\bar{w}}{db}$  is a measure of private welfare. Note however that there is still a moral hazard aspect to  $\frac{d\bar{w}}{db}$  as it determines the duration elasticity. We discuss in subsection 2.4 why we interpret the duration elasticity as moral hazard.

the responsiveness of the reservation wage to changes in benefits in an extremely simple way – all that is needed is data on the unemployment rate.<sup>13</sup> For the U.S. over the period 1999–2009,  $u \in [3.8\%, 10.1\%]$ .<sup>14</sup> On the other hand, Feldstein and Poterba (1984) empirically estimate, using variation in UI benefits and reservation wages,  $\frac{\partial \bar{w}}{\partial b} \in [13\%, 42\%]$ . In order to reconcile this range of estimates with the model-based expression for  $\frac{\partial \bar{w}}{\partial b}$ , it must be the case that risk aversion is relevant at existing UI benefit levels.

It is worth emphasizing that we are not expressing the individual’s decision problem explicitly in terms of the unemployment rate to see how it affects her behavior. This is different from decision problems that explicitly model the impact of aggregate variables on individual outcomes.<sup>15</sup> Rather, the result we obtain is due to the fact that the search model implies an *equilibrium* or *steady-state* relationship between the responsiveness of the reservation wage to benefits and the unemployment rate. Equation (6) tells us that the equilibrium unemployment rate is a sufficient statistic for the marginal effect of benefits on the reservation wage. While others have derived similar expressions for  $\frac{\partial \bar{w}}{\partial b}$ , we believe that this is a novel point that has not been highlighted in the literature on job search.<sup>16</sup>

To develop some intuition for the expression for  $\frac{\partial \bar{w}}{\partial b}$ , let us start by considering the simplest case where individuals are risk-neutral and  $\rho \rightarrow \infty$ . Under these assumptions, equation (4) implies that  $\bar{w} = b$ . Intuitively, a \$1 increase in benefits raises the marginal gain of rejecting a wage offer  $\bar{w}$  relative to the marginal cost by \$1, so the reservation wage increases by \$1 to restore the optimum,  $\frac{\partial \bar{w}}{\partial b} = 1$ .

Now consider  $\rho < \infty$ . In this case, a \$1 increase in benefits corresponds to a less than \$1 increase in the reservation wage. The key thing to note is that a \$1 increase in  $b$  raises the benefit level in every period. This has two effects on the reservation wage. First, there is a direct effect as the \$1 increase in  $b$  *today* drives a wedge between the marginal benefit and cost of rejecting a wage offer of  $\bar{w}$ . Holding fixed the option value of unemployment,

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<sup>13</sup>Estimating the *elasticity* of the reservation wage with respect to the benefit level requires additional information on benefit levels and reservation wages, at the given unemployment rate.

<sup>14</sup>Source: Bureau of Labor Statistics

<sup>15</sup>For example, consider the consumer utility maximization problem where individual demand depends on the market price, which is determined in equilibrium.

<sup>16</sup>Chesher and Lancaster (1983) derive a similar expression for  $\frac{\partial \bar{w}}{\partial b}$  but since they assume  $s = 0$ , they do not highlight the connection to the unemployment rate.

this causes the reservation wage to increase by \$1. Second, the \$1 increase in benefits raises the value of unemployment in the future. This latter effect reduces the option value of unemployment and tends to lower the reservation wage today, mitigating the effect of the benefit increase on the reservation wage. One can see that this option value effect depends on the ratio of  $\lambda$  relative to  $s$ . Taking  $\rho = 0$ , this ratio determines the unemployment rate. This logic establishes the connection between the responsiveness of reservation wages to benefits and the unemployment rate.

Another intuitive way to think of this result is through the term  $\rho + s + \lambda(1 - F(\bar{w}))$ . This represents the agent's effective discount rate when there is uncertainty due to layoffs and random job offer arrivals. An adverse shock to  $\lambda$  reduces the agent's discount rate, effectively making him more responsive to variation in his future income stream.

We have shown that we can unambiguously determine how the responsiveness of reservation wages to benefits varies with the unemployment rate. Next, we consider the partial elasticity of expected duration:

$$\varepsilon_{D,b} = \frac{\partial \log D}{\partial \log b} = \theta(\bar{w}) \times \bar{w} \times \frac{\partial \log \bar{w}}{\partial \log b} \quad (7)$$

$$\varepsilon_{D,b} = \theta(\bar{w}) \frac{U'(b)}{U'(\bar{w} - \tau)} \frac{\rho + s}{\rho + s + \lambda(1 - F(\bar{w}))} b \quad (8)$$

where  $\theta(\bar{w}) \equiv \frac{f(\bar{w})}{1 - F(\bar{w})}$  is the hazard rate (or failure rate) of the wage offer distribution evaluated at the reservation wage. Moreover, if  $\rho \approx 0$ ,

$$\varepsilon_{D,b} \approx \frac{U'(b)}{U'(\bar{w} - \tau)} \theta(\bar{w}) u b \quad (9)$$

This expression is positive so that an increase in  $b$  raises  $\bar{w}$  and increases  $D$ . The fact that benefits increase unemployment does not necessarily mean the individual is worse off. Since she *chooses* to be unemployed longer, by revealed preference, she must be better off from a private welfare standpoint.<sup>17</sup>

Expression (9) shows that the duration elasticity depends on four factors: (1) risk aversion

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<sup>17</sup>This does not imply that social welfare is increased since the agent imposes a negative externality on the government's budget. We return to the normative implications below.

(through the ratio of marginal utilities), (2) the hazard rate of the wage offer distribution, (3) the unemployment rate and (4) the unemployment benefit level. How moral hazard varies with the unemployment rate depends crucially on how  $\theta(\bar{w})$  varies with  $u$ . In principle, we cannot sign this relationship since it depends on the functional form of the wage offer distribution and also on whether the wage distribution directly varies with the unemployment rate.

If we assume that  $F$  does not vary directly with unemployment, we would need to know how  $\bar{w}$  varies with  $u$  and how  $\theta(\bar{w})$  varies with  $\bar{w}$ . According to Van den Berg (1994), most of the distributions used in structural job search analysis have hazards that are decreasing in  $\bar{w}$ ,  $\frac{\partial \theta(\bar{w})}{\partial \bar{w}} < 0$ . In this case, the model predicts that the moral hazard cost of UI increases during recessions for conservative levels of risk aversion, in contrast to the hypothesis of Krueger and Meyer discussed in the introduction. In section 2.3, we present simulations of the model that explore the relationship between  $\varepsilon_{D,b}$  and  $u$  under a parametric assumption on the wage offer distribution.

The effect of the unemployment rate on the duration elasticity is working purely through the reservation wage channel in this model, since the job offer arrival rate is exogenous. Below we study a model which incorporates endogenous search effort. In this case, the effect of the unemployment rate on the duration elasticity comes both from variation in the reservation wage elasticity and variation in the search effort elasticity.

### 2.2.1 Incorporating Endogenous Search Effort

The search model shows that UI benefits raise unemployment durations since they put upward pressure on reservation wages, which in turn reduces the probability that a worker gets an acceptable wage offer. Several empirical studies, however, find that increases in benefits do not affect the distribution of accepted wage offers, suggesting that the effect on reservation wages is small (e.g., Card, Chetty, and Weber 2007).<sup>18</sup> In this section, we allow for the possibility that individuals can affect the job offer arrival rate through costly search effort (Rogerson, Shimer, and Wright 2005). This provides an additional channel through

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<sup>18</sup>One can show that the expected wage satisfies  $E_w[w|w \geq \bar{w}] = \bar{w} + \frac{\int_{\bar{w}}^{\infty} [1-F(w)]dw}{1-F(\bar{w})}$ . Thus, if benefits do not affect average wages, they must not greatly affect reservation wages.

which UI benefits can increase the length of unemployment spells.

Let search effort be denoted by  $e$  and let the arrival rate be given by  $\lambda(e)$ , where  $\lambda' \geq 0$  and  $\lambda'' \leq 0$ . In this case, it is easy to show that

$$\varepsilon_{D,b} = \theta(\bar{w}) \times \bar{w} \times \frac{\partial \log \bar{w}}{\partial \log b} - \delta(e) \times e \times \frac{\partial \log e}{\partial \log b} \quad (10)$$

$$\varepsilon_{D,b} \equiv \varepsilon_{D,b}^{\bar{w}} + \varepsilon_{D,b}^e \quad (11)$$

where  $\delta(e) \equiv \frac{\lambda'(e)}{\lambda(e)}$ . The first part of expression (10), which we denote by  $\varepsilon_{D,b}^{\bar{w}}$ , is simply the duration elasticity with no search decision. The second term of expression (10), which we label  $\varepsilon_{D,b}^e$ , is the duration elasticity that would prevail in a model with a fixed wage and an endogenous arrival rate. Clearly, how the duration elasticity varies with the unemployment rate depends crucially on how  $\frac{\partial \log e}{\partial \log b}$  varies with  $u$  in addition to how  $\frac{\partial \log \bar{w}}{\partial \log b}$  varies with  $u$ .

To analyze this expression, we study the optimality conditions for search effort and the reservation wage. We assume a non-pecuniary and separable search cost, denoted by  $\psi(e)$ , that is strictly increasing and convex. To simplify the algebra, it is convenient to define the *surplus function*  $\varphi(\bar{w}) \equiv \int_{\bar{w}}^{\infty} [U(w - \tau) - U(\bar{w} - \tau)] dF(w)$ , with the following property,  $\frac{\partial \varphi(\bar{w})}{\partial \bar{w}} = -(1 - F(\bar{w}))U'(\bar{w} - \tau)$ . The implicit equation for the reservation wage can be written compactly as

$$U(\bar{w} - \tau) = U(b) - \psi(e) + \frac{\lambda(e)}{r + s} \varphi(\bar{w}) \quad (12)$$

The optimal level of effort,  $e$ , can be found by maximizing  $U(\bar{w} - \tau)$ . The first-order condition assuming an interior optimum is

$$\psi'(e) = \frac{\lambda'(e)}{r + s} \varphi(\bar{w}) \quad (13)$$

Thus, the optimal search level equates the marginal cost of effort (left-hand side) with the marginal value of effort (right-hand side).<sup>19</sup> The marginal value of effort depends on the marginal increase in the likelihood of obtaining a job in response to an increase in effort and

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<sup>19</sup>UI benefits in this model affect search effort only through the marginal benefit of search via the reservation wage,  $\bar{w}$ . In a model with a monetary cost of search that reduced consumption and/or a time cost of search, UI benefits would also affect optimal search effort through the marginal cost of search. This alternative formulation is considered in Mortensen (1977).

the expected discounted surplus of getting a job. Note that searching harder only affects the likelihood of getting an offer, but does not affect expected income, conditional on getting a job.<sup>20</sup> The model therefore predicts that a positive shift in the marginal efficiency of search effort increases search intensity of the unemployed; in other words, search intensity is procyclical.

Substituting equation (13) into equation (12) yields the following expression:

$$U(\bar{w} - \tau) = U(b) + \frac{\lambda(e)}{\lambda'(e)}\psi'(e) - \psi(e) \quad (14)$$

The conditions (13) and (14) comprise a system of equations, which implicitly (and jointly) determine the optimal reservation wage and the optimal level of search effort, as functions of the level of UI benefits. We differentiate this system with respect to  $b$  to solve for  $\frac{\partial \bar{w}}{\partial b}$  and  $\frac{\partial e}{\partial b}$ . The results are stated in the next lemma.

**Lemma 1** *The marginal effects with endogenous search intensity satisfy*

$$\frac{\partial \bar{w}}{\partial b} = \frac{U'(b)}{U'(\bar{w} - \tau)} \frac{\rho + s}{\rho + s + \lambda(e)(1 - F(\bar{w}))} \quad (15)$$

$$\frac{\partial e}{\partial b} = -\frac{U'(b)}{\psi''(e) - \frac{\lambda''(e)}{s}\varphi(\bar{w})} \frac{\lambda'(e)(1 - F(\bar{w}))}{\rho + s + \lambda(e)(1 - F(\bar{w}))} \quad (16)$$

**Proof.** See Appendix A. ■

**Corollary 2** *If  $\rho \approx 0$*

$$\frac{\partial \bar{w}}{\partial b} = \frac{U'(b)}{U'(\bar{w} - \tau)} u \quad (17)$$

$$\frac{\partial e}{\partial b} = -\frac{U'(b)}{\psi''(e) - \frac{\lambda''(e)}{s}\varphi(\bar{w})} \delta(e)(1 - u) \quad (18)$$

First, consider the expression for  $\frac{\partial \bar{w}}{\partial b}$ . Adding endogenous search effort does not change the formula for how the reservation wage responds to the benefit level. This result follows directly from the envelope theorem.<sup>21</sup> Next, consider the expression for  $\frac{\partial e}{\partial b}$ . Note that

<sup>20</sup>This follows from the assumption that search effort affects only the arrival rate, not the wage distribution.

<sup>21</sup>However,  $\frac{\partial \bar{w}}{\partial b}$  still depends on search effort indirectly through  $u$  and  $\bar{w}$ .

$\frac{\partial e}{\partial b} < 0$ ; that is, an increase in benefits lowers the marginal gain of search since it decreases expected surplus from employment,  $\varphi(\bar{w})$ .

Examining expression (16), a decline in labor demand impacts the effect of UI benefits on search effort through several channels. First, a negative labor demand shock lowers  $\lambda(e)$ . Second, a negative labor demand shock lowers  $\lambda'(e)$ . When  $\lambda(e)$  is low, the reduction in the marginal return to search effort from an increase in benefits is high. This follows from the result above that a low value for  $\lambda(e)$  makes the reservation wage more responsive to UI benefits. Since the marginal gain of effort depends directly on the reservation wage through the surplus function,  $\varphi(\bar{w})$ , this makes the marginal gain of effort more responsive to UI benefits and acts to increase  $\frac{\partial s}{\partial b}$ .

On the other hand, a low  $\lambda'(e)$  directly affects the incentive to search harder. This is because the marginal return to effort is increasing in  $\lambda'(e)$ . Thus, a low value for  $\lambda'(e)$  translates into a low value for  $\frac{\partial s}{\partial b}$ . It follows that the net effect of depends on how fast  $\lambda'(e)$  falls relative to  $\lambda(e)$ .<sup>22</sup> This is visible in equation (18). Since a negative labor demand shock increases the unemployment rate, the net effect ultimately depends on how the shock affects  $\delta(e)$ . As a reminder,  $\delta(e)$  represents the *percentage change* in the job offer arrival rate from an additional unit of search. A larger value of  $\delta(e)$  means that search is more productive. Thus, the key is whether search is more productive on the margin in a weak or strong local labor market. In a weak market, we would expect  $\lambda(e)$  to be small, which would act to increase  $\delta(e)$ . On the other hand,  $\lambda'(e)$  is also likely to be small which lowers  $\delta(e)$ , so the net effect depends on the rate at which  $\lambda'(e)$  falls relative to  $\lambda(e)$ . As Kiley (2003) discusses, it is possible to specify functional forms so that the net effect can go either way. As a result, the question is ultimately an empirical one.

The main result of this section is to show that whether moral hazard increases or decreases with the unemployment rate depends on the precise specification of the search model; in particular, the relative strength of the reservation wage channel and search effort channel. We present an illustrative calibration in the next section that demonstrates these two channels and shows how they vary with the unemployment rate.

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<sup>22</sup>It is possible that a period of low labor demand affects the term  $\frac{\lambda''(e)}{s}\varphi(\bar{w})$ , although signing this effect seems less intuitive.

## 2.3 Calibrating $\varepsilon_{D,b}$

This section evaluates the duration elasticity numerically by calibrating the search model. The calibrations allow us to evaluate the key factors that drive the relationship between the duration elasticity and the unemployment rate. Additionally, the calibrations shed light on the potential quantitative impact of the local unemployment rate on the duration elasticity, making them a useful power calculation. We first present results from the reservation wage model, and then we present a separate set of results from a fixed wage, endogenous search effort model; finally, we present results from the model with both stochastic wage offers and an endogenous job offer arrival rate.

### 2.3.1 Functional Form Assumptions

The unit of time for the calibrations is a week. For all of these calculations, we assume  $r = 0$ .

*Wage Offer Distribution.* In the reservation wage model, we assume wages are distributed log-normally, with a mean weekly wage of \$250 and standard deviation of \$50. In fixed wage model, we assume the weekly wage is \$250.

*Arrival Rates.* In the reservation wage model, we assume job offers arrive exogenously at rate  $\lambda$ . In the fixed wage, search effort model, we assume that job offers arrive according to  $\lambda(e) = \Lambda e^\lambda$ , where  $e$  is endogenous search effort decision. In both models, separations end exogenously at rate  $s$ . Following Shimer (2007), we use weekly separation rate of  $s = .0089$ .

*UI Benefits.* Following Chetty (2008), we assume a UI replacement rate of 50%. For these simulations, we assume taxes are set so that the budget is balanced in expectation.

*Preferences over consumption.* We assume standard CRRA utility function,  $U(c) = \frac{c^{1-\gamma}}{1-\gamma}$ , where  $\gamma > 0$  is the coefficient of relative risk aversion (and as  $\gamma \rightarrow 1$ ,  $U(c) \rightarrow \log c$ ). Given the considerable uncertainty over this parameter in the literature, we explore several values in our simulations ( $\gamma = 1.75$  and  $\gamma = 3$ ).

*Search Effort.* We model search costs as a function of effort as  $\psi(e) = \phi \frac{e^{1+\kappa}}{1+\kappa}$ , where  $\phi$  is a scaling parameter. The elasticity of search costs with respect to search effort is  $1 + \kappa$ . So a higher  $\kappa$  increases the marginal cost of search and lowers search effort.



### 2.3.2 Results

Table 1 reports results from the reservation wage model calibration. Several values of  $\lambda$  are chosen, each representing an alternative labor market condition; as  $\lambda$  declines the unemployment rate ( $u$ ) increases. There are several patterns evident in this table. First, the reservation wage declines as  $\lambda$  decreases. However, the duration elasticity decreases with  $\lambda$ . This implies that the welfare gain of expanding UI decreases with the unemployment rate (i.e.,  $dW/db$  is increasing in  $\lambda$ ).

Table 2 reports results from the fixed wage, endogenous search effort model. As in previous table, we report results across alternative values of  $\lambda$ , where (as before) lower values of  $\lambda$  correspond to higher unemployment rates. Because effort and  $\lambda$  are complements, as  $\lambda$  decreases, the agent chooses lower search effort. However, in contrast to the previous table, the duration elasticity is increasing with  $\lambda$ , which translates into a welfare gain of expanding UI which is larger when the unemployment rate is high (i.e.,  $dW/db$  is decreasing in  $\lambda$ ). It is also worth emphasizing the magnitude of this relationship. Moving from  $\lambda = 0.5$  to  $\lambda = 0.4$ , the unemployment rate increases by roughly 1.4 percentage points and the duration elasticity declines by roughly 20%.

Lastly, Table 3 reports results from a model which incorporates both a reservation wage decision and a search effort decision. The table decomposes the duration elasticity into two components ( $\varepsilon_{D,b}^e$  and  $\varepsilon_{D,b}^{\bar{w}}$ ), where  $\varepsilon_{D,b}^e$  is the component of the duration elasticity coming through search effort and  $\varepsilon_{D,b}^{\bar{w}}$  is the component of the duration elasticity coming through the reservation wage decision (see equation (10)). As would be expected based on the results of Tables 1 and 2,  $\varepsilon_{D,b}^e$  is decreasing in  $u$  and  $\varepsilon_{D,b}^{\bar{w}}$  is increasing in  $u$ . For the specific parameters chosen in this calibration, the overall duration elasticity ( $\varepsilon_{D,b}$ ) is decreasing in  $u$ , and this translates into a welfare gain of expanding UI which is larger when the unemployment rate is high.

We conclude that for sensible parameter values, the duration elasticity can vary substantially with the unemployment rate, and that the direction it varies depends on the specific parameters used to calibrate the model. This suggests that, in contrast with some claims in the literature, the reservation wage model and the fixed wage, endogenous search effort

model may have very different welfare implications when considering how UI should optimally vary with the unemployment rate.<sup>23</sup> The next section considers a welfare analysis for the full model, including both choice of the reservation wage and endogenous search effort.

## 2.4 Welfare Analysis: Optimal Unemployment Benefits

In this section, we consider the welfare implications of our findings above. We assume that a social planner chooses the UI benefit level to maximize expected utility of an unemployed individual. The benefit level must satisfy a balanced-budget condition in expectation. We allow the planner to condition the benefit level on the unemployment rate,  $u$ . The social planner solves the following problem:

$$\begin{aligned} & \max_{b, \tau} V_u \\ \text{s.t. } & Db = \frac{\tau}{r + s} \end{aligned}$$

We begin by considering the first-best solution to this problem. This allows us to shed light on the source of the moral hazard or inefficiency when we turn to a second-best setting. The social planner sets  $b$ ,  $\bar{w}$  and  $e$  jointly.

**Theorem 3** *At the optimum, the first-best benefit level satisfies the Borch condition*

$$U'(b) = E[U'(w - \tau) | w \geq \bar{w}] \tag{19}$$

*Proof.* See Appendix A. ■

Equation (19) is a standard condition for full insurance. Since the wage is stochastic, marginal utilities across states cannot perfectly be equated; rather they are equated, on average. We now consider a second-best world where the social planner sets the optimal

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<sup>23</sup>For example, Lentz and Traenes (2005) write that “We do not believe that it is crucial whether the problem is formulated as a choice of reservation wage given a fixed search intensity or (as here) as a choice of search intensity given a fixed wage.” While there are many settings where this is true, our calibration results in this section suggest that when studying the *interaction* between optimal UI and the unemployment rate, this modelling choice is not innocuous.

UI policy, taking the agent's optimal behavior  $(\bar{w}, e)$  as given. The following theorem characterizes the money-metric marginal welfare gain of increasing benefits by \$1.<sup>24</sup>

**Theorem 4** *With  $r = \rho = 0$ , the money-metric welfare gain of raising  $b$  is given by*

$$\frac{dW}{db} = \frac{u}{1-u} \left\{ \frac{U'(b) - E[U'(w-\tau)|w \geq \bar{w}]}{E[U'(w-\tau)|w \geq \bar{w}]} - \varepsilon_{D,b} \right\} \quad (20)$$

*At the optimum,*

$$\frac{U'(b) - E[U'(w-\tau)|w \geq \bar{w}]}{E[U'(w-\tau)|w \geq \bar{w}]} = \varepsilon_{D,b} \quad (21)$$

**Proof.** See Appendix A. ■

A heuristic derivation of equation (21) is as follows.<sup>25</sup> Let  $\bar{g} = \frac{U'(b)}{E[U'(w-\tau)|w \geq \bar{w}]}$  be the money-metric amount such that, the government is indifferent between giving \$1 to someone who is unemployed and  $\bar{g}$  to someone who is employed. Next, consider a \$1 increase in benefits. This has a mechanical effect on UI expenditures and a behavioral effect. First, the mechanical effect,  $M$ , is given by  $Ddb$ . By definition of the welfare weight  $\bar{g}$ , this mechanical effect is valued by the government at  $(1 - \bar{g})M$ , because each dollar given to the unemployed decreases the net wage of the employed and this loss in income is valued  $\bar{g}$  by the government.

Second, there is an increase in expenditures that must be financed due to the behavioral response, and the total behavioral cost is given by  $B = \frac{\partial D}{\partial b} b db = \varepsilon_{D,b} D db$ . There is no welfare effect due to behavioral responses which follows from a simple application of the envelope theorem. At the optimal benefit level, the sum of the mechanical and behavioral effects must be equal to zero. Thus, at an optimum,  $(1 - \bar{g})M + B = 0$ . Rearranging this equation delivers the result.

The way to interpret equation (20) is as follows. If at current levels of UI benefits,  $dW/db > 0$ , this implies that raising UI benefits would increase welfare. Thus,  $dW/db$

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<sup>24</sup>Shimer & Werning (2007) note that since  $V_u = U(\bar{w} - \tau)/\rho$ , the planner's problem is simply to maximize the worker's after-tax reservation wage,  $\bar{w} - \tau$ . By maximizing  $\bar{w} - \tau$ , Shimer & Werning implicitly derive a money-metric expression for the welfare gain of UI that normalizes  $\frac{dV_u}{db}$  by  $U'(\bar{w} - \tau)/\rho$ . To get a money-metric welfare gain, we take a different approach and follow Chetty (2008) by normalizing by the welfare gain of increasing the wage by \$1 in the high state. The connection between the two approaches is formalized in Appendix A.

<sup>25</sup>This derivation closely follows the derivation of the optimal top tax rate in Saez (2001).

should be viewed as a test for whether current benefit levels are optimal. The test for the optimality of UI benefits illustrates the standard trade-off between the insurance role of UI benefits against the disincentive effect. Moral hazard arises in the second-best world, since agents do not internalize the planner's balanced-budget constraint. Thus, they impose an externality on the planner's budget, which is captured by the elasticity of duration with respect to UI benefits,  $\varepsilon_{D,b}$ . Chetty (2008) shows in a search effort model that an increase in UI benefits has both a liquidity effect and a substitution effect on search effort. Conditional on  $\varepsilon_{D,b}$ , a higher liquidity effect relative to substitution effect leads to a higher  $dW/db$ . This decomposition is implicit in equation (20). A stronger liquidity effect would show up as a large gap in the marginal utilities. To take the extreme case where individuals are "hand-to-mouth", unemployment consumption increases one-for-one with the benefit level. Thus, the formula implies higher UI benefits when liquidity effects are strong.

Expression (20) shows that marginal value of unemployment insurance is increasing in the unemployment rate through the term  $u/(1-u)$ . Intuitively, when shocks are more common, unemployment insurance is more valuable. We now examine the effect of the unemployment rate on the optimal benefit level.

#### 2.4.1 Optimal UI and Unemployment

To see how the optimal benefit level varies with the unemployment rate, we need to consider how both sides of equation (21) vary with the unemployment rate. Since we already considered how  $\varepsilon_{D,b}$  varies with the unemployment rate, let us focus our attention on how the consumption smoothing or insurance effect varies with the unemployment rate. First, the unemployment rate has an effect on the left-hand side of equation (21) that operates through the balanced-budget constraint. To see this, consider the case where UI benefits are not distortionary. The government budget constraint implies that for  $r = 0$ ,

$$\frac{\partial \tau}{\partial b} = \frac{u}{1-u}$$

Thus, when unemployment is high, more taxes need to be raised to finance a given level of benefits. This lowers the marginal utility of consumption for the employed relative to

marginal utility of consumption for the unemployed since the net wage is  $w - \frac{u}{1-u}b$ ; in order to restore optimality, benefits need to be reduced. Andersen and Svarer (2009) label this a "budget effect" since the effect comes purely from the need to satisfy the balanced-budget constraint.<sup>26</sup> This shows that the insurance effect depends indirectly on the unemployment rate and implies that benefits should be procyclical.

Second, there is an additional channel through which the unemployment rate can affect consumption smoothing. This is due to the fact that the expected marginal utility of consumption when employed is conditional on the reservation wage. If the reservation wage varies with the unemployment rate, this affects consumption smoothing. Clearly with a fixed wage, there is no reservation wage decision. Thus, the extent to which consumption smoothing varies with the unemployment rate depends on whether search is more accurately characterized by a reservation wage model or a search effort model.

On the other hand, if the moral hazard effect of UI increases with the job finding rate (when unemployment is low), this tends to raise the optimal benefit level when unemployment is high. Thus, the net effect of the unemployment rate on the optimal benefit level depends on the relative strengths of the budget and consumption smoothing effect and the distortion effect. In section 5, we show how we can use our empirical estimates of how the duration elasticity varies with the local unemployment rate to compute how UI benefit levels should optimally respond to local labor market conditions. The next section describes our empirical strategy which estimates how the duration elasticity varies with unemployment.

### 3 Estimation Strategy and Data

Our empirical strategy consists of two parts: (1) graphical evidence and nonparametric tests of survival curves and (2) semi-parametric estimates of proportional hazard models (Cox models). The empirical strategy closely follows Chetty (2008).

We use unemployment spell data from the SIPP spanning 1985-2000. We impose the same sample restrictions as in Chetty (2008): we focus on prime-age males who (a) report

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<sup>26</sup>In our model, we implicitly assume that the budget constraint has to balance in expectation in each state (e.g., at each  $u$  or  $\lambda$ ). One can imagine a budget constraint where benefits paid out and taxes collect in expectation must balance *across* states. This problem is taken up in Anderson and Svarer (2009).

searching for a job, (b) are not on temporary layoff, (c) have at least three months of work history, and (d) took up UI benefits.<sup>27</sup> We focus on two alternative proxies for individual’s actual UI benefits: (1) average benefits for each state-year pair and (2) maximum weekly benefit amount. In ongoing work, we are working to implement an instrumental variables hazard model, where the goal is to construct a simulated instrument which isolates policy variation in individual UI benefits that is driven purely by change in UI laws (Gruber 1997).

### 3.1 Graphical evidence and nonparametric tests

We begin by providing graphical evidence on the effect of unemployment benefits on durations. We split the sample into two sub-samples, according to whether individuals begin their unemployment spell in states with above-median unemployment or in states with below-median unemployment. Each year we define the median unemployment rate across states. We then categorize a state as having either above or below median unemployment that year. We then assign monthly unemployment rates to unemployment spells based on the unemployment rate in the state that the individual resides in when the spell began. We also categorize unemployment spells based on whether the prevailing UI benefit level at the start of the spell in a given state and year is above or below the median UI benefit level for that year.

Figures 1 and 2 show the effect of UI benefits on the probability of unemployment for individuals in above-average and below-average unemployment state-years, respectively. In each figure, we plot Kaplan-Meier survival curves for individuals in low-benefit and high-benefit states.<sup>28</sup> The results in figure 1 show that the curves are fairly similar in both low-benefit and high-benefit states when the unemployment rate in a state-year is above the median unemployment rate. The curve in high-benefit states is slightly higher, indicating that UI benefits may marginally increase benefits, but a nonparametric test that the curves are identical does not reject at conventional levels ( $p = 0.156$ ). By contrast, in figure 2 the curves are noticeably different; in particular, the durations are significantly longer in

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<sup>27</sup>In ongoing work, we are expanding the sample to include eligible, non-takers, in order to empirically examine whether take-up varies with the unemployment rate.

<sup>28</sup>Following Chetty (2008), the plotted curves are adjusted for the “seam effect” in the SIPP panel data, but the test that the survival curves are identical is fully nonparametric and does not make this adjustment.

high-benefit states, and the difference between the survival curves is strongly statistically significant ( $p < 0.001$ ).

These figures show that the moral hazard effect of UI benefits depends crucially on whether unemployment is high or low. In particular, our findings suggest that the effect of UI benefits on durations is not statistically significant when the unemployment rate is high but is strongly statistically significant when the unemployment rate is low.<sup>29</sup> These comparisons are based on simple comparisons across spells. It is possible, however, that the characteristics of individuals vary with unemployment rate in a way that would bias these comparisons. To investigate this potential bias, the next subsection reports semi-parametric proportional hazard models which include a rich set of individual-level controls. The results from the hazard models are broadly consistent with the results based on these figures.

### 3.2 Semiparametric Hazard Models

We investigate robustness of the graphical results by estimating a set of Cox proportional hazard models in Tables 5 through 11.<sup>30</sup> Each table reports results with alternative sets of control variables in the columns. The baseline estimating equation is the following:

$$\log d_{i,s,t} = \alpha_t + \alpha_s + \beta_1 \log(b_{i,s,t}) + \beta_2 (\log(b_{i,s,t}) \times u_{s,t}) + \beta_3 u_{s,t} + \mathbf{X}_{i,s,t} \Gamma + e_{i,s,t} \quad (22)$$

where  $d_{i,s,t}$  is the duration of the unemployment spell,  $\alpha_t$  and  $\alpha_s$  represents year and state fixed effects,  $b_{i,s,t}$  is the unemployment benefit for individual  $i$  at start of spell,  $u_{s,t}$  is the state unemployment rate at the start of the spell and  $\mathbf{X}_{i,s,t}$  is a set of (possibly time-varying) control variables.<sup>31</sup> The unemployment rate at the start of the spell is de-measured so that

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<sup>29</sup>We have also looked at the subsample of workers with above-median liquid wealth, and we find broadly similar results (see Appendix Figures A1 and A2). These results suggest that liquidity effects are not primarily accounting for the differential duration elasticity between high and low unemployment, which is broadly consistent with our results in Table 7, described below.

<sup>30</sup>We are looking into alternative semiparametric hazard models to broaden the scope of the empirical analysis. Concerns have been raised that Cox models may not be reliable in the presence of ties. As such, we are planning to also report Han-Hausman (1990) estimates, which are more reliable when the number of ties is large relative to the sample size.

<sup>31</sup>The notation of the estimating equation is a simplified presentation of the actual model. The actual (latent) hazard rate is the true left-hand side variable, but is not actually observed in the data; additionally, there is a flexible (nonparametric) baseline hazard rate which is also estimated when fitting the Cox pro-

the coefficient  $\beta_1$  is the elasticity of unemployment durations with respect to UI benefits at the average unemployment rate. The coefficient on the interaction term ( $\beta_2$ ) is the incremental change in the duration elasticity for a one percentage point change in the state unemployment rate.

The identifying assumption that allows us to interpret  $\beta_2$  as a test of whether the duration elasticity varies with the unemployment rate is the following: conditional on the average UI weekly benefit amount, state unemployment rate, state fixed effects, year fixed effects, and controls variables, there are no omitted determinants of the duration of an unemployment spell that vary with the *interaction* of average UI weekly benefit amount and the state unemployment rate. This assumption is considerably more plausible with the inclusion of state and year fixed effects. In the same spirit as a typical difference-in-difference setting, it is only a problem for our analysis if average UI weekly benefit changes within states vary across states with different unemployment rates in ways that are correlated with unemployment duration. In Section 3.2.1, we discuss several potential threats to validity and a number of alternative specifications. Our results generally support this identifying assumption.

Before turning to our regression results, we present descriptive statistics in Table 4. The table presents summary statistics for the overall sample and the two sub-samples used to create figures 1 and 2. One can see that in high unemployment states, average income, education, the fraction married, UI benefits, are all lower than in low unemployment states. Individuals are also slightly older in these states. Since the distribution of observables is different across the two samples, one question that arises when considering how the duration elasticity varies with unemployment is whether this relationship is coming from “selection” (i.e., compositional changes in the unemployed population due to changes in the local labor market conditions) and how much of it is coming from an actual change in the behavioral response. This will depend on the extent to which the duration elasticity varies directly with demographics, which we investigate in detail in Table 9 below.

The main results are reported in Table 5. Column (1) of Table 5 reports results of a

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proportional hazard model. Following Chetty (2008), we fit a separate baseline hazard rate for each quartile of net liquid wealth, although our results are similar when a single nonparametric baseline hazard rate is estimated instead.



specification broadly similar to the previous literature (Moffitt (1985), Meyer (1990), Chetty (2008)). This specification controls for age, marital status, years of education, a full set of state, year, industry and occupation fixed effects, and a 10-knot linear spline in log annual wage income. The results indicate that the elasticity of durations with respect to the UI benefit level is  $-0.651$  (s.e.  $0.318$ ) and the estimate is statistically significant at conventional levels ( $p = 0.041$ ). Column (2) reports estimates of equation (22) above. This column includes the same set of controls in column (1) and estimates the same hazard model; the only difference is the addition of an interaction term between the UI benefit level and the state unemployment rate. The coefficient on the interaction term ( $\beta_2$ ) represents the change in the duration elasticity for a one percentage point increase in the state unemployment rate. The results in column (2) show an estimate of  $\beta_2$  of  $0.142$  (s.e.  $0.068$ ). The bottom two rows show an alternative way to interpret the interaction term. These rows report the duration elasticity and one standard deviation above and below the mean unemployment rate. At one standard deviation below the mean, the duration elasticity is  $0.502$  (s.e.  $0.326$ ), while at one standard deviation above the mean the duration elasticity is  $0.980$  (s.e.  $0.388$ ). These results imply that the moral hazard effect of UI varies significantly with unemployment, and that the magnitude of the duration elasticity is decreasing with local labor market conditions.

### 3.2.1 Robustness Tests

#### *Alternative Measures of Interaction Term.*

Table 6 reports results which replace the interaction of UI benefit generosity (average weekly benefit amount) and the state unemployment rate with alternative measures of each variable in the interaction term. Each row reports alternative measures of the interaction term.

The first row of Table 6 reproduces our baseline estimates for comparison. The second row replaces the state unemployment rate with a dummy for whether or not the unemployment rate is greater than the median state unemployment rate in that year. This specification corresponds more closely to the nonparametric results presented above. The third row replaces the average weekly benefit amount with the maximum weekly benefit amount. The maximum weekly benefit amount corresponds more to a specific policy para-

meter that states directly adjust from time-to-time. Thus, the robustness of the estimates to the use of this measure is likely to shed some light on whether the variation in average weekly UI benefits is plausibly exogenous (conditional on state and year fixed effects). The estimates of the interaction term is similar in magnitude to the baseline specification.

Finally, in the last two rows, we report results from a specification where we decompose variation in the unemployment rate into variation between and within states. Rows (4) and (5) in Table 6 report results from interacting benefits with these two measures separately. This allows us to see *separately* how variation in unemployment rate coming from across states and within states affect the duration elasticity. Reassuringly, we find that the effects in the two rows are fairly similar to the baseline specification and also fairly similar to each other (the p-value of the test that the two interaction terms are equal is 0.298). Therefore, we conclude that the variation in unemployment rate affects the duration elasticity regardless of whether that variation is coming from between states or within states.

*State-Occupation Cells as an Alternative Definition of Local Labor Market.*

While the results in Table 6 suggest that our results are robust to alternative definitions of the interaction term, there remains the possibility that UI benefit levels respond endogenously to unobserved local labor market conditions, which themselves directly affect both the local unemployment rate as well as the expected unemployment duration. This would violate our identifying assumption and bias our results. We address this concern in Table 7, but we first note that this scenario likely biases against our findings in the baseline specification (i.e., causes negative bias in  $\beta_2$ ). If UI benefit levels respond endogenously to poor local labor market conditions, this will mechanically increase duration elasticity during times of high unemployment, which works against our findings (i.e., attenuates negative relationship between duration elasticity and unemployment rate). As a result of this, one may interpret our baseline results as an underestimate of the relationship between the duration elasticity and the unemployment rate.

To address this endogeneity bias directly, we gathered data on annual unemployment rates by state-occupation cells, and we used data on workers' previous occupation category to assign workers to cells.<sup>32</sup> We then estimate a variant of equation (22) where we replace

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<sup>32</sup>Roughly 1/3 of workers had missing data on previous occupation category. These workers are not

the state unemployment rate with the unemployment rate in a worker's state-occupation cell, and we control for both the state unemployment rate as well as the state-occupation unemployment rate. Table 7 presents these results. Though the interaction term is not estimated precisely in any of the specifications, the magnitudes of the point estimates are qualitatively similar. The bottom two rows of the table show that the duration elasticity varies negatively with the state-occupation unemployment rate by a similar magnitude to the baseline specification.

*Alternative Measure of Local Labor Market Conditions.*

So far, our specifications have used the unemployment rate as a measure of local labor demand. One concern with this measure is that it reflects both labor demand and labor supply shocks. We construct variation in state unemployment rates that is driven by plausibly exogenous shifts in local labor demand using a well-established procedure developed in Bartik (1991).<sup>33</sup> Figures 3 and 4 plot survival curves comparing the effect of UI benefits across high and low predicted employment to population ratios. Consistent with figures 1 and 2, this nonparametric evidence indicates that most of the effect of UI benefits is during periods of high predicted employment. Table 8 reports hazard model estimates, where we find similar point estimates to our baseline specifications, though our estimates are extremely imprecise with the inclusion of state fixed effects.

*Composition Bias and Selection on Observables.*

As explained above, the observation that the duration elasticity varies with unemployment can in principle be explained by two possibilities: first, a change in a given individual's job finding or job separation rate directly changes her responsiveness to benefits. Alternatively, if there is heterogeneity in moral hazard across demographic groups and the distribution of demographics of the unemployed varies with the level of unemployment, then this compositional change could be responsible for the change in the average duration elasticity. To test how much of the magnitude is coming through this compositional channel, we report estimates of our baseline specification where we add interactions between benefits and

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included in Table 7. Our baseline results are very similar when we drop these workers from the sample

<sup>33</sup>We closely following the implementation of the Bartik (1991) procedure in Autor and Duggan (2003). We predict the employment to population ratio by interacting initial cross-sectional distribution of state-level employment shares with national industry employment trends.

demographic controls. If the estimates of the interaction term in the baseline specification is mostly due to compositional changes (among demographic groups with different duration elasticities), then we would expect to see a reduction in the magnitude of the coefficient on the interaction between benefits and unemployment. Table 9 shows that our main result is quite robust to including such controls. Looking across columns, we see that adding interactions between demographics and benefits does not change the coefficient on our main coefficient of interest (the interaction term) in any substantive way. This appears to be primarily due to the fact that the duration elasticity does not appear to vary greatly with observable demographics.<sup>34</sup>

*Moral Hazard versus Liquidity.*

Recent work by Chetty (2008) raises a concern with interpreting the duration elasticity as a pure moral hazard effect. He presents compelling evidence that part of the observed duration elasticity is due to a “liquidity effect.” This suggests that the interaction term which we estimate in our baseline specification could plausibly represent a liquidity effect which varies systematically with local labor market conditions. We deal with this concern in two ways. First, we note that if it was the case that liquidity effects vary with local labor market conditions, we believe it is likely that liquidity constraints will tend to be more binding when local labor market conditions are poor. This will cause our estimates of how moral hazard varies with local labor market conditions to be downward biased, making it even more likely that the moral hazard cost of UI decreases with the unemployment rate. Second, we report results in Table 10 which directly address concerns about liquidity constraints. Column (1) reports our baseline specification for comparison. Columns (2) and (3) report results for subsamples where liquidity effects are likely to be less important. Column (2) focuses on the subsample of unemployed workers without a mortgage, while column (3) focuses on the subsample of unemployed workers in the 3rd and 4th quartiles of net liquid wealth. In both cases the coefficient on the interaction term is larger than in the baseline. The last two columns report results which include a full set of liquid wealth quartile dummy

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<sup>34</sup>Of course, the duration elasticity could vary with unobservable characteristics, though we cannot test this directly. To the extent that the distribution of these unobservable characteristics varies with local unemployment, then our estimates will include the effect of unobserved compositional changes in the sample of individuals experiencing unemployment spells.

variables interacted with a combination of occupation fixed effects, industry fixed effects, unemployment duration, and the UI benefit level. The results consistently support the interpretation that the moral hazard cost of UI decreases with the unemployment rate.

*Alternative Specifications and Controls.*

Finally, we report additional results in Table 11 which vary the specification and the set of controls. In column (2), we include region-specific linear time trends and show that our result gets stronger. Column (3) includes a full set of region fixed effects interacted with year fixed effects. Identification in this specification is coming from only from variation in benefits within region-year cells. In column (4), we include state-specific linear time trends. Our main results are fairly robust to these alternative specifications. Finally, columns (5) drops the control variables; the coefficient on the interaction terms fall in magnitude by 33% and is no longer statistically significant at conventional levels ( $p = 0.162$ ).

Overall, we interpret the results in this section as broadly consistent with our baseline specification which finds that the duration elasticity varies negatively with the unemployment rate. We now turn to a quantitative analysis of our model to try to match the empirical results presented in this section.

## 4 Quantitative Analysis of the Model

In this section, we demonstrate that the model in the paper can quantitatively account for the empirical estimates presented in the previous section. Rather than assuming parameters from the existing literature as we did in Section 2, we search for parameter values which can match the relationship between the duration elasticity and the unemployment rate that we observe in the data.<sup>35</sup> After searching over a large combination of randomly selected parameter values, we find that the parameter values which most closely match the data are plausible, providing further evidence that the variation in duration elasticity we estimate is indeed due to local labor market conditions affecting the return to search effort.

The details of this procedure are as follows. We construct 25,000 random configurations of the following parameters: coefficient of relative risk aversion ( $\gamma$ ), separation rate ( $s$ ), search

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<sup>35</sup>See Redding and Sturm (2008) for a similar quantitative analysis.

cost elasticity ( $1 + \kappa$ ), search cost scale parameter ( $\varphi$ ), and job offer arrival scale parameter ( $\Lambda$ ). Each random configuration is constructed by drawing independently from the following distributions (corresponding to the distributions for  $\gamma$ ,  $s$ ,  $1 + \kappa$ ,  $\varphi$ , and  $\Lambda$ , respectively): *Uniform*[1.1, 10], *Uniform*[0, 0.05], *Uniform*[0.1, 10], *Uniform*[0.1, 10], *Uniform*[0, 0.1]. For each parameter configuration, we compute the duration elasticity at  $u = 5.4\%$  (Shimer and Werning, 2007). We then compute how the duration elasticity varies with unemployment rate by considering local variation in  $\lambda$  and computing a numerical derivative. We then compare these simulated values of  $\beta_1$  and  $\beta_2$  to the empirical estimates of  $\hat{\beta}_1$  and  $\hat{\beta}_2$  and we compute mean squared error as follows:  $MSE = ((\beta_1 - \hat{\beta}_1)/\hat{\beta}_1)^2 + ((\beta_2 - \hat{\beta}_2)/\hat{\beta}_2)^2$ .

Table 12 reports the 10 parameter configurations with the lowest *MSE* values. We discuss the parameter configuration with the lowest *MSE* in the first row of the table. The value of the coefficient of relative risk aversion ( $\gamma$ ) of 4.03 is close to the value of 4.75 estimated in Chetty (2004) for a sample of unemployed individuals, though we emphasize that the literature contains a large range of estimates of this parameter (Cohen and Einav, 2007). The job separation rate ( $s$ ) of 0.0096 is close to the 0.0089 from Shimer (2007). The search cost elasticity value of 5.20 is close to the structural search cost elasticity estimate of 6.7 in Liu (2009). The very low MSE values indicate that the search model in this paper can quantitatively account for the empirical estimates. Overall, we interpret the results in this table as providing evidence that our model can very closely match the magnitude of the empirical relationship between the duration elasticity and the unemployment rate for plausible values of structural parameters. The combination of the closeness of the quantitative fit and the realistic values of structural parameters suggest that the model is suitable for welfare analysis.

## 5 Calibrating the Welfare Implications

Our empirical findings suggest that moral hazard decreases with the unemployment rate. To see what this finding implies for optimal policy, we now calibrate the optimal UI level implied by our model, following the spirit of the “sufficient statistic” approach to welfare analysis. To review, this method requires using the reduced form empirical estimates as

inputs into the optimal UI formula.

Our search model implies the following approximate structural relationship for the duration elasticity:

$$\varepsilon_{D,b} = \frac{U'(b)}{U'(\bar{w} - \tau)} \theta(\bar{w}) ub + \frac{U'(b)}{\psi''(e) - \frac{\lambda''(e)}{s} \varphi(\bar{w})} (\delta(e))^2 (1 - u)b$$

One can think of  $\varepsilon_{D,b} = h(u)$ , where  $h(\cdot)$  is a non-linear function. In order to exploit our empirical estimates, we assume that  $h(\cdot)$  can be locally approximated by a linear function of  $u$ . A first-order approximation of  $h(u)$  around  $u = \bar{u}$  yields:

$$\varepsilon_{D,b}(u) = \varepsilon_{D,b}(\bar{u}) + \frac{d\varepsilon_{D,b}(\bar{u})}{du} \times (u - \bar{u})$$

This can also be derived directly from our reduced-form estimating equation (22):

$$-\log h = \alpha + \beta_1 \log(b) + \beta_2 \log(b) \times (u - \bar{u}) + e \quad (23)$$

With this specification,

$$\varepsilon_{D,b}(u) = \frac{d(-\log(h))}{d \log(b)} = \beta_1 + \beta_2 \times (u - \bar{u})$$

Thus,  $\beta_1 = \varepsilon_{D,b}(\bar{u})$  and  $\beta_2 = \frac{d\varepsilon_{D,b}(\bar{u})}{du}$ . Our empirical results imply that  $\hat{\beta}_1 = 0.741$  and  $\hat{\beta}_2 = -.142$ . To analyze the welfare implications, we will assume that the budget effect can be ignored.<sup>36</sup> In practice, whether the budget effect is likely to bind is related to whether a change in unemployment is temporary or permanent. If the change in unemployment is transitory, it seems safe to assume that the government wouldn't alter financing arrangements. On the other hand, moral hazard varies with unemployment regardless of whether or the change in unemployment is temporary or permanent.

Recall, the consumption smoothing benefit of UI

$$\frac{U'(b) - E[U'(w - \tau)|w \geq \bar{w}]}{E[U'(w - \tau)|w \geq \bar{w}]}$$

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<sup>36</sup>In ongoing work, we are working to incorporate this effect.

Chetty (2006) shows that the consumption smoothing benefit can be approximated as

$$\gamma \frac{\Delta c}{c}(b) \left[ 1 + \frac{1}{2} \delta \frac{\Delta c}{c}(b) \right]$$

where  $\delta$  is the coefficient of relative prudence. We calibrate the consumption smoothing benefit using the estimate for the consumption drop ( $\frac{\Delta c}{c} = 0.24 - 0.28 \times b$ ) in Gruber (1997), along with  $\gamma = 4$  and  $\delta = 5$ , based on the simulation results from Section 4.

Table 13 presents results from the numerical implementation of expression (21). At  $u = 5.4\%$ , the optimal replacement rate is 37%. At an unemployment rate of 7.1% (roughly one standard deviation above the mean unemployment rate), the formula implies an optimal replacement rate of 50%. Thus, we see that variation in the unemployment rate can substantially affect replacement rates. The basic lesson to emerge from the table is that plausible variation in the unemployment rate generates wide variation in the optimal level of UI. To give a sense of the quantitative importance of this variation, the magnitude is roughly equivalent to a one unit change in the coefficient of relative risk aversion in the model (e.g., from  $\gamma = 3$  to  $\gamma = 4$ ).<sup>37</sup>

## 6 Conclusions

In this paper, we have considered a standard search model and have shown that it predicts a relationship between the moral hazard cost of UI and the unemployment rate. This relationship is theoretically ambiguous and depends on the relative strengths of two behavioral channels: the search channel and reservation wage channel. This motivated our empirical strategy which estimated how the elasticity of unemployment duration with respect to the UI benefit level varies with the unemployment rate.

Our empirical findings indicate that moral hazard is lower when unemployment is high, consistent with the speculation of Krueger and Meyer (2002) who claimed that there is likely

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<sup>37</sup>The results in the second column of Table 13 show that at one standard deviation below the mean unemployment rate ( $u = 3.7\%$ ), the optimal replacement rate is 24.5%. Changing the coefficient of relative risk aversion from 4 to 3 and holding rest of parameters constant results in optimal replacement rate of 24.1% (at  $u = 5.4\%$ ).



less of an efficiency loss from reduced search effort by the unemployed when local labor market conditions are poor. We have also shown how one can use the empirical relationship between the duration elasticity and the unemployment rate to calibrate a simple optimal UI formula, and that the calibration is valid regardless of the relative importance of the reservation wage elasticity and the search effort elasticity in determining the duration elasticity.

We view the concept that the moral hazard cost of social policies may vary with local labor market conditions as quite general, extending beyond the application of Unemployment Insurance considered in this paper. It is plausible that the disincentive effects of other government policies may also be lower in times of high unemployment. For example, if the labor supply response to tax changes is lower during recessions, it may be more efficient to redistribute during recessions. In the case of Disability Insurance and Workers Compensation, the adverse incentive effect of such programs may be influenced by the severity of the health or income shock. It would be interesting to study whether moral hazard varies with the size of the shock that triggers these programs, particularly since, as we showed here, benefits can be conditioned on the size of the shock.

While we focused on the UI benefit level as the policy parameter, in practice, the potential benefit duration is typically extended during times of high unemployment. In ongoing work, we are studying theoretically how government should optimally set the potential benefit duration. This will naturally depend on the responsiveness of UI durations to changes in the potential duration parameter. We hope that this analysis will hopefully shed light on the federal supplemental benefits programs in the U.S. and other developed countries.

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## Appendix A: Proofs

### Proof of Lemma 1.

Start by differentiating the optimal condition for search with respect to  $b$

$$\psi''(e) \frac{\partial e}{\partial b} = \frac{\lambda''(e)}{\rho + s} \frac{\partial e}{\partial b} \varphi(\bar{w}) + \frac{\lambda'(e)}{\rho + s} \frac{\partial \varphi(\bar{w})}{\partial \bar{w}} \frac{\partial \bar{w}}{\partial b}$$

Note that  $\lambda'' < 0$ ,  $\psi'' > 0$ , and  $\frac{\partial \varphi(\bar{w})}{\partial \bar{w}} < 0$  so that  $\text{sign}(\frac{\partial e}{\partial b}) \neq \text{sign}(\frac{\partial \bar{w}}{\partial b})$ . Next, totally differentiating the reservation wage equation with respect to  $b$  yields

$$\begin{aligned} U'(\bar{w} - \tau) \frac{\partial \bar{w}}{\partial b} &= U'(b) + \frac{\partial e}{\partial b} \frac{\lambda(e)}{\lambda'(e)} \left( \psi''(e) - \psi'(e) \frac{\lambda''(e)}{\lambda'(e)} \right) \\ U'(\bar{w} - \tau) \frac{\partial \bar{w}}{\partial b} &= U'(b) + \frac{\partial e}{\partial b} \frac{\lambda(e)}{\lambda'(e)} \left( \psi''(e) - \frac{\lambda''(e)}{\rho + s} \varphi(\bar{w}) \right) \end{aligned}$$

where the last line made use of the FOC. Lets substitute in using the the equation above:

$$\begin{aligned} U'(\bar{w} - \tau) \frac{\partial \bar{w}}{\partial b} &= U'(b) + \frac{\lambda(e)}{\lambda'(e)} \frac{\lambda'(e)}{\rho + s} \frac{\partial \varphi(\bar{w})}{\partial \bar{w}} \frac{\partial \bar{w}}{\partial b} \\ U'(\bar{w} - \tau) \frac{\partial \bar{w}}{\partial b} &= U'(b) + \frac{\lambda(e)}{\rho + s} \frac{\partial \varphi(\bar{w})}{\partial \bar{w}} \frac{\partial \bar{w}}{\partial b} \\ U'(\bar{w} - \tau) \frac{\partial \bar{w}}{\partial b} &= U'(b) - \frac{\lambda(e)}{\rho + s} (1 - F(\bar{w})) U'(\bar{w} - \tau) \frac{\partial \bar{w}}{\partial b} \\ U'(\bar{w} - \tau) \frac{\partial \bar{w}}{\partial b} \left( 1 + \frac{\lambda(e)(1 - F(\bar{w}))}{\rho + s} \right) &= U'(b) \\ \frac{\partial \bar{w}}{\partial b} &= \frac{U'(b)}{U'(\bar{w} - \tau)} \frac{\rho + s}{\rho + s + \lambda(e)(1 - F(\bar{w}))} \\ \frac{\partial \bar{w}}{\partial b} &\approx \frac{U'(b)}{U'(\bar{w} - \tau)} u \end{aligned}$$

Therefore,

$$\begin{aligned} \frac{\partial e}{\partial b} \left( \psi''(e) - \frac{\lambda''(e)}{\rho + s} \varphi(\bar{w}) \right) &= \frac{\lambda'(e)}{\rho + s + \lambda(e)(1 - F(\bar{w}))} \frac{\partial \varphi(\bar{w})}{\partial \bar{w}} \frac{U'(b)}{U'(\bar{w} - \tau)} \\ \frac{\partial e}{\partial b} \left( \psi''(e) - \frac{\lambda''(e)}{\rho + s} \varphi(\bar{w}) \right) &= - \frac{\lambda'(e)(1 - F(\bar{w}))}{r + s + \lambda(e)(1 - F(\bar{w}))} U'(b) \\ \frac{\partial e}{\partial b} \left( \psi''(e) - \frac{\lambda''(e)}{s} \varphi(\bar{w}) \right) &\approx - \frac{\lambda'(e)}{\lambda(e)} (1 - u) U'(b) \\ \frac{\partial e}{\partial b} &= - \frac{\delta(e)(1 - u) U'(b)}{\psi''(e) - \frac{\lambda''(e)}{s} \varphi(\bar{w})} \end{aligned}$$

**Proof of Theorem 3.**

Let us consider the first-best case where the planner sets  $b$ ,  $\bar{w}$ , and  $e$  simultaneously. Note that with  $\tau(b) = (\rho + s)Db$ , unemployment utility becomes

$$\rho V_u(b) = U(b) + \frac{\lambda(e)}{\rho + s} \int_{\bar{w}}^{\infty} U(w - (\rho + s)Db) dF(w) - \rho V_u(b) \frac{\lambda(e)(1 - F(\bar{w}))}{\rho + s} - \psi(e)$$

First, holding fixed  $\bar{w}$  and  $e$ , differentiate with respect to  $b$ :

$$\rho \frac{dV_u}{db} = U'(b) - \lambda(e)D \int_{\bar{w}}^{\infty} U'(w - \tau) dF(w) - \frac{\rho}{\rho + s} \lambda(e) [1 - F(\bar{w})] \frac{dV_u}{db}$$

Next, differentiate with respect to  $\bar{w}$ :

$$\begin{aligned} \rho \frac{dV_u}{d\bar{w}} &= -\frac{\lambda(e)}{\rho + s} f(\bar{w}) U(\bar{w} - \tau) - \lambda(e) \frac{\partial D}{\partial \bar{w}} b \int_{\bar{w}}^{\infty} U'(w - \tau) dF(w) \\ &\quad - \frac{\rho}{\rho + s} \lambda(e) [1 - F(\bar{w})] \frac{dV_u}{d\bar{w}} - \frac{\rho}{\rho + s} V_u(b) \frac{\partial}{\partial \bar{w}} [\lambda(e)(1 - F(\bar{w}))] \end{aligned}$$

Finally, the FOC with respect to  $e$  satisfies:

$$\begin{aligned} \rho \frac{dV_u}{de} &= \frac{\lambda'(e)}{\rho + s} \int_{\bar{w}}^{\infty} U(w - \tau) dF(w) - \lambda(e) \frac{\partial D}{\partial e} b \int_{\bar{w}}^{\infty} U'(w - \tau) dF(w) \\ &\quad - \frac{\rho}{\rho + s} \lambda(e) [1 - F(\bar{w})] \frac{dV_u}{de} - \frac{\rho}{\rho + s} V_u(b) \frac{\partial}{\partial e} [\lambda(e)(1 - F(\bar{w}))] - \psi'(e) \end{aligned}$$

At the optimum,  $\frac{dV_u}{db} = \frac{dV_u}{d\bar{w}} = \frac{dV_u}{de} = 0$ . Thus, the optimal benefit level satisfies

$$\begin{aligned} U'(b) &= \frac{1}{1 - F(\bar{w})} \int_{\bar{w}}^{\infty} U'(w - \tau) dF(w) \\ U'(b) &= E[U'(w - \tau) | w \geq \bar{w}] \end{aligned}$$

This is the standard "Borch condition" for full insurance.

The socially optimal reservation wage satisfies

$$U(\bar{w} - \tau) = \rho V_u(b) - (\rho + s)b \frac{\partial D}{\partial \bar{w}} \frac{E[U'(w - \tau) | w \geq \bar{w}]}{\theta(\bar{w})}$$

Recall that the privately optimal reservation wage satisfies the equation,  $U(\bar{w} - \tau) = \rho V_u(b)$ . The difference between this and the socially optimal reservation wage is the last

term, which reflects the fact that the planner takes into account that a higher reservation wage lowers the job finding rate ( $\partial D/\partial \bar{w} > 0$ ), which in turn increases the tax rate. Since  $\frac{\partial D}{\partial \bar{w}} > 0$ , the implication is that the privately optimal reservation wage will be too high, from a social perspective.

Lastly, the socially optimal level of search satisfies

$$\frac{\lambda'(e)}{\rho + s} \left( \int_{\bar{w}}^{\infty} (U(w - \tau) - \rho V_u(b)) dF(w) \right) - \lambda(e) \frac{\partial D}{\partial e} b \int_{\bar{w}}^{\infty} U'(w - \tau) dF(w) = \psi'(e)$$

Recall that the privately optimal search effort satisfies

$$\frac{\lambda'(e)}{\rho + s} \left( \int_{\bar{w}}^{\infty} (U(w - \tau) - \rho V_u(b)) dF(w) \right) = \psi'(e)$$

This differs from the socially optimal level of effort since the planner takes into account the fact that more effort at the margin increases the employment rate ( $\partial D/\partial e < 0$ ), which in turn lowers the tax rate. This additional effect arises since the planner internalizes the budget constraint, whereas the agent does not. As a result, the privately optimal level of job search will be inefficiently low.

**Proof of Theorem 4.**

The planner chooses  $(b, \tau)$  to maximize expected unemployed utility, taking the agent's optimal behavior as given. We solve this problem by treating the UI tax  $\tau$  as an endogenous function of  $b$  and we solve for the optimal  $b$ . Formally, the problem is stated as:

$$\max_b V_u(b) = \max_b \left\{ \max_{\bar{w}, e} \frac{1}{\rho} \left\{ U(b) + \frac{\lambda(e)}{\rho + s} \int_{\bar{w}}^{\infty} [U(w - \tau(b)) - \rho V_u(b)] dF(w) - \psi(e) \right\} \right\}$$

Let us consider the welfare-gain associated with a revenue-neutral benefit increase. We will exploit the envelope theorem which says that the individual does not gain by adjusting his reservation wage or search effort, since he was indifferent to being employed and unemployed to begin with. Thus,

$$\rho \frac{dV_u}{db} = U'(b) - \frac{\rho}{\rho + s} \lambda(e) [1 - F(\bar{w})] \frac{dV_u}{db} - \frac{d\tau}{db} \frac{\lambda(e)}{\rho + s} \int_{\bar{w}}^{\infty} U'(w - \tau(b)) dF(w)$$

The first term represents the standard "mechanical effect" on welfare of raising UI benefits by \$1, the second term represents the option value effect and the third term represents the distortionary cost of UI due to the behavioral response. The third term is essentially the expected dollars that need to be raised to finance the benefit increase, multiplied by the marginal value of that dollar. Rearranging this expression gives

$$\begin{aligned} \rho \frac{dV_u}{db} \left( \frac{\rho + s + \lambda(e)[1 - F(\bar{w})]}{\rho + s} \right) &= U'(b) - \frac{d\tau}{db} \frac{\lambda(e)}{\rho + s} \int_{\bar{w}}^{\infty} U'(w - \tau(b)) dF(w) \\ \frac{dV_u}{db} &= \frac{\sigma}{\rho} \left[ U'(b) - \frac{d\tau}{db} \frac{\lambda(e)}{\rho + s} F(\bar{w}) E[U'(w - \tau(b)) | w \geq \bar{w}] \right] \end{aligned}$$

where  $\sigma = \frac{\rho + s}{\rho + s + \lambda(e)[1 - F(\bar{w})]}$ .

*Money-Metric Welfare Gain of UI.*

Let us follow Chetty (2008) and get a money-metric expression for the welfare gain of UI by normalizing by the welfare gain from raising wages in the high state by \$1. Let  $w_m$  be the location of the wage offer distribution. Decompose the offered wage as  $w = w_m + \varepsilon$  and let  $F$  be the distribution function for  $\varepsilon$ . The value of unemployment becomes

$$\rho V_u = U(b) + \frac{\lambda(e)}{\rho + s} \int_{\varepsilon(\bar{w})}^{\infty} [U(w_m + \varepsilon - \tau) - \rho V_u] dF(\varepsilon) - \psi(e)$$

It follows that

$$\rho \frac{dV_u}{dw_m} = \frac{\lambda(e)}{\rho + s} \int_{\varepsilon(\bar{w})}^{\infty} [U'(w_m + \varepsilon - \tau) - \rho \frac{dV_u}{dw_m}] dF(\varepsilon)$$



$$\frac{dV_u}{dw_m} = \frac{\sigma}{\rho} \frac{\lambda(e)}{\rho+s} F(\bar{w}) E[U'(w - \tau(b)) | w \geq \bar{w}]$$

Therefore,

$$\frac{dW}{db} \equiv \frac{\frac{dV_u}{db}}{\frac{dV_u}{dw_m}} \quad (24)$$

$$\frac{dW}{db} = \frac{\frac{\sigma}{\rho} \left[ U'(b) - \frac{d\tau}{db} \frac{\lambda(e)}{\rho+s} F(\bar{w}) E[U'(w - \tau(b)) | w \geq \bar{w}] \right]}{\frac{\sigma}{\rho} \frac{\lambda(e)}{\rho+s} F(\bar{w}) E[U'(w - \tau(b)) | w \geq \bar{w}]}$$

$$\frac{dW}{db} = \frac{U'(b)}{\frac{\lambda(e)}{\rho+s} F(\bar{w}) E[U'(w - \tau(b)) | w \geq \bar{w}]} - \frac{d\tau}{db} \quad (25)$$

$$\frac{dW}{db} = \frac{u}{1-u} \frac{U'(b)}{E[U'(w - \tau(b)) | w \geq \bar{w}]} - \frac{d\tau}{db} \quad (26)$$

*Elasticity Expression for  $\frac{d\tau}{db}$ .*

Finally, note that the balanced-budget constraint  $\tau = (r+s)Db = (\rho+s)Db$  implies that

$$\frac{d\tau}{db} = (\rho+s)D + (\rho+s) \frac{\partial D}{\partial b} b + (\rho+s) \frac{\partial D}{\partial \tau} \frac{d\tau}{db} b$$

$$\frac{d\tau}{db} = \frac{D \left( 1 + \frac{\partial D}{\partial b} \frac{b}{D} \right)}{\frac{1}{\rho+s} - \frac{\partial D}{\partial \tau} b}$$

Alternatively, one can define the  $\frac{d\tau}{db}$  in terms of the *total* duration elasticity which includes the UI response needed to balance the budget:

$$\frac{d\tau}{db} = (\rho+s)D + (\rho+s) \frac{dD}{db} b$$

$$\frac{d\tau}{db} = D(\rho+s)(1 + \varepsilon_{D,b})$$

$$\frac{d\tau}{db} = \frac{u}{1-u} (1 + \varepsilon_{D,b})$$

where the last equality follows if  $\rho \rightarrow 0$ . The first equality can be decomposed into two effects, a mechanical effect which is the increase in taxes if the agent does not change his behavior, and a behavioral effect, which is the increase in taxes that are necessary because the agent re-optimizes his reservation wage. Plugging in the last line into expression (24) yields

$$\frac{dW}{db} = \frac{u}{1-u} \left\{ \frac{U'(b) - E[U'(w - \tau(b)) | w \geq \bar{w}]}{E[U'(w - \tau(b)) | w \geq \bar{w}]} - \varepsilon_{D,b} \right\}$$

This establishes the proof of Theorem 4.

*Shimer and Werning (2007).*

Expected utility in Shimer and Werning is

$$V_u = \frac{U(\bar{w} - \tau)}{\rho}$$

Therefore,

$$\frac{dV_u}{db} = \frac{U'(\bar{w} - \tau)}{\rho} \left[ \frac{d\bar{w}}{db} - \frac{d\tau}{db} \right]$$

Thus, by asserting that  $\frac{dW}{db} = \frac{d\bar{w}}{db} - \frac{d\tau}{db}$ , Shimer and Werning are implicitly normalizing utility by  $\frac{U'(\bar{w}-\tau)}{\rho}$ . In other words,

$$\frac{dW}{db} \equiv \frac{\frac{dV_u}{db}}{\frac{U'(\bar{w}-\tau)}{\rho}} = \frac{d\bar{w}}{db} - \frac{d\tau}{db}$$

Since we use a different normalization – one that follows Baily (1978) and Chetty (2008) – we will get a slightly different expression for the welfare gain of UI. We now formally show the connection between the two expressions below.

*Expressing Marginal Utilities in Terms of Behavioral Responses.*

We will now exploit the fact that the ratio of marginal utilities can be calculated using the comparative statics for the agent's reservation wage. To see this, let us exploit the agent's reservation wage equation which is defined as:

$$\begin{aligned} U(\bar{w} - \tau(b)) &= \rho V_u \\ U(\bar{w} - \tau(b)) &= U(b) + \frac{\lambda(e)}{\rho + s} \int_{\bar{w}}^{\infty} [U(w - \tau(b)) - U(\bar{w} - \tau(b))] dF(w) - \psi(e) \end{aligned}$$

First, note that raising wages by \$1 in the employed state yields<sup>38</sup>

$$\frac{\partial \bar{w}}{\partial w_m} = \frac{\frac{\lambda(e)}{\rho + s} \int_{\bar{w}}^{\infty} U'(w - \tau(b)) dF(w)}{U'(\bar{w} - \tau(b))} \sigma$$

Next, differentiating this expression with respect to  $b$  holding taxes constant, one can show that:

$$\frac{\partial \bar{w}}{\partial b} = \frac{U'(b)}{U'(\bar{w} - \tau)} \sigma$$

---

<sup>38</sup>As in Chetty (2008), can think of  $w \sim w_m + F(w)$ .

Hence, combining the previous two expressions, we get

$$\begin{aligned} \frac{U'(b)}{\frac{\lambda}{\rho+s} F(\bar{w}) E[U'(w - \tau(b)) | w \geq \bar{w}]} &= \frac{U'(b)}{U'(\bar{w} - \tau(b)) \left( \frac{\rho+s+p}{\rho+s} \right) \frac{\partial \bar{w}}{\partial w_m}} \\ \frac{u}{1-u} \frac{U'(b)}{E[U'(w - \tau(b)) | w \geq \bar{w}]} &= \frac{\frac{\partial \bar{w}}{\partial b}}{\frac{\partial \bar{w}}{\partial w_m}} \end{aligned}$$

*Welfare Gain of UI in terms of "Sufficient Statistics".*

Substituting the expression for the ratio of marginal utilities, we can express the welfare gain of UI as

$$\frac{dW}{db} = \frac{\frac{\partial \bar{w}}{\partial b}}{\frac{\partial \bar{w}}{\partial w_m}} - \frac{u}{1-u} (1 + \varepsilon_{D,b})$$

Thus, the welfare gain of UI may be written as a function of comparative statics of the agent's problem. It is illustrative to note the connection to Chetty (2008) who derives a very similar expression in a search effort model. Chetty's expression replaces the comparative statics of the optimal reservation wage with comparative statics of search effort. To see the connection between this "sufficient statistics" formula and the formula in Shimer & Werning, let us express  $\frac{dW}{db}$  in terms of  $\frac{d\bar{w}}{db}$ , the total derivative. First, differentiate the reservation wage equation with respect to taxes, holding benefits constant:

$$\begin{aligned} U'(\bar{w} - \tau(b)) \left( \frac{\rho + s + \lambda(e)[1 - F(\bar{w})]}{\rho + s} \right) \left( \frac{\partial \bar{w}}{\partial \tau} - 1 \right) &= -\frac{\lambda(e)}{\rho + s} \int_{\bar{w}}^{\infty} U'(w - \tau(b)) dF(w) \\ \frac{\partial \bar{w}}{\partial \tau} &= 1 - \frac{d\bar{w}}{dw_m} \end{aligned}$$

Putting this all together,

$$\begin{aligned} \frac{d\bar{w}}{db} - \frac{d\tau}{db} &= \frac{\partial \bar{w}}{\partial b} + \frac{\partial \bar{w}}{\partial \tau} \frac{d\tau}{db} - \frac{d\tau}{db} \\ &= \frac{\partial \bar{w}}{\partial b} - \frac{d\tau}{db} \left( 1 - \frac{\partial \bar{w}}{\partial \tau} \right) \\ &= \frac{\partial \bar{w}}{\partial b} - \frac{d\tau}{db} \frac{\partial \bar{w}}{\partial w_m} \end{aligned}$$

Hence,

$$\frac{\frac{d\bar{w}}{db} - \frac{d\tau}{db}}{\frac{\partial \bar{w}}{\partial w_m}} = \frac{\frac{\partial \bar{w}}{\partial b}}{\frac{\partial \bar{w}}{\partial w_m}} - \frac{d\tau}{db}$$

Therefore, we may express the welfare gain from UI as

$$\frac{dW}{db} = \frac{\frac{d\bar{w}}{db} - \frac{d\tau}{db}}{\frac{\partial \bar{w}}{\partial w_m}}$$

To connect this to Shimer and Werning (2007), recall from above that  $U'(\bar{w} - \tau(b)) \frac{1}{\sigma} \frac{\partial \bar{w}}{\partial w_m} = \frac{\lambda(e)}{\rho+s} F(\bar{w}) E[U'(w - \tau(b)) | w \geq \bar{w}]$ . Therefore, re-normalizing social welfare, we get

$$\begin{aligned} \frac{dW}{db} &= \frac{\frac{\sigma}{\rho} \frac{\lambda(e)}{\rho+s} F(\bar{w}) E[U'(w - \tau(b)) | w \geq \bar{w}]}{\frac{U'(\bar{w} - \tau(b))}{\rho}} \\ &= \frac{\frac{d\bar{w}}{db} - \frac{d\tau}{db} \frac{\sigma}{\rho} U'(\bar{w} - \tau(b)) \frac{1}{\sigma} \frac{\partial \bar{w}}{\partial w_m}}{\frac{\frac{\partial \bar{w}}{\partial w_m}}{\frac{U'(\bar{w} - \tau(b))}{\rho}}} \\ &= \frac{d\bar{w}}{db} - \frac{d\tau}{db} \end{aligned}$$

Thus, a simple re-normalization delivers the expression in Shimer and Werning. The key idea here is that  $\bar{w}$  measures expected utility so  $\frac{d\bar{w}}{db}$  directly measures the marginal value of insurance.

Table 1: Model Simulation  
Reservation wage model, no search effort decision

| $\lambda$                 | 3.0   | 2.0   | 1.2   | 0.8   | 0.6   |
|---------------------------|-------|-------|-------|-------|-------|
| $u$                       | 7.05% | 7.61% | 8.39% | 9.14% | 9.79% |
| $e^*$                     | -     | -     | -     | -     | -     |
| $w_R^*$                   | 0.389 | 0.380 | 0.368 | 0.358 | 0.352 |
| $\mathcal{E}_{D,b}^e$     | -     | -     | -     | -     | -     |
| $\mathcal{E}_{D,b}^{w_R}$ | 1.486 | 1.495 | 1.566 | 1.583 | 1.585 |
| $\mathcal{E}_{D,b}$       | 1.486 | 1.495 | 1.566 | 1.583 | 1.585 |
| $dW/db$                   | 0.098 | 0.093 | 0.077 | 0.068 | 0.059 |

Notes:

Wage offers distributed log-normally with mean of .25 and standard deviation of 0.05. Remaining parameters in calibration:  $\gamma = 1.75$ ,  $b = .188$ ,  $s = 0.0089$ ,  $r = 0.0$ .

Table 2: Model Simulation  
Fixed wage, endogenous search effort model

| $\lambda$                 | 0.7   | 0.6   | 0.5   | 0.4   | 0.3    |
|---------------------------|-------|-------|-------|-------|--------|
| $u$                       | 4.46% | 5.61% | 6.97% | 8.55% | 10.30% |
| $e^*$                     | 6.76  | 6.22  | 5.64  | 5.01  | 4.31   |
| $w_R^*$                   | -     | -     | -     | -     | -      |
| $\varepsilon_{D,b}^e$     | 0.90  | 0.77  | 0.65  | 0.52  | 0.39   |
| $\varepsilon_{D,b}^{w_R}$ | -     | -     | -     | -     | -      |
| $\varepsilon_{D,b}$       | 0.896 | 0.773 | 0.649 | 0.523 | 0.394  |
| $dW/db$                   | 0.262 | 0.333 | 0.419 | 0.521 | 0.637  |

Notes:

Fixed wage set to 0.25. Search cost parameters are the following:  $\kappa = 1.1$ ,  $\varphi = 0.3$ . Job offer arrival rate given by  $\lambda(e) = \Lambda e^\lambda$ , with  $\Lambda = 0.05$ . Remaining parameters in calibration:  $\gamma = 3$ ,  $b = 0.125$ ,  $s = 0.0089$ ,  $r = 0.0$ .

Table 3: Model Simulation  
Reservation wage, endogenous search effort model

| $\lambda$                 | 1.3   | 1.1   | 0.9   | 0.7   | 0.5   |
|---------------------------|-------|-------|-------|-------|-------|
| $u$                       | 4.83% | 5.78% | 6.87% | 8.09% | 9.43% |
| $e^*$                     | 3.11  | 2.91  | 2.71  | 2.49  | 2.25  |
| $w_R^*$                   | 0.259 | 0.253 | 0.248 | 0.243 | 0.238 |
| $\varepsilon_{D,b}^e$     | 0.81  | 0.69  | 0.57  | 0.45  | 0.32  |
| $\varepsilon_{D,b}^{w_R}$ | 0.948 | 0.983 | 1.013 | 1.041 | 1.060 |
| $\varepsilon_{D,b}$       | 1.756 | 1.670 | 1.581 | 1.487 | 1.380 |
| $dW/db$                   | 0.474 | 0.533 | 0.598 | 0.669 | 0.746 |

Notes:

Wage offers distributed log-normally with mean of .25 and standard deviation of 0.05. Search cost parameters are the following:  $\kappa = 3.0$ ,  $\varphi = 0.5$ . Job offer arrive rate given by  $\lambda(e) = \Lambda e^\lambda$ , with  $\Lambda = 0.1$ . Remaining parameters in calibration:  $\gamma = 3$ ,  $b = 0.125$ ,  $s = 0.0089$ ,  $r = 0.0$ .

Table 4  
Descriptive Statistics

|                               | Full Sample |           | State Unemp. Rate<br>< Median |           | State Unemp. Rate<br>≥ Median |           |
|-------------------------------|-------------|-----------|-------------------------------|-----------|-------------------------------|-----------|
|                               | Mean        | Std. Dev. | Mean                          | Std. Dev. | Mean                          | Std. Dev. |
| Annual Income (\$000's)       | 20.925      | 13.570    | 20.769                        | 12.863    | 21.012                        | 13.952    |
| Age                           | 37.165      | 11.066    | 36.699                        | 11.113    | 37.426                        | 11.034    |
| Years of Education            | 12.171      | 2.877     | 12.151                        | 2.820     | 12.183                        | 2.909     |
| Marital Dummy                 | 0.616       | 0.486     | 0.610                         | 0.488     | 0.619                         | 0.486     |
| Weekly Benefit Amount (\$'s)  | 163.33      | 26.80     | 163.98                        | 25.71     | 162.96                        | 27.39     |
| Replacement Rate              | 0.491       | 0.082     | 0.492                         | 0.080     | 0.490                         | 0.084     |
| Unemployment Duration (weeks) | 18.510      | 14.351    | 17.158                        | 13.757    | 19.267                        | 14.620    |
| Number of Spells              | 4307        |           | 1545                          |           | 2762                          |           |

Notes: Data are individual-level unemployment spells from 1985-2000 SIPP. Final sample of unemployment spells is described in Appendix.



Table 5  
How does Duration Elasticity vary with the  
State Unemployment Rate?

|   |            | (1)                          | (2)                          |
|---|------------|------------------------------|------------------------------|
| log(Average UI WBA)                                 | <b>(A)</b> | -0.651<br>(0.318)<br>[0.041] | -0.741<br>(0.340)<br>[0.029] |
| log(Average UI WBA) ×<br>State Unemployment Rate    | <b>(B)</b> |                              | 0.142<br>(0.068)<br>[0.038]  |
| State Unemployment Rate                             |            | 0.008<br>(0.017)<br>[0.655]  | 0.009<br>(0.016)<br>[0.598]  |
| log(Average UI WBA) ×<br>Unemployment Duration      |            | 0.004<br>(0.009)<br>[0.674]  | 0.003<br>(0.009)<br>[0.707]  |
| Age   |            | -0.017<br>(0.002)<br>[0.000] | -0.017<br>(0.002)<br>[0.000] |
| Marital Dummy                                       |            | 0.208<br>(0.040)<br>[0.000]  | 0.208<br>(0.040)<br>[0.000]  |
| Years of Education                                  |            | 0.004<br>(0.006)<br>[0.489]  | 0.004<br>(0.006)<br>[0.499]  |
| Number of Spells                                    |            | 4307                         | 4307                         |
| Post-estimation: <b>(A)</b> + $\sigma$ × <b>(B)</b> |            |                              | -0.502<br>(0.326)<br>[0.124] |
| Post-estimation: <b>(A)</b> - $\sigma$ × <b>(B)</b> |            |                              | -0.980<br>(0.388)<br>[0.012] |

Notes: All columns report semiparametric (Cox proportional) hazard model results from estimating equation (22). Data are individual-level unemployment spells from 1985-2000 SIPP. Final sample of unemployment spells is described in the Appendix. Dependent variable is always the log of the individual unemployment duration (in weeks). All specifications include state, year, industry and occupation fixed effects, 10-knot linear spline in log annual wage income, controls for national unemployment rate and national unemployment rate interacted with the log of Average UI WBA and a control for being on the seam between interviews to adjust for the "seam effect." The Average UI WBA is the average weekly benefit amount paid to individuals claiming unemployment insurance. All columns estimate nonparametric baseline hazards stratified by quartile of net liquid wealth. The final two rows reports linear combinations of parameter estimates to produce the duration elasticity when the state unemployment rate is one standard deviation above/below average. Standard errors, adjusted to allow for an arbitrary variance-covariance matrix for each state over time, are in parentheses and p-values are in brackets.



Table 7  
State-Occupation Cells as Alternative Definition of Local Labor Market

|   |            | (1)                          | (2)                          | (3)                          | (4)                          |
|---|------------|------------------------------|------------------------------|------------------------------|------------------------------|
| log(Average UI WBA)   | <b>(A)</b> | -0.841<br>(0.312)<br>[0.007] | -0.842<br>(0.344)<br>[0.014] | -0.973<br>(0.336)<br>[0.004] | -0.931<br>(0.376)<br>[0.013] |
| log(Average UI WBA) ×<br>State-Occupation Unemployment Rate | <b>(B)</b> | 0.025<br>(0.036)<br>[0.495]  | 0.073<br>(0.074)<br>[0.325]  | 0.035<br>(0.039)<br>[0.365]  | 0.093<br>(0.084)<br>[0.265]  |
| State-Occupation Unemployment Rate                          |            | 0.003<br>(0.016)<br>[0.840]  | -0.005<br>(0.019)<br>[0.781] | -0.002<br>(0.018)<br>[0.927] | -0.012<br>(0.022)<br>[0.589] |
| State Unemployment Rate                                     |            | 0.015<br>(0.027)<br>[0.570]  | 0.021<br>(0.028)<br>[0.449]  | 0.027<br>(0.028)<br>[0.329]  | 0.033<br>(0.030)<br>[0.262]  |
| Number of Spells  |            | 3345                         | 3345                         | 3345                         | 3345                         |
| Occupation x State FEs                                      |            | N                            | Y                            | N                            | Y                            |
| Occupation x Year FEs                                       |            | N                            | N                            | Y                            | Y                            |
| Post-estimation: <b>(A)</b> + $\sigma$ × <b>(B)</b>         |            | -0.743<br>(0.378)<br>[0.050] | -0.553<br>(0.446)<br>[0.215] | -0.835<br>(0.399)<br>[0.036] | -0.564<br>(0.470)<br>[0.230] |
| Post-estimation: <b>(A)</b> - $\sigma$ × <b>(B)</b>         |            | -0.939<br>(0.305)<br>[0.002] | -1.131<br>(0.459)<br>[0.014] | -1.111<br>(0.337)<br>[0.001] | -1.299<br>(0.529)<br>[0.014] |

Notes: All columns report semiparametric (Cox proportional) hazard model results from estimating equation (22). See Table 5 for more details on the baseline specification. Data are individual-level unemployment spells from 1985-2000 SIPP, restricting sample to spells where individual has non-missing occupation code. To address noise in measured unemployment rate in each state-occupation cell, spells are weighted by total number of spells in sample with same occupation code. The final two rows reports linear combinations of parameter estimates to produce the duration elasticity when the state unemployment rate is one standard deviation above/below average. Standard errors, adjusted to allow for an arbitrary variance-covariance matrix for each state over time, are in parentheses and p-values are in brackets.

Table 8  
Alternative Measures of Local Labor Market Conditions

|   | Hazard Model Results         |                              |                              | Post-estimation              |                              |
|---|------------------------------|------------------------------|------------------------------|------------------------------|------------------------------|
|   | (A)                          | (A) × (B)                    | (B)                          | (A) + $\sigma$ × (B)         | (A) - $\sigma$ × (B)         |
| (1) (A) log(Average UI WBA) ×<br>(B) State Unemployment Rate                  | -0.741<br>(0.340)<br>[0.029] | 0.142<br>(0.068)<br>[0.038]  | 0.009<br>(0.016)<br>[0.598]  | -0.502<br>(0.326)<br>[0.124] | -0.980<br>(0.388)<br>[0.012] |
| (2) (A) log(Average UI WBA) ×<br>(B) -1 * (Employment-to-Pop Ratio)           | -0.500<br>(0.304)<br>[0.100] | -3.642<br>(3.627)<br>[0.315] | -1.461<br>(1.179)<br>[0.215] | -0.641<br>(0.293)<br>[0.029] | -0.359<br>(0.371)<br>[0.334] |
| (3) (A) log(Average UI WBA) ×<br>(B) -1 * (Predicted Employment-to-Pop Ratio) | -0.898<br>(0.353)<br>[0.011] | 1.984<br>(4.093)<br>[0.628]  | -2.860<br>(1.175)<br>[0.015] | -0.814<br>(0.319)<br>[0.011] | -0.981<br>(0.455)<br>[0.031] |
| Number of Spells  | 4307                         |                              |                              |                              |                              |

Notes: All rows report semiparametric (Cox proportional) hazard model results from estimating equation (22); each column reports separate parameter estimate. Data are individual-level unemployment spells from 1985-2000 SIPP. See Table 5 for more details on the baseline specification. The Average UI WBA is the average weekly benefit amount paid to individuals claiming unemployment insurance. The Predicted Employment to Population Ratio is computed following the "shift share" procedure of Bartik (1991); see text for details. The standard deviation in the unemployment rate ( $\sigma$ ) is 1.68%. Standard errors, adjusted to allow for an arbitrary variance-covariance matrix for each state over time, are in parentheses and p-values are in brackets.

Table 9  
How Much Do Demographics Explain Why Moral Hazard Varies  
with the State Unemployment Rate?

|   |            | (1)                          | (2)                          | (3)                          | (4)                          | (5)                          | (6)                          | (7)                          |
|---|------------|------------------------------|------------------------------|------------------------------|------------------------------|------------------------------|------------------------------|------------------------------|
| log(Average UI WBA)                                 | <b>(A)</b> | -0.741<br>(0.340)<br>[0.029] | -0.719<br>(0.337)<br>[0.033] | -0.742<br>(0.339)<br>[0.029] | -0.718<br>(0.334)<br>[0.032] | -0.628<br>(0.347)<br>[0.070] | -0.618<br>(0.359)<br>[0.085] | -0.577<br>(0.349)<br>[0.098] |
| log(Average UI WBA) ×<br>State Unemployment Rate    | <b>(B)</b> | 0.142<br>(0.068)<br>[0.038]  | 0.141<br>(0.068)<br>[0.040]  | 0.142<br>(0.068)<br>[0.037]  | 0.140<br>(0.067)<br>[0.037]  | 0.143<br>(0.070)<br>[0.042]  | 0.136<br>(0.069)<br>[0.048]  | 0.138<br>(0.068)<br>[0.043]  |
| State Unemployment Rate                             |            | 0.009<br>(0.016)<br>[0.598]  | 0.008<br>(0.016)<br>[0.610]  | 0.009<br>(0.016)<br>[0.598]  | 0.008<br>(0.016)<br>[0.611]  | 0.008<br>(0.016)<br>[0.605]  | 0.009<br>(0.016)<br>[0.596]  | 0.008<br>(0.016)<br>[0.606]  |
| log(Average UI WBA) × Age                           |            |                              | 0.007<br>(0.008)<br>[0.398]  |                              |                              |                              |                              | 0.008<br>(0.010)<br>[0.428]  |
| log(Average UI WBA) × Marital Dummy                 |            |                              |                              | 0.020<br>(0.180)<br>[0.912]  |                              |                              |                              | -0.046<br>(0.210)<br>[0.827] |
| log(Average UI WBA) × Years of Education            |            |                              |                              |                              | 0.049<br>(0.025)<br>[0.052]  |                              |                              | 0.051<br>(0.031)<br>[0.099]  |
| Number of Spells                                    |            | 4307                         | 4307                         | 4307                         | 4307                         | 4307                         | 4307                         | 4307                         |
| log(Average UI WBA) × Occupation FEs                |            | N                            | N                            | N                            | N                            | Y                            | N                            | Y                            |
| log(Average UI WBA) × Industry FEs                  |            | N                            | N                            | N                            | N                            | N                            | Y                            | Y                            |
| Post-estimation: <b>(A)</b> + $\sigma$ × <b>(B)</b> |            | -0.502<br>(0.326)<br>[0.124] | -0.483<br>(0.327)<br>[0.139] | -0.504<br>(0.324)<br>[0.120] | -0.482<br>(0.320)<br>[0.132] | -0.388<br>(0.329)<br>[0.238] | -0.389<br>(0.336)<br>[0.246] | -0.345<br>(0.322)<br>[0.285] |
| Post-estimation: <b>(A)</b> - $\sigma$ × <b>(B)</b> |            | -0.980<br>(0.388)<br>[0.012] | -0.955<br>(0.383)<br>[0.013] | -0.980<br>(0.389)<br>[0.012] | -0.953<br>(0.382)<br>[0.013] | -0.867<br>(0.400)<br>[0.030] | -0.846<br>(0.414)<br>[0.041] | -0.809<br>(0.407)<br>[0.047] |

Notes: All columns report semiparametric (Cox proportional) hazard model results from estimating equation (22). Data are individual-level unemployment spells from 1985-2000 SIPP. See Table 5 for more details on the baseline specification. The final two rows reports linear combinations of parameter estimates to produce the duration elasticity when the state unemployment rate is one standard deviation above/below average. Standard errors, adjusted to allow for an arbitrary variance-covariance matrix for each state over time, are in parentheses and p-values are in brackets.

Table 10  
Moral Hazard and Liquidity

|   |            | (1)                          | (2)                          | (3)                          | (4)                          | (5)                         |
|---|------------|------------------------------|------------------------------|------------------------------|------------------------------|-----------------------------|
| log(Average UI WBA)                                 | <b>(A)</b> | -0.741<br>(0.340)<br>[0.029] | -0.780<br>(0.520)<br>[0.134] | -0.609<br>(0.533)<br>[0.253] | -0.664<br>(0.320)<br>[0.038] |                             |
| log(Average UI WBA) ×<br>State Unemployment Rate    | <b>(B)</b> | 0.142<br>(0.068)<br>[0.038]  | 0.419<br>(0.112)<br>[0.000]  | 0.164<br>(0.127)<br>[0.196]  | 0.158<br>(0.070)<br>[0.025]  | 0.165<br>(0.074)<br>[0.026] |
| State Unemployment Rate                             |            | 0.009<br>(0.016)<br>[0.598]  | 0.011<br>(0.024)<br>[0.636]  | -0.004<br>(0.024)<br>[0.852] | 0.005<br>(0.017)<br>[0.771]  | 0.006<br>(0.017)<br>[0.727] |
| Number of Spells                                    |            | 4307                         | 2355                         | 2170                         | 4307                         | 4307                        |
| No mortgage only                                    |            | N                            | Y                            | N                            | N                            | N                           |
| 3rd and 4th liquid wealth quartiles only            |            | N                            | N                            | Y                            | N                            | N                           |
| Occupation FEs × Liquid wealth quartile             |            | N                            | N                            | N                            | Y                            | Y                           |
| Industry FEs × Liquid wealth quartile               |            | N                            | N                            | N                            | Y                            | Y                           |
| Unemployment duration × Liquid wealth quartile      |            | N                            | N                            | N                            | N                            | Y                           |
| log(Average UI WBA) × Liquid wealth quartile        |            | N                            | N                            | N                            | N                            | Y                           |
| Post-estimation: <b>(A)</b> + $\sigma$ × <b>(B)</b> |            | -0.502<br>(0.326)<br>[0.124] | -0.076<br>(0.551)<br>[0.890] | -0.333<br>(0.553)<br>[0.547] | -0.399<br>(0.318)<br>[0.210] |                             |
| Post-estimation: <b>(A)</b> - $\sigma$ × <b>(B)</b> |            | -0.980<br>(0.388)<br>[0.012] | -1.483<br>(0.555)<br>[0.007] | -0.884<br>(0.594)<br>[0.137] | -0.929<br>(0.362)<br>[0.010] |                             |

Notes: All columns report semiparametric (Cox proportional) hazard model results from estimating equation (22). Data are individual-level unemployment spells from 1985-2000 SIPP. See Table 5 for more details on the baseline specification. The final two rows reports linear combinations of parameter estimates to produce the duration elasticity when the state unemployment rate is one standard deviation above/below average. Standard errors, adjusted to allow for an arbitrary variance-covariance matrix for each state over time, are in parentheses and p-values are in brackets.

Table 11  
Robustness to Alternative Specifications and Controls

|   |            | (1)                          | (2)                          | (3)                          | (4)                          | (5)                          |
|---|------------|------------------------------|------------------------------|------------------------------|------------------------------|------------------------------|
| log(Average UI WBA)                                 | <b>(A)</b> | -0.741<br>(0.340)<br>[0.029] | -1.010<br>(0.420)<br>[0.016] | -1.019<br>(0.480)<br>[0.034] | -1.078<br>(0.523)<br>[0.039] | -0.787<br>(0.352)<br>[0.025] |
| log(Average UI WBA) ×<br>State Unemployment Rate    | <b>(B)</b> | 0.142<br>(0.068)<br>[0.038]  | 0.157<br>(0.077)<br>[0.041]  | 0.156<br>(0.124)<br>[0.207]  | 0.151<br>(0.095)<br>[0.113]  | 0.095<br>(0.068)<br>[0.162]  |
| State Unemployment Rate                             |            | 0.009<br>(0.016)<br>[0.598]  | 0.028<br>(0.018)<br>[0.116]  | 0.038<br>(0.023)<br>[0.104]  | 0.029<br>(0.020)<br>[0.134]  | 0.012<br>(0.015)<br>[0.408]  |
| Number of Spells                                    |            | 4307                         | 4307                         | 4307                         | 4307                         | 4307                         |
| Baseline controls                                   |            | Y                            | Y                            | Y                            | Y                            | N                            |
| Region-specific linear time trends                  |            | N                            | Y                            | N                            | N                            | N                            |
| Region × Year FEs                                   |            | N                            | N                            | Y                            | N                            | N                            |
| State-specific linear time trends                   |            | N                            | N                            | N                            | Y                            | N                            |
| Post-estimation: <b>(A)</b> + $\sigma$ × <b>(B)</b> |            | -0.502<br>(0.326)<br>[0.124] | -0.746<br>(0.420)<br>[0.076] | -0.757<br>(0.472)<br>[0.109] | -0.825<br>(0.551)<br>[0.134] | -0.627<br>(0.299)<br>[0.036] |
| Post-estimation: <b>(A)</b> - $\sigma$ × <b>(B)</b> |            | -0.980<br>(0.388)<br>[0.012] | -1.274<br>(0.458)<br>[0.005] | -1.281<br>(0.568)<br>[0.024] | -1.331<br>(0.542)<br>[0.014] | -0.947<br>(0.430)<br>[0.028] |

Notes: All columns report semiparametric (Cox proportional) hazard model results from estimating equation (22). Data are individual-level unemployment spells from 1985-2000 SIPP. See Table 5 for more details on the baseline specification. The final two rows reports linear combinations of parameter estimates to produce the duration elasticity when the state unemployment rate is one standard deviation above/below average. Standard errors, adjusted to allow for an arbitrary variance-covariance matrix for each state over time, are in parentheses and p-values are in brackets.

**Table 12**  
**Parameter Configurations with the Smallest Mean Squared Error**

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Search cost as a function of effort =  $(\varphi / (1 + \kappa))e^{1+\kappa}$  , Job arrival rate as a function of effort =  $\Lambda e^\lambda$

| Coefficient of<br>Relative Risk<br>Aversion, ( $\gamma$ ) | Job separation<br>rate, ( $s$ ) | Search cost<br>elasticity, ( $1 + \kappa$ ) | Search cost scale<br>coefficient, ( $\varphi$ ) | Job arrival scale<br>coefficient, ( $\Lambda$ ) | Simulated<br>duration elasticity<br>at $u = 5.4\%$ | Simulated<br>interaction term,<br>$d(\text{dur elast})/du$ | Mean<br>Squared<br>Error |
|---|---------------------------------|---|---|---|--|--|--------------------------|
| (1)   | (2)                             | (3)   | (4)   | (5)   | (6)  | (7)  | (8)                      |
| 4.030   | 0.0096                          | 5.195                                       | 4.425   | 0.076   | 0.737  | -0.141   | 0.00009                  |
| 5.504   | 0.0059                          | 2.626                                       | 4.819   | 0.044   | 0.741  | -0.145   | 0.00031                  |
| 5.263   | 0.0034                          | 3.549                                       | 4.941   | 0.025   | 0.752  | -0.140   | 0.00034                  |
| 3.941   | 0.0101                          | 2.054                                       | 1.545   | 0.078   | 0.749  | -0.140   | 0.00039                  |
| 3.306   | 0.0100                          | 4.642                                       | 4.738   | 0.087   | 0.752  | -0.144   | 0.00044                  |
| 5.265   | 0.0118                          | 2.526                                       | 3.260   | 0.085   | 0.755  | -0.140   | 0.00046                  |
| 3.225   | 0.0108                          | 4.307                                       | 2.714   | 0.092   | 0.728  | -0.139   | 0.00070                  |
| 4.088   | 0.0022                          | 4.025                                       | 3.757   | 0.017   | 0.761  | -0.140   | 0.00101                  |
| 4.202   | 0.0121                          | 3.637                                       | 4.009   | 0.095   | 0.765  | -0.143   | 0.00111                  |
| 4.196   | 0.0083                          | 3.331                                       | 3.760   | 0.066   | 0.758  | -0.145   | 0.00114                  |

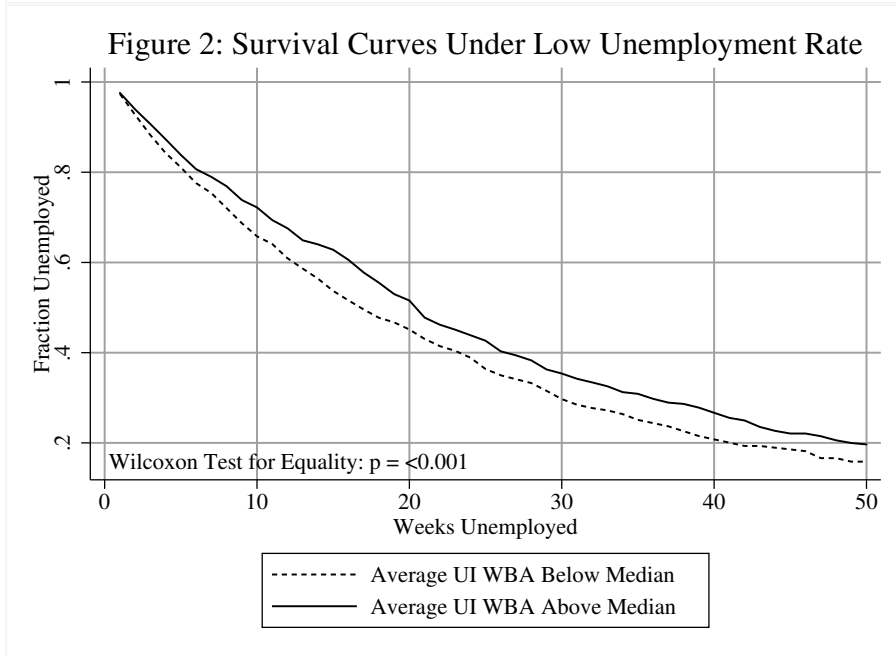
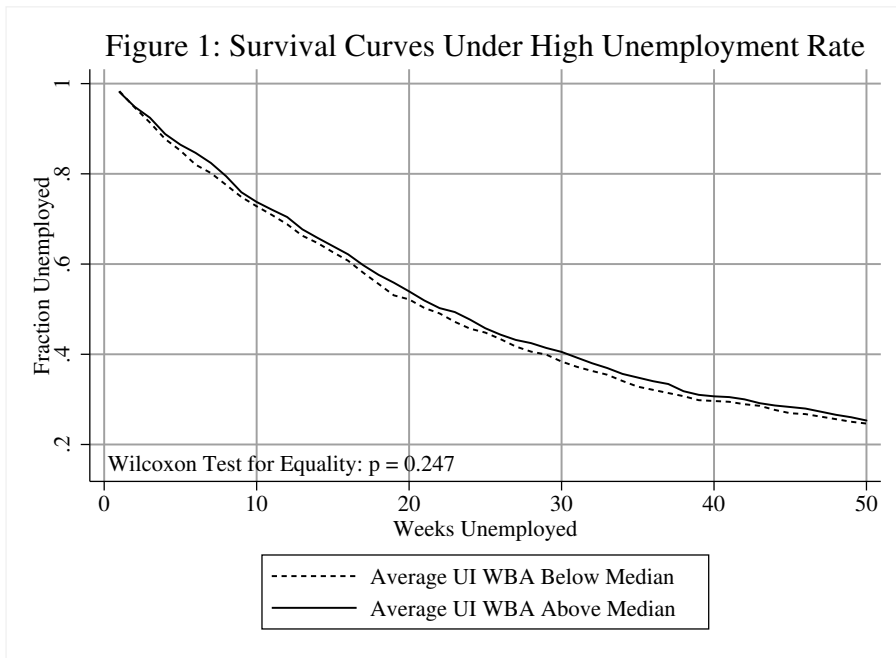
Notes: This table displays the ten parameter configurations (out of 25,000) with the smallest mean squared error between the simulated model data and the estimated treatment effects in Table 5. The simulated model is the same model used in the simulations in Table 2. The 25,000 parameter configurations are chosen by sampling independently from the following distributions (corresponding to columns (1) through (5), respectively): Uniform[1.1, 10], Uniform[0,0.1], Uniform[0,10], Uniform[0,10], Uniform[0,1]. The estimated duration elasticity (at  $u = 5.4\%$ ) is 0.742 and the estimated interaction term is -0.142 (see Table 5 for more details). The following parameters are common across all configurations:  $w = 0.25$ ,  $b = 0.125$ .



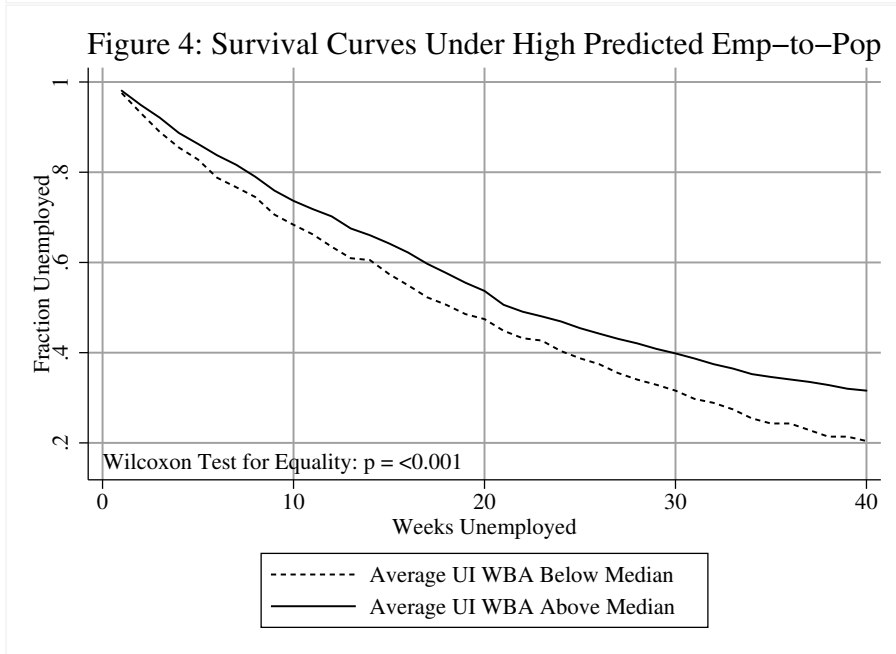
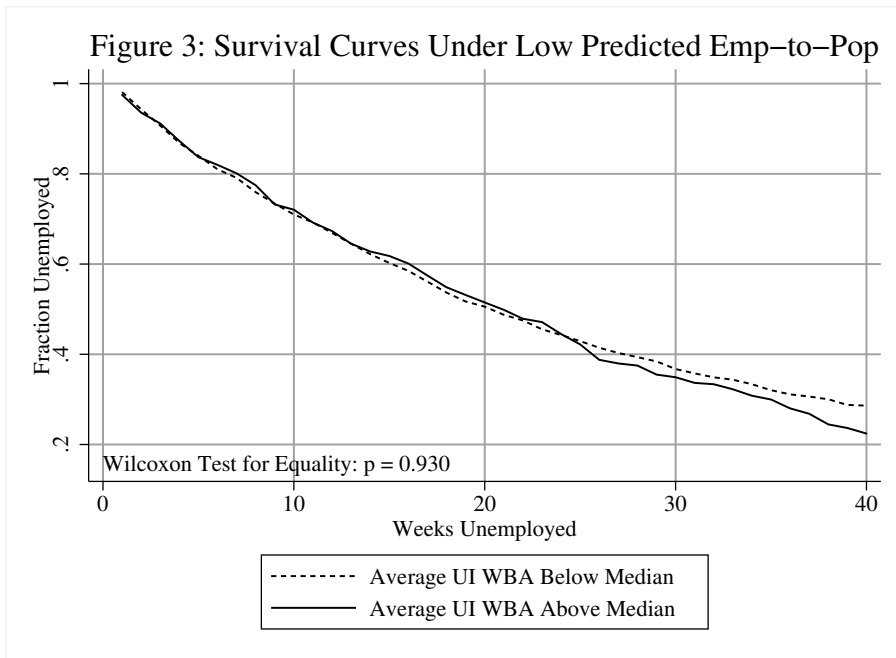
Table 13  
Sufficient Statistics Calibrations: Optimal UI and the  
Unemployment Rate

| $u$                 | 2.0%  | 3.7%  | 5.4%  | 7.1%  | 8.8%  |
|---------------------|-------|-------|-------|-------|-------|
| $\varepsilon_{D,b}$ | 1.218 | 0.979 | 0.741 | 0.503 | 0.264 |
| $r^*$               | 13.5% | 24.5% | 36.5% | 49.8% | 65.1% |
| $b^*$               | \$47  | \$86  | \$128 | \$174 | \$228 |

Notes: All columns report optimal UI benefit levels at various levels of the unemployment rate. Subsequent rows report the elasticity of unemployment duration with respect to UI benefit level, the optimal UI benefit level ( $b^*$ ) and the optimal UI replacement rate ( $r^*$ ). The optimal replacement rate is computed by dividing UI benefit level by the average wage. See Section 4 for more details on the computations. The optimal benefit level is computed assuming a weekly wage of \$350.



Notes: Data are individual-level unemployment spells from 1985-2000 SIPP. Each figure plots (Kaplan-Meier) survival curves for two groups of individuals based on whether or not Average UI Weekly Benefit Amount (WBA) in individual’s state is above or below the median. The survival curves are adjusted following Chetty (2008), which parametrically adjusts for “seam effect” by fitting a Cox proportional hazard model with a seam dummy and then recovering the baseline hazard.



Notes: Data are individual-level unemployment spells from 1985-2000 SIPP. Each figure plots (Kaplan-Meier) survival curves for two groups of individuals based on whether or not Average UI Weekly Benefit Amount (WBA) in individual’s state is above or below the median. The survival curves are adjusted following Chetty (2008), which parametrically adjusts for “seam effect” by fitting a Cox proportional hazard model with a seam dummy and then recovering the baseline hazard. The employment to population ratio is predicted following Bartik (1991); see text for details.

Figure A1: Survival Curves Under High Unemployment Rate

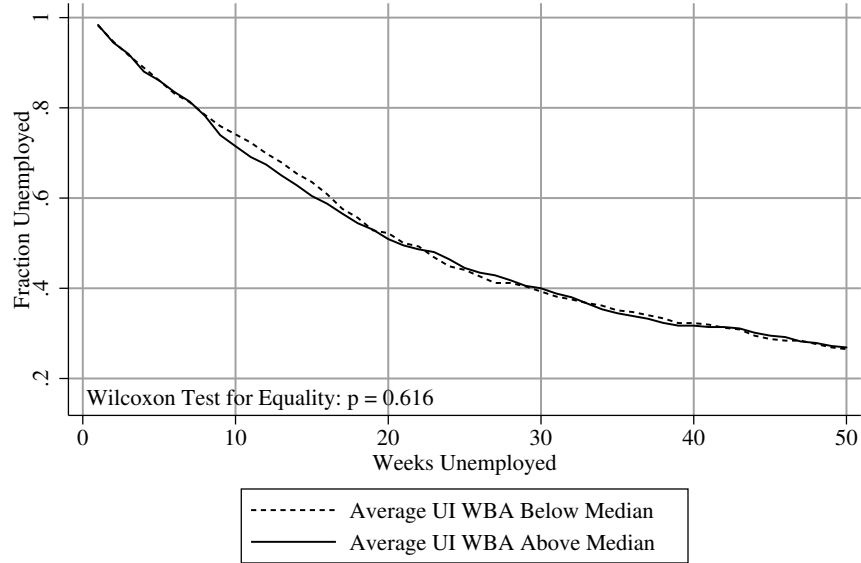
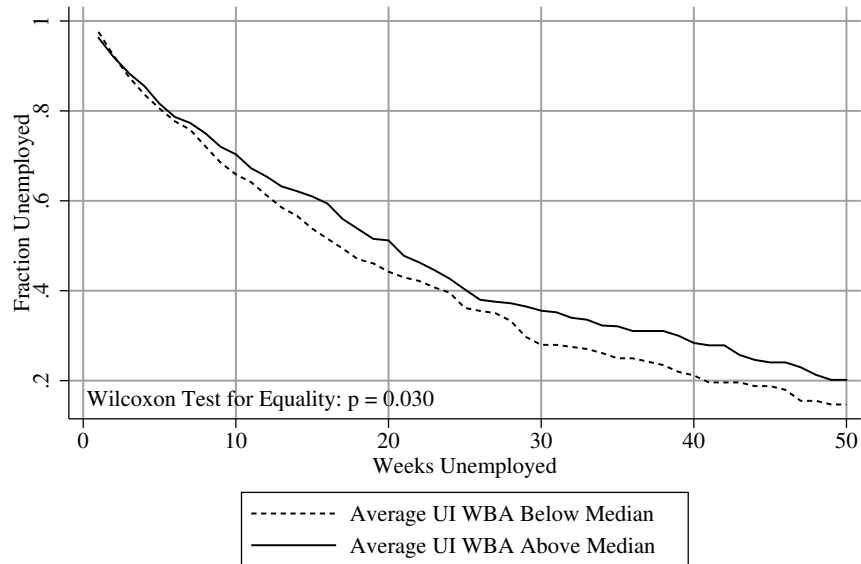


Figure A2: Survival Curves Under Low Unemployment Rate



Notes: Data are individual-level unemployment spells from 1985-2000 SIPP. In order to minimize liquidity effects, the sample is limited to individuals with net liquid wealth above the median. Each figure plots (Kaplan-Meier) survival curves for two groups of individuals based on whether or not Average UI Weekly Benefit Amount (WBA) in individual's state is above or below the median. The survival curves are adjusted following Chetty (2008), which parametrically adjusts for "seam effect" by fitting a Cox proportional hazard model with a seam dummy and then recovering the baseline hazard.