Unemployment Insurance and Moral Hazard on the Job

Ignacio Amaral*

Arizona State University

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Abstract

This paper studies how Unemployment Insurance (UI) affects labor market outcomes through the incentives of employed workers to exert effort on the job, in addition to the well-documented effects on unemployed workers' search behavior. Using US data, I find that higher UI benefits significantly increase the likelihood of job separations due to discharge or layoff. I rationalize this finding and quantify its policy implications in a dynamic model that features hidden effort on the job as well as hidden job search effort. In this environment, long-term wage contracts arise endogenously to mitigate moral hazard on the job, prescribing wage cuts and separations when firms receive signals of low effort. In a naive calibration that ignores on-the-job moral hazard, doubling the replacement rate reduces aggregate output by only 0.6% and would appear close to optimal. In the benchmark calibration, disciplined by my empirical estimate of the firing elasticity and observed wage-cut patterns, the generosity of the current US system is already roughly optimal, and doubling the replacement rate would reduce aggregate output by 4.8%. These results highlight the importance of considering the optimal responses of all workers, not just the unemployed, when evaluating UI policy.

JEL Classification: J65; J64; J41; J68; D82
Keywords: Unemployment Insurance, Effort, Moral Hazard, Firing, Job Search

*Arizona State University, W.P. Carey School of Business, Department of Economics.
Email: iamaral1@asu.edu.
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1 Introduction

Public unemployment insurance (UI) addresses an important market incompleteness: in the absence of private insurance against job loss, it allows workers to smooth consumption across employment states. At the same time, by raising the value of unemployment, UI distorts incentives in the labor market. Unemployed workers may reduce their search effort, and employed workers may lower their on-the-job effort when dismissal becomes less costly. The latter channel is central to efficiency-wage theory,[1] since generous UI weakens firms' ability to discipline effort through the threat of firing. However, research on UI policy has largely focused on the distortion of job search incentives.

This paper shows that moral hazard on the job (MHOJ) is an important factor in evaluating UI policy. Using U.S. data, I document that higher UI benefits significantly increase the likelihood of separations through discharge or layoff, consistent with lower worker effort. I rationalize this finding and quantify its policy implications in a dynamic model that features hidden effort on the job as well as hidden search effort off the job. In this setting, long-term wage contracts arise endogenously to discipline effort, prescribing wage cuts and separations when firms receive signals of shirking. The model, disciplined by my empirical evidence on the elasticity of separations to UI benefits, shows that the economic costs of generous UI—measured in forgone output—are considerably larger once MHOJ is taken into account.

The quantitative importance of moral hazard on the job (MHOJ) arises through three channels: job separations, labor productivity, and labor demand. I measure the effect of UI generosity on job separations directly from the data by exploiting variation in benefits across states and over time. The empirical approach mirrors that of Chetty (2008) and Michelacci and Ruffo (2015), who estimate the elasticity of job finding rates to UI benefits. I construct employment spells from the Survey of Income and Program Participation (SIPP) and impute the UI benefits that employed workers would receive if they were fired, based on administrative data from the Benefit Accuracy Measurement (BAM) program. The BAM data contains information on unemployed workers' earnings histories and actual benefits received, which I use to recover state-specific rules for benefit determination. Estimating a Cox hazard model of firm-initiated separations—discharges or layoffs—I obtain an elasticity of 0.69 with respect to UI benefits. This magnitude is

[1] See, for example, Shapiro and Stiglitz (1984).

comparable to the elasticity of job-finding rates with respect to UI benefits estimated by Moffitt (1985), Meyer (1990), and Chetty (2008), which range from -0.40 to -0.80, suggesting that UI influences both unemployment inflows and outflows to a similar degree.

To quantify how UI generosity affects productivity and labor demand, I develop a structural model that embeds the standard moral hazard problem of unemployed workers who must be incentivized to search, but extends it to incorporate MHOJ in a tractable way. In the model, employed workers generate a fixed output each period but must exert effort to prevent negative shocks that cause output losses or job destruction. Because effort is unobservable while output losses are observable, firms and workers enter into long-term contracts that condition wages on the occurrence of such losses. Wages fall when an output loss occurs and rise otherwise. This contractual structure links observed wage cuts to unobserved effort, providing a way to infer the magnitude of output losses due to MHOJ from the data.

I discipline the model to match key features of the U.S. labor market between 1990 and 2019, including my estimate of the elasticity of the firing rate to UI benefits and existing estimates of the elasticity of job-finding rates. In the benchmark calibration, the generosity of the current U.S. system is already roughly optimal, and further expanding UI would come at sizable costs: doubling the replacement rate from 45% to 90% reduces aggregate output by 4.8%. By contrast, in a naïve calibration that ignores MHOJ by assuming zero effort costs on the job, the same policy change lowers output by only 0.6% and appears close to optimal. Importantly, job-finding rates fall by about 9% in both calibrations, precisely because the model is disciplined to match the same empirical elasticity of job finding to UI benefits. The difference comes from additional margins that respond only when MHOJ is present: firing rates rise by 41% and average output per employed worker declines by 2.1%. This contrast highlights the importance of accounting for MHOJ when evaluating UI policy.

The paper is organized as follows: I discuss my contribution to the literature in section 1.1. Section 2 presents the data and empirical findings. Section 3 sets up the model, whereas section 4 defines and characterizes the equilibrium. Section 5 describes the calibration, and 6 performs the optimal policy analysis and obtains the main quantitative results. Section 7 concludes.

1.1 Related Literature

The idea that workers' productivity depends crucially on their outside option lies at the heart of several efficiency wage theories[2]. In particular, this paper builds on the shirking model of Shapiro and Stiglitz (1984) where workers' choice of effort on the job is unobservable to firms, who can only monitor workers' effort imperfectly and incentivize them to exert effort by offering a fixed wage under the threat of firing. However, closer to the tradition in personnel economics −Lazear (1979) and Lazear and Rosen (1981)−, I endow firms and workers with the ability to mitigate moral hazard through flexible long-term contracting by making not only permanence at the firm but also future wages conditional on firm's imperfect monitoring. By combining these ideas from efficiency wage theory and personnel economics, this paper studies the core trade-offs in UI policy.

Central to this paper is the idea that UI affects separation rates through workers' effort on the job. Early evidence for this mechanism comes from Canada: Christofides and McKenna (1996) and Green and Riddell (1997) document lower separation rates following a 1990 reform that tightened eligibility requirements. Using Dutch data, Tuit and van Ours (2010) exploit a 2003 reform affecting workers over age 57 and estimate an elasticity of separations with respect to UI benefits of 0.45—close to the 0.69 I find in this paper.[3] More recently, Hartung, Jung and Kuhn (2024) examine the German Hartz reforms of the mid-2000s, which reduced UI generosity. They find that the reforms led to a sizable decline in the unemployment rate, with three-quarters of the effect driven by lower separation rates, and only the remainder explained by higher job-finding rates. Taken together, this evidence highlights the need for a framework to study optimal UI in which both separations and job-finding are endogenously determined.

A large body of literature has studied optimal unemployment insurance in different environments. Baily (1978) and Chetty (2006) show that within a class of models that abstract from general equilibrium effects, the optimal level of unemployment depends on three parameters that can be estimated from the data: risk aversion, the consumption-smoothing benefit of UI, and the elasticity of unemployment durations with respect to UI

[2] Katz (1986) provides a review of different efficiency wage theories. Three such theories where workers' productivity depends crucially on their outside option are the shirking model of Shapiro and Stiglitz (1984), the labor turnover models of Salop (1979), Stiglitz (1974) and Stiglitz (1985), and the adverse selection models of Stiglitz (1992) and Weiss (1980).

[3] They focus on a narrow demographic group, whereas my estimate uses all prime-aged male workers in the United States.

benefits. Closer to this paper, Mitman and Rabinovich (2015) show how the presence of general equilibrium effects can have important implications for UI policy, but they focus on the cyclicality of the optimal policy. However, in the presence of MHOJ, UI also affects firing rates and the level of effort of employed workers. These margins are introduced and quantified in the model developed in this paper.

Few papers have studied UI policy in the presence of MHOJ. Two notable exceptions are Wang and Williamson (1996) and Wang and Williamson (2002), who analyze an economy where workers must exert effort both to find and to retain a job. My contribution relative to theirs is threefold. First, while their calibrated model matches average job-finding and separation rates, it does not capture how responsive these rates are to UI benefits, as they do not discipline the model with measures of the relevant elasticities. In contrast, my quantitative exercises are consistent with existing estimates of the elasticity of job-finding with respect to UI benefits and with my new estimate of the elasticity of firing. Second, I introduce a labor demand channel that responds to UI policy, generating long-term labor contracts that mitigate moral hazard. Third, I show that modeling MHOJ is quantitatively important for assessing the consequences of UI policy in terms of output.

Contemporary to this paper, Cai and Heathcote (2023) study an environment where firms do not observe workers' outside options and the government cannot distinguish between involuntary separations and quits. They show that under these frictions, optimal UI is lower than in a public-information economy. Like this paper, they emphasize the quantitative importance of analyzing UI in a setting where separation rates are policy-dependent. However, in their framework the mechanism operates through the quitting margin, whereas in mine—motivated by my empirical findings—the link runs through firing, driven by unobservable worker effort. As a result, UI in my model influences not only separation rates but also the productivity of employed workers.

Finally, this paper builds on the frictional search literature that incorporates long-term labor contracts—Burdett and Coles (2003), Shi (2009), Menzio and Shi (2010). Within this framework, Tsuyuhara (2016) shows that unobservable worker effort creates moral hazard, giving rise to wage-tenure profiles and heterogeneous separation rates by job tenure. Balke and Lamadon (2022) use a related approach to study how idiosyncratic productivity shocks pass through to wages and mobility decisions. My contribution relative to this literature is to embed the government's choice of UI policy into the framework and to quantify the importance of MHOJ for policy design.

2 Empirical Evidence

Generous UI comes at the cost of an enhanced outside option for employed workers who may be discouraged from exerting effort at their jobs. In this section, I provide a crucial measure for the size of this cost: the elasticity of firing rates to the size of UI benefits. If this elasticity is high, then the optimal generosity of UI should, at the very least, account for its impact on job separations. Moreover, if generous UI leads to more frequent firing, then it must lead to lower labor productivity as well; otherwise, why would workers be fired more frequently?

To estimate the elasticity of firing rates to UI benefits, I mirror the strategy in Chetty (2008) and Michelacci and Ruffo (2015) who estimated the elasticity of the job finding rate to UI benefits. The strategy exploits changes in UI benefits within states and over time. My estimates for the elasticity of firing rates are a crucial input in the analysis of section 6 where I evaluate the quantitative importance of moral hazard on the job for optimal unemployment insurance.

2.1 The Data

I use the Survey of Income and Program Participation (SIPP) and the Benefit Accuracy Measure (BAM) spanning 2004 to 2016. The SIPP provides a collection of panels with monthly information on individuals surveyed for 2-4 years. An important feature of the SIPP is its detailed information on workers' jobs, including the time and reason for separation if a separation occurs while the individual is in the sample. I construct employment spells for male workers aged 25 to 55 who are not self-employed and work for a unique employer since workers with multiple employers would not be entitled to UI after losing a job. The amount of UI benefits that a worker could perceive upon losing her job though is not observable, but it can be estimated based on her earnings history, particularly using earnings during the year before separation. Therefore, I keep only employment spells with at least 12 months consecutive months of earnings information, allowing the estimation of UI benefits in case of firing. The final dataset consists of 16,367 employment spells.

I use the BAM data to produce a UI benefits estimator as described in 2.2. The dataset contains work history information for unemployed workers who applied for UI, including administrative records of their wages before the unemployment spell, as well as the actual UI benefit amount received. I use this dataset to build a UI benefit estimator that takes as inputs the wage history of workers and the month and state where they become unemployed, and delivers an estimate of the UI benefit. The estimator is then used to impute the UI benefits employed workers in the SIPP would receive if they became unemployed.

2.2 Estimating Unemployment Benefits

In many states of the US, the size of UB follows a simple rule: up to a cap, they are calculated as a fraction of either annual earnings during the year before becoming unemployed or earnings in the quarter of the year before becoming unemployed where earnings were the highest. Other states have used more complex rules: for example, in 2015, the weekly amount of UB in Colorado was up to a cap, the maximum between two formulas, one of which used annual earnings and the other one used the two consecutive quarters with higher earnings. My estimation procedure for each state-month pair consists of determining (*i*) a cap, (*ii*) whether annual earnings or highest quarter earnings should be used, and (*iii*) the fraction of the appropriate earnings to be used. Using this procedure, I can predict UB perfectly in some states that use a simple rule. For those states that use more complex rules and where my prediction is not perfect, I set a threshold for the prediction errors of UI benefits in a year in the BAM dataset, beyond which I drop the state-year pair.

The cap is estimated as the maximum UI benefit observed in BAM. Let this estimate for state j and month t be $\bar{b}_{jt}$. Next, I keep only workers with UI benefits strictly lower than $\bar{b}_{jt}$ and estimate the following two regressions for each month-state pair:

$$b_{ijt} = \phi^A_{jt} y^A_{ijt} + \epsilon^A_{ijt} \tag{1}$$

$$b_{ijt} = \phi^H_{jt} y^H_{ijt} + \epsilon^H_{ijt} \tag{2}$$

where ϕ^H_{jt} and ϕ^H_{jt} are the parameters of interest to be estimated; b_{ijt} is the benefit amount perceived by individual i in state j at time t; y^A_{ijt} and y^A_{ijt} are labor earnings in the last year and in the quarter where earnings where the highest during the last year respectively; and ϵ^A_{ijt} and ϵ^H_{ijt} are prediction errors. All state-month pairs are classified based on the R-squared in regressions (1) and (2). If the R-squared is lower than 0.99 in both regressions for nine or more months within a year for a given state, then I conclude that neither annual earnings nor highest quarter earnings provide a good fit for how UB is computed, and I drop the state-year pair from the sample; only 4.6 states are dropped on average each year using this procedure.[4] All surviving state-year pairs are assigned to the set where annual earnings are used, A, if the R-squared is higher for 1 and to the set where highest quarter earnings are used, H, if the R-squared is higher for 2. The estimated UI benefits are then given by the formula

$$\hat{b}_{ijt} = \begin{cases} \min\{y^A_{ijt}\hat{\phi}^A_{jt}, & \bar{b}_{jt}\} \quad \text{if } \{j,t\} \in A \\ \min\{y^H_{ijt}\hat{\phi}^H_{jt}, & \bar{b}_{jt}\} \quad \text{if } \{j,t\} \in H \end{cases}$$

where $\hat{\phi}^A_{jt}$ and $\hat{\phi}^H_{jt}$ are the OLS estimates from (1) and (2) respectively. Table 1 shows the fit of this method: 83% of all UI benefits observed in the BAM dataset are predicted with an error lower than 1%, whereas in only 5% of cases the prediction is off by more than 10%.

Table 1: UI Benefit Prediction Errors

% Prediction Error	% Frequency
0	39
$\in (0,1]$	44
$\in (1,5]$	9
$\in (5,10]$	4
>10	5

2.3 Hazard Model Estimates

Mirroring the strategy in Chetty (2008) and Michelacci and Ruffo (2015) to estimate the elasticity of the job finding rate to UB, my estimate of the elasticity of the firing rate to UI benefits exploits variations in the rules that determine UB over time within states. In concrete, I estimate the following Cox hazard model

$$log(h_{it}) = \alpha_t + \gamma'_{\text{state}} S_{it} + \gamma'_{\text{duration}} D_{it} + \beta log(b_{it}) + \theta' X_{it} + \epsilon_{it}. \tag{3}$$

[4]The states that are dropped in at least one year are Colorado, Connecticut, Florida, Illionois, Massachusetts, Maine, Minnesota, North Carolina, New Jersey, New York, Ohaio, Oklahoma and Vermont.

The dependent variable h_{it} is the firing rate for individual i at time t. The parameter α_t is a time fixed effect; S_{it} is a binary vector indicating the state of individual i at time t, therefore γ'_{state} is a vector of state fixed effects; similarly, D_{it} is a vector indicating the duration of worker i's employment spell at time t, therefore $\gamma'_{\text{duration}}$ is a spell duration fixed effect; b_{it} is the estimated UB for worker i at time t; and X_{it} is a set of controls. The controls include age, marital status, years of education, a 10-piece log-linear spline for annual earnings, and the log of earnings in the highest quarter earnings during the last year. This last control is crucial: in those states that use the highest quarter earnings to determine UI benefits, workers with more volatile earnings throughout the year are entitled to higher UI benefits compared to workers who have the same level of annual earnings but evenly distributed over time. If firing rates differ for workers with a different distribution of earnings throughout the year for reasons other than the UI benefits they obtain upon firing, then failing to control for earnings in the highest quarter would lead to an estimate of β in 3 that confounds the effect of volatine earnings with the effect of UI benefits.

I estimate 3 using maximum likelihood[5]. Table 2 provides the estimates of β using three different definitions of firing in columns 1 to 3. In the first column, only separations due to discharge are considered firing. This type of firing is most tightly linked to the story of this paper, where the outside option of workers affects the frequency of firing because it affects workers' choice of effort. The point estimate for the elasticity of discharges to UI benefits is indeed positive and sizable, but the dataset contains only 133 discharges leading to a nosy estimate with large standard errors.[6] In the second column, I consider firings due to layoffs only, resulting in a large point estimate and statistically higher than zero at a 95% significance level, implying that firms actually lay off workers more often when UI is more generous. This a finding is consistent with evidence found for Canada in Christofides and McKenna (1996) and Green and Riddell (1997). The most precise estimate is given by the third column, where the left-hand side variable in 3 is the firing rate due to discharge or layoff. The elasticity of firing to UI benefits using this definition of firing is estimated to be 0.69, and it is statistically higher than 0.

[5]Notice that the left hand side variable can not be computed in the data independently from parameters β and θ. Instead, h_{itd} is computed for a given set of parameters, and the likelihood function is constructed based on h_{itd}.

[6]The relatively low number of separation events in my sample partly reflects that transition rates between employment states in the SIPP are consistently lower than those observed in the CPS; see Footnote 13 in Menzio, Telyukova and Visschers (2016) for a detailed discussion. Additionally, my sample is restricted to individuals who qualify for UI, which excludes short-lived jobs.

Table 2: Elasticities to Unemployment Benefits

	(1) Discharges	(2) Layoffs	(3) Discharges/layoffs	(4) Quits to non-employment
$log(b_{it})$	0.71	0.59	0.69**	−0.31
	(0.75)	(0.37)	(0.34)	(0.45)
Spells	16,367	16,367	16,367	16,367
Event occurrences	133	419	552	309

Notes: Estimates of β in the Cox regression (3), where the left-hand side differs by column. In the first column, h_{it} is the discharge rate for worker i in period t. In the second column, h_{it} refers to the lay off rate. In the third column, h_{it} refers to the rate of discharge or laid off. In the fourth column, h_{it} refers to the rate of quitting to non-employment. Standard errors clustered by state are reported in parentheses. Event occurrences refer to the number of discharges, layoffs, discharges or layoffs, and quits to non-employment occur in the sample used in each column.

* Significant at 10% level.

** Significant at 5% level.

*** Significant at 1% level.

Finally, column 4 reports the estimated elasticity of the quit rate with respect to UI benefits. This estimate is motivated by the idea that if the government cannot distinguish between quits and firings, then more generous UI benefits may incentivize workers to quit, knowing they may still qualify for benefits. However, based on self-reported separation motives in the SIPP, the quit rate does not appear responsive to UI generosity: the point estimate is negative and statistically indistinguishable from zero.

One potential concern is misclassification—if surveyors, like government agencies, are unable to reliably distinguish quits from firings, the SIPP data might underreport quits. While this is plausible, it is worth noting that workers have a stronger incentive to conceal quits from the government (to retain UI eligibility) than from survey interviewers, who pose no direct threat to their benefit status.

The evidence in this section shows that separation rates are responsive to UI generosity, with a clear policy implication: the cost of a generous UI system involves not only disincentivizing job searching for unemployed workers but also more frequent job separations. Moreover, job separations respond to UI benefits due to more frequent layoffs and discharges, consistent with the presence of moral hazard on the job: higher UI benefits imply an enhanced outside option for workers who may then adjust their choice of effort on the job downward at the risk of being fired. Determining the optimal generosity of UI requires a framework that accounts for these mechanisms.

3 Model

In this section, I develop a framework to study optimal UI where the key innovation is the presence of MHOJ. The presence of UI allows workers to transfer resources from states of the world where they are employed by paying taxes to states of the world where they are unemployed by collecting UI benefits. However, UI distorts the incentives of unemployed workers who need to exert effort to search for jobs, and also the incentives of employed workers who need to exert effort to prevent output losses.

3.1 Model Setup

Time is discrete and runs forever. There is a continuum of homogeneous firms whose measure is determined endogenously by competitive entry. Entering firms need to incur in a vacancy posting cost κ to search for a worker. There is a continuum of homogeneous workers with measure 1 that can be employed or unemployed. Employed workers produce z units of output in any given period, but they need to exert effort in order to prevent negative events that are costly to the firm. The workers' choice of effort is not observable to the firm, but negative events are. Moreover, if a negative event occurs, the firm needs to incur a fixed cost to keep the worker. Upon matching, firms and workers sign labor contracts specifying the worker's compensation conditional on the history of negative events.

Job Search and Matching. Firms and workers direct their search to submarkets that are indexed by the promise value to be delivered to the worker upon matching V, and a corresponding market tightness $\theta(V)$.[7] These submarkets are governed by a matching function $M(S(V), v(V))$ where $S(V)$ and $v(V)$ are the aggregate search effort and the number of vacancies in the submarket with promised value V, respectively. This function satisfies constant returns to scale, and it is strictly increasing and strictly concave in both arguments. Market tightness is defined as $\theta(V) = v(V)/S(V)$ for any submarket with $S(V) > 0$.[8] Workers can search in up to one market, and they find a job with

[7] Because search is directed, there is no distinction between meeting and matching. All job offers are accepted.

[8] In submarkets that are not visited by any worker, $\theta(V)$ is an out-of-equilibrium conjecture that helps determining the equilibrium behavior. I impose a condition for this conjecture in the equilibrium definition.

a probability per efficiency search unit $p(\theta(V)) = M(S(V), v(V))/S(V) = M(1, \theta(V))$. The job-finding probability of a worker who searches in a market with promised value V and exerts effort s equals $sp(\theta(V))$. Search effort has an increasing and strictly convex cost $\psi_u(\cdot)$. Moreover, this search effort function satisfies the following two properties: (i) $\psi_u'(s)$ converges to zero as s converges to zero; (ii) $\psi_u'(s)$ converges to infinity as s converges to 1. These two properties guarantee that the optimal search effort is in the open interval $(0, 1)$. The probability that a vancancy is filled in a market with promised value V equals $q(\theta(V)) = p(\theta(V))/\theta(V) = M(1/\theta(V), 1)$.

The Value of Vacancies. To post a vacancy, firms incur in cost κ. The value of posting a vacancy in a market where the promised value to workers is V is given by

$$J(V) = -\kappa + \beta \left[q(\theta(V))\Pi(V) + (1 - q(\theta(V)))\, J(V) \right]. \tag{4}$$

where β is the time discount factor.

Problem of Unemployed Workers. Unemployed workers can have current or expired UI benefits, and expiration occurs stochastically: if UI benefits are current, they expire at the end of the period with probability λ. The parameter λ will be calibrated to generate an average UI benefit duration of 6.5 months. All unemployed workers choose the market j where to search and search effort, taking the market tightness θ_j as given. The value of unemployment with current benefits is given by

$$V^U = \max_{s,V} \; u(b) - \psi_u(s) + \beta \left[sp(\theta(V))V + (1 - sp(\theta(V))) \left(\lambda V^U_{expired} + (1-\lambda) V^U \right) \right] \tag{5}$$

whereas the value of unemployment with expired benefits is given by

$$V^U_{expired} = \max_{s,V} \; u\left(\underline{c}\right) - \psi_u\left(s\right) + \beta \left[sp(\theta(V))V + (1 - sp(\theta(V)))\, V^U_{expired} \right]. \tag{6}$$

Production. Employed workers produce z units of output in any given period, but they need to exert effort in order to prevent the occurrence of negative events. In particular, they choose a level of effort $x_e \in [0, 1]$ for which they incur a cost given by strictly increasing and strictly convex function $\psi_e(\cdot)$. Similarly to the search cost function, this effort cost function satisfies two properties that guarantee an interior solution: (i) $\psi_e(x)$ converges to zero as x converges to zero; and (ii) $\psi_e(x)$ converges to infinity as x converges to 1. A negative event occurs with probability $1 - x_e$, and its magnitude can be low or high: with probability $1 - \mu$ the magnitude is low, and the firm needs to incur the fixed cost f to keep the worker, where f is assumed to be low enough so that the firm would rather pay this cost than let the worker go. With probability μ though, the magnitude of the negative event is high, and the fixed cost needed to pay in order to keep the worker is assumed to be so high that the firm chooses to let the worker go. These negative events provide a simple way to link workers' effort to the productivity of the firm-worker match.

Labor Contracts. Upon matching, firms and workers sign labor contracts that specify the worker's compensation conditional on the past history of negative events. Following Spear and Srivastava (1987), I write the optimal contract recursively using the promised value to the worker V as a state variable. At any point in time, this promised value is the present discounted utility that the contract delivers to the worker. Conditional on a promised value V, the recursive optimal contract specifies (i) the current wage w, (ii) the level of effort to induce x^e, (iii) the continuation value for next period if no negative event occurs V^H, and (iv) the continuation value for next period if a negative event does occur V^L. Additionally, for any given V, the optimal contract is allowed to randomize between any two choices $\{w_i, x_i^e, V_i^H, V_i^L\}_{i=1,2}$. Although the underlying preference and technology functions satisfy the standard curvature properties, incentive constraints can, in general, create additional gains from randomization because the allocation space may become nonconvex. Lotteries are a standard way to convexify the feasible set, thus guaranteeing the concavity of the value function of the firm, which in turn is useful to establish some properties of the optimal contract.[9]. Let $\xi = \{w_i, x_i^e, V_i^H, V_i^L, \pi_i\}_{i=1,2}$ where π_i is the probability that the outcome of the lottery is $(w_i, x_i^e, V_i^H, V_i^L)$. The firm's maximized value of a match $\Pi(V)$ satisfies the following functional equation:

[9] Menzio and Shi (2010), Balke and Lamadon (2022) and Tsuyuhara (2016) also use lotteries in a similar context to convexify the feasible set.

$$\Pi(V) = \max_{\xi} \sum_{i=1,2} \pi_i \Big\{ z - w_i + \beta(1-\delta)\left[x_i^e \Pi(V_i^H) + (1-x_i^e)(1-\mu)(-f + \Pi(V_i^L)) \right] \Big\} \tag{7}$$

Subject to:

$$\text{(PK)} \quad \sum_{i=1,2} \pi_i \Big\{ u\left(w_i(1-\tau)\right) - \psi_e(x_i^e)$$
$$+ \beta(1-\delta)\left[x_i^e V_i^H + (1-x_i^e)(\mu V^U + (1-\mu)V_i^L) \right] + \beta\delta V^U \Big\} \geq V$$

$$\text{(IC)} \quad x_i^e \in \text{argmax}_{x \in [0,1]} \sum_{i=1,2} \pi_i \Big\{ u\left(w_i(1-\tau)\right) - \psi_e(x)$$
$$+ \beta(1-\delta)\left[x V_i^H + (1-x)(\mu V^U + (1-\mu)V_i^L) \right] + \beta\delta V^U \Big\}$$

$$\text{(PC)} \quad \Pi(V_j) \geq 0, \quad V_j \geq V^U \qquad \text{for } j \in \{L, H\}$$
$$w_i \geq 0, \quad x_i^e \in [0,1].$$
$$\pi_1 \geq 0, \quad \pi_2 \geq 0, \quad \pi_1 + \pi_2 = 1.$$

The value of the firm when separation occurs is normalized to zero. This occurs exogenously with probability δ, and endogenously with probability $(1-\delta)(1-x_e)\mu$ if a high magnitude negative event occurs. The firm's choice is subject to a promise-keeping constraint (PK), an incentive compatibility constraint (IC), two participation constraints (PC), and the constraints that wages must be weakly positive and workers' effort must lie in the interval $[0,1]$.

Free Entry. I impose a free entry condition in each labor submarket. This implies that as long as the value of posting a vacancy in the submarket that delivers a value V to workers is positive, firms increase the number of vacancies posted. However, more vacancies posted in a market that is visited by a positive number of workers increases market tightness, lowering the vacancy filling rate and therefore the value of posting a vacancy. It follows that in any submarket that is visited by a positive number of workers, the following inequalities must be satisfied

$$0 \geq J(V), \quad \theta(V) \geq 0 \tag{8}$$

with complementary slackness. In any submarket that workers do not visit $\theta(V)$ is a conjecture that helps determining the equilibrium behavior. Following Shi (2009) and Menzio and Shi (2010), I restrict attention to equilibria in which complementary slackness of inequalities 8 holds in every submarket.

4 Equilibrium

Since I will use the model to assess the consequences of changing the generosity of UI, the tax rate τ needs to be treated as an endogenous object that adjusts to balance government budget. I focus on a stationary equilibrium where the distribution of workers across employment states and values of employment are constant. Denoting by $G(\cdot)$ the cumulative distribution function of workers across promised values, government budget balance requires

$$(1 - u^c - u^e)\tau \int w(V) dG(V) = u^c b + u^e \underline{c} \tag{9}$$

where $w(\cdot)$ is the wage policy function.

Definition 4.1 *A **Recursive Search Stationary Equilibrium (RSSE)** consists of a market tightness function θ, values of unemployment V^U and $V^U_{expired}$, search policy functions $\{x^u, V_0\}$ and $\{x^u_{expired}, V_{0,expired}\}$, a firm's value function Π, a contract policy function ξ, number of workers with current and expired unemployment benefits $\{u^c, u^e\}$, a cumulative distribution function of employed workers across promised values G, and a tax rate τ. These objects satisfy the following requirements:*

1. *θ satisfies inequalities 8 with complementary slackness.*

2. *V^U and $V^U_{expired}$ satisfy equations 5 and 6 respectively. Moreover, $\{x^u, V_0\}$ and $\{x^u_{expired}, V_{0,expired}\}$ are the associated optimal policies;*

3. *Π satisfies the functional equation 7, and ξ is the associated optimal policy.*

4. *u^c, u^n and G are constant over time.*

5. *τ satisfies 9.*

The stationarity conditions for u^c, u^n and G to be constant over time are provided in the appendix C.

Endogenizing the tax rate τ brings about two difficulties, one computational and one analytical. The computational difficulty is that the equilibrium I just defined is not block recursive, as is usually the case in models with directed search:[10] policy functions depend on τ, which in turn depends on the distribution of workers across employment states and promised values. Therefore, policy functions cannot be found independently from the distribution of workers given by u^c, u^e, and $G(\cdot)$. Solving the model numerically therefore involves fixing τ, finding the policies, finding the distribution of workers, and updating τ.

The analytical difficulty is that the existence and uniqueness of an RSSE are not guaranteed: if unemployment benefits b are too large and the probability of expiration π is too low, then employed workers would have little incentive to exert effort on the job, and similarly, unemployed workers would be happy to remain unemployed. The number of

[10] See Menzio and Shi (2010).

employed workers could be so low that no tax rate can raise enough tax revenue. Moreover, setting $\tau = 0$ or $\tau = 1$ would produce a government budget deficit in both cases, in the second case because all workers would rather be unemployed than receive a wage after tax equal to zero. It follows that as long as the government's budget result is continuous in τ, the only way to obtain a unique RSSE is if the maximum possible budget result is exactly zero. However, if the maximum possible budget result is strictly positive, there must be (at least) two RSSE: one with a low tax rate and high employment and another one with a high tax rate and low employment.

4.1 Promotions and Demotions

A crucial property of the equilibrium is the behavior of wages over time conditional on the occurrence of negative events. Intuitively, because workers' effort is unobservable but they are associated with the occurrence of negative events are associated with workers' effort, a firm can incentivize effort by conditioning wages on the occurrence of negative events. The following proposition formalizes the result:

Proposition 4.1 *In any RSSE, There exists a wage interval* $[\underline{w}, \overline{w}]$ *such that*

1. *An employed worker's wage always belongs to this interval.*
2. *In the absense of negative events, the wage increases weakly.*
3. *If a negative event occurs, the wage decreases weakly.*

Proof: See appendix A.

I refer to wage increases and decreases as promotions and demotions. The promotion result in this paper mirrors the backloading result in Tsuyuhara (2016). The demotion result, though, is a novel feature of the model, stemming from the fact that negative events are informative to the firm about workers' effort. Moreover, the size of wage cuts upon demotion is tightly linked to the size of the output loss f, a feature that I exploit to take the model to the data.

5 Calibration

I look for a set of parameters where an RSSE exists and matches several features of the US labor market in the 1990-2019 period. For this purpose, the multiplicity of equilibria associated with different tax rates is not an issue because the tax rate is (almost) pinned down by the targets: dividing 9 by the average wage in the economy, denoted by $\hat{w}$, delivers

$$(1-(u^c+u^e))\tau = u^c\frac{b}{\hat{w}} + u^e\frac{\underline{c}}{\hat{w}}. \tag{10}$$

The unemployment rate $u^c + u^e$ is targeted, as well as the average replacement rate $b/\hat{w}$ and the average size of the consumption floor after UI benefits expiration $\underline{c}/\hat{w}$. If unemployment benefits did not expire, then we would have $u^e = 0$ and the tax rate in the calibrated economy would be exactly pinned down from 10. Unemployment benefits do expire though, and the distribution of unemployed workers between those with current and expired benefits is not targeted. However, the average duration of unemployment is targeted and lower than the average duration of UI benefits, implying that most unemployed workers must have current UI benefits and restricting the values that τ can take to a small interval. In practice, I pin down τ from 10 using $u^e = 0.012$ and calibrate the model ignoring budget balance. Once all targets have been closely matched, I check that $u^e = 0.012$ and, therefore, the budget balance is satisfied.

Solving the model with dynamic wages with the use of lotteries is computationally intensive: one needs optimize the right hand side of the Bellman equation in 7 over ten choice variables, where only the two wages conditional on the lottery outcome can be found in closed form given the other eight choice variables. However, when I calibrate the model without the use of lotteries, the resulting profit function turns out to be concave. Therefore, I ignore lotteries in the quantification of the model, but because the profit function is concave, the implications of proposition 4.1 still hold. Figure 1 illustrates promotions and demotions in the calibrated model with dynamic wage contracts.

The model period is set to a month. Table 3 lists the data moments I target and shows the model fit for each version of the model that I calibrate, while table 4 lists the calibrated parameters as well as their respective calibration targets.[11] I only show the model with

[11] The transition rates used as targets are based on the SIPP, which consistently gives lower rates than the CPS. See footnote 13 in Menzio, Telyukova and Visschers (2016) for a detailed discussion.

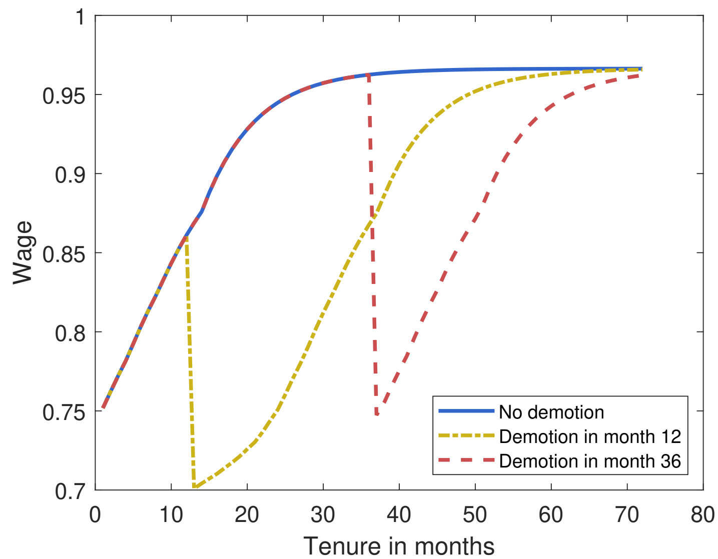

Figure 1: Promotions and Demotions

Notes: the figure shows the wage paths during four years for three workers who start at a job with the same initial value. These paths are computed using the calibrated full version of the model. The path in the solid line corresponds to a worker who does not experience any negative event and is thus not demoted. The path in the dash-dotted line corresponds to a worker who is demoted after the 10th month of tenure only. The path in the dashed line corresponds to a worker who is demoted after the 24th month of tenure only.

dynamic wages in 4 for ease of presentation. Panel A lists the parameters that were normalized or calibrated based on an external target, whereas Panel B lists the parameters that were chosen to match the moments listed in Table 3. The latter are jointly calibrated, but each moment is strongly associated with one parameter.

Preferences and Costs of Effort. The time discount factor β is set to 0.9967, consistent with a discount rate of 4%. Preferences over consumption are CRRA according to the utility function $u(c) = c^{1-\sigma}/(1-\sigma)$, and the parameter σ is set to 2, corresponding to an intertemporal elasticity of substitution of 0.5.

The disutility of effort for employed workers $\psi_e(x)$ and for unemployed workers $\psi_u(x)$ shapes the level and the responsiveness of job finding and firing rates. In particular, the curvature of these functions is a key determinant of the elasticity of job finding and

Moment	(1) Data	(2) Dynamic Wage	(3) Fixed Wage	(4) No MOHOJ
Job finding rate	18.7%	18.6%	18.7%	18.7%
Firing rate	1.0%	1.0%	1.0%	–
Job finding - UB elast.	−0.53	−0.54	−0.53	−0.53
Firing - UB elast.	0.69	0.70	0.69	–
Firing-to-demotions ratio	0.52	0.52	–	–
Share of exog. separations	0.14	0.14	0.14	–
Average wage cut	0.24	0.25	–	–
UI benefit / wage	45.0%	45.0%	45.0%	45.0%
Floor benefit / wage	5.0%	5.0%	5.0%	5.0%

Table 3: Targeted Moments in the Data and in the Model

Notes: the job finding and firing rates are in monthly frequency. The average wage cut is the average of the ratio between the annual wage after a demotion occur and the annual wage before the demotion.

firing rates to changes in unemployment benefit. I calibrate these disutility functions to

$$\psi_i(x) = \frac{\alpha_i}{1+\frac{1}{\gamma_i}} \frac{(x-\zeta_i)^{1+\frac{1}{\gamma_i}}}{(1-x_i)^{\frac{1}{\gamma_i}}}$$

for $i \in \{u, e\}$. These function satisfies the following crucial properties: (*i*) $\psi_e(\zeta_i) = \psi_e'(\zeta_i) = 0$, where ζ_i is interpreted as a minimum level of effort that workers can exert at no cost; (*ii*) $\psi_e(x_i)$ and $\psi_e'(x_i)$ both go to infinity as x_i approaches 1; (*iii*) γ_i controls the curvature of this function. The first two properties guarantee that the optimal choice of effort is always interior, whereas the third property provides a clear connection between the model and the empirical responsiveness of flows in and out of unemployment to changes in UI benefits. In particular, γ_e is chosen to generate the curvature in $\psi_e(x)$ required to match an elasticity of the firing rate to UI benefits of 0.69, as estimated in section 2. Meanwhile, γ_u is chosen to generate an elasticity of job finding rates to UI benefits of 0.53, as estimated in Chetty (2008). The level parameter α_u targets the average unemployment duration, 21.4 weeks, equivalent to a monthly job finding rate of 18.7%. The level parameter α_e is chosen to be consistent with the average unemployment rate and with the share of employment-to-unemployment transitions that are involuntary for workers. The average unemployment rate is 5.8%, implying an employment-to-unemployment transition rate of 1.15% monthly. The share of employment-to-unemployment transitions that are due to discharges or layoffs in my sample of employment spells is 86%, therefore I target a firing rate of $1.15\% \times 86\% = 1\%$ monthly.[12] The parameters ζ_i simply shift the level of effort associated with a certain cost, and they help computationally. The reason is that to be consistent with the firing rate measured in the data, the average effort on the job chosen by workers needs to be close to 1. Therefore, low levels of effort will not be chosen in the calibrated economy and choosing a high ζ_e makes it easier to find combinations of α_e and γ_e consistent with both the level and elasticity of firing rates. I set $\zeta_e = 0.8$ and $\zeta_u = 0$.

Production. I normalize the per-period output $z = 1$. The exogenous separation rate δ is chosen to be consistent with the share of total employment-to-unemployment transitions that are due to workers quitting. The parameters μ and f are associated with demotion patterns: μ is the ratio of firing to demotion, whereas f is the severity of the low-loss negative event, so it determines the size of wage cuts upon demotions. To construct data counterparts for these moments, I turn to the SIPP and compute the annual real wage changes between two calendar years for all jobs in the sample of employment spells described in section 2. I restrict the sample to only the years 2005-2007 to avoid observing changes in real wages associated with the recession. The resulting histogram is shown in figure 2. I define demotions in the data as annual real wage changes that are lower than -10% and find: (i) that on average, 11% of all jobs suffered demotion; (ii) that conditional on the ocurrance of a demotion, the average wage cut was 24%. I choose μ and f to be consistent with these findings.

Search and Matching Technology. The vacancy posting cost is set to $\kappa = 0.145$ to be consistent with the evidence in Hagedorn and Manovskii (2008) who estimate the combined capital and labor costs of vacancy creation to be 58% of weekly labor productivity. The matching function is assumed to be $M(S, v) = Sv/(S + v)$.[13] This function has the convenient property that both the job finding and job filling rates are always strictly lower than 1.

[12]Using CPS data, Qiu (2022) finds that the share of employment-to-unemployment transitions that are for involuntary reasons to the worker is about 86% as well, consistent with my finding using the SIPP.

[13]This is a particular case of the matching function used in den Haan, Ramey and Watson (2000), where the parameter is set equal to 1.

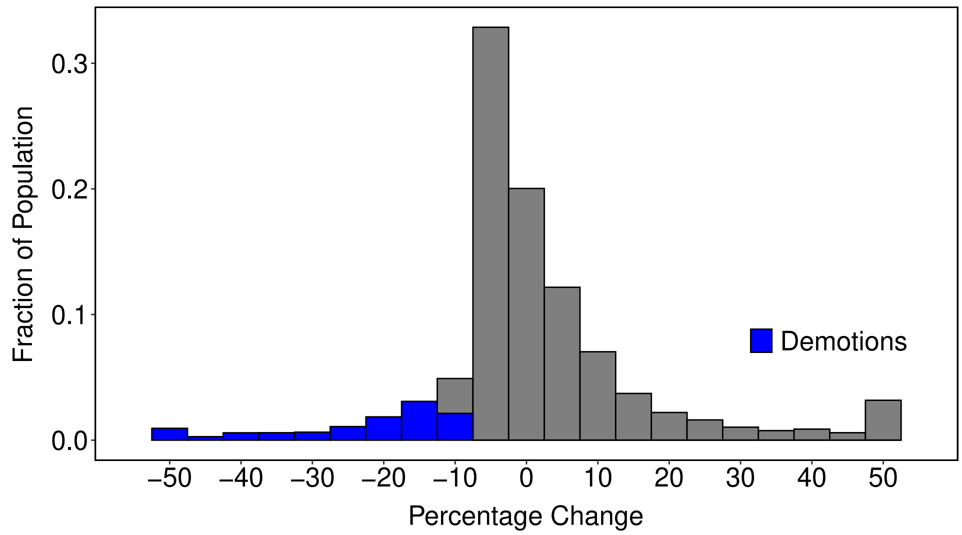

Figure 2: Real wage changes

Notes: Histogram of real wage changes between two calendar years for all jobs in the employment spells dataset constructed in section 2 using SIPP data. Demotions are defined as changes in real wage lower than 10%.

Government Policy. The probability of UB expiration π is chosen to match an expected UB duration of 26 weeks, consistent with most states policy in the US. The benefit size b is chosen to match an average replacement rate in the model of 45%, which is the average replacement rate in the BAM dataset after excluding outliers.

Floor consumption. The floor consumption $\underline{b}$ is chosen to match the generosito of the SNAP program benefits (food stamps) which are worth around $250 per month or 5% of the average monthly salary in the US.

6 Unemployment Insurance Policy

The goal of this section is to assess the quantitative importance of modeling MHOJ in conducting UI policy analysis. For this purpose, I compare the implications of UI policy changes obtained using the benchmark calibration of the model with the implications obtained using a recalibration of the model where MHOJ is shut down by setting the cost of doing effort on the job $\psi_e(x)$ equal to zero. The rationale is that if MHOJ were to be ignored in the policy analysis, one would still be able to make the model consistent with

Symbol	Parameter Description	Value	Source/Target
A. Externally calibrated parameters and normalizations			
β	Disco	0.9967	Annual discount rate = 4%
σ	Risk aversion	2	IES = 0.5
ξ_e, ξ_u	Search cost shifters	0.8, 0	Normalization
z	Productivity	1	Normalization
λ	Expected UB duration	1/6.5	6.5 months
B. Internally calibrated parameters			
α_e, α_u	Search cost level	39.28, 105.51	Separation/job finding rates
γ_e, γ_u	Search cost elast.	117.72, 6.53	Separation/job finding elast.
δ	Exog. separation rate	0.002	Share of exog. separations
μ	Probab. of high loss event	0.52	Firing-to-demotions ratio
f	Low loss event cost	5.32	Avg. wage cut if demotion
b	UB size	0.40	Average replacement rate
$\underline{c}$	Consumption with expired UB	0.042	Food stamps

Table 4: Calibrated Parameter Values in the Model

the levels of job-finding and separation rates, as well as the elasticity of job-finding rates to UI benefits. However, separations would become exogenous after shutting down MHOJ, so this recalibrated model would be unable to reproduce the elasticity of separations to UI benefits estimated in 2.

6.1 Optimal Replacement Rate

The first quantitative exercise is to compare the optimal UI policy accounting for versus ignoring MHOJ. There are two UI policy parameters in the model: the size of the UI benefits, b, and the probability of expiration that maps directly into the average duration of benefits, π. I fix the average duration of benefits at 6.5 months and look for the UI benefit size b that maximizes aggregate welfare, defined as the average net present value of utility in the economy:

$$W = u^n V^U + u^e V^U_{\text{expired}} + (1 - u^n - u^e) \int V f(V) dV.$$

Panel A of table 5 shows the optimal replacement rate in each calibration of the model, where the optimal replacement rate is the optimal b divided by the average wage in the economy. The main quantitative result in the paper is the comparison between columns

1 and 2: the optimal replacement rate is about twice in the version of the model with no moral hazard on the job relative to the full version with moral hazard on the job and dynamic wage contracts.

	(1) Benchmark	(2) No MHOJ	(3) No Output Losses
A. Optimal Replacement Rate			
	45%	86%	62%
B. Implications of Doubling the Replacement Rate			
Job finding rate	↓ 9.7%	↓ 9.0%	↓ 10.1%
Firing rate	↑ 41%	0%	↑ 51%
Output/Employment	↓ 2.1%	0%	0%
Output	↓ 4.8%	↓ 0.6%	↓ 3.4%

Table 5: UI Policy Across Different Versions of the Model

Notes: Panel *A* shows the optimal replacement rate using three different model calibrations. The first column uses the benchmark calibration of the full model, the second column uses the calibrated model after shutting down MHOJ, and the third column uses the calibrated model with MHOJ but setting the output loss parameter f equal to zero. Panel *B* shows the implications of setting the UI replacement rate equal to 86% using the different model calibrations.

Remarkably, the full model with indicates that the current generosity of the UI system in the US is optimal: fixing the duration of UI benefits, the optimal replacement rate is 45%, which coincides with the average replacement rate in the US. I emphasize, however, that the model lacks some crucial ingredients to speak to the optimal generosity of UI, perhaps most notably, the capacity of households to self-insure. Incorporating self-insurance into the model, perhaps via precautionary savings or spousal income, would lower the value of providing public insurance and result in a lower optimal replacement rate. But this is true for all versions of the model, and I find it unlikely that self-insurance would mitigate the need for public insurance differently in a world with or without MHOJ. The model in this paper contains the crucial ingredient to compare the optimal generosity of UI ignoring vs accounting for MHOJ: the presence of hidden effort on the job.

Relative to the calibration with no MHOJ, the benchmark calibration accounts for two additional adverse effects of generous UI: more frequent firing and more frequent output losses due to lower effort on the job. How much of do each of these forces contribute to the difference in the optimal replacement rate between the two calibrations? I address this question in the third column of table 5, where I recalibrate the model with MHOJ but set the output loss parameter f equal to zero. Accounting for the effects of UI on the firing rate only reduces the optimal replacement rate in roughly one quarter, from 86% to 62%. I view this exercise as providing a conservative magnitude of the quantitative importance of MHOJ because it only accounts for an adverse effect of UI through MHOJ that is directly estimated from the data, i.e. the effect on the firing rate. The benchmark calibration goes a step further and uses the structure of the model to back out the effect of UI on workers' (average) output from wage cuts observed in the data. Including this indirect estimate of output losses arising from MHOJ in the model calibration reduces the optimal replacement rate further to 45%.

6.2 Labor Market Implications of More Generous UI

Panel B of table 5 investigates the mechanisms behind the main result by comparing the implications of doubling the average replacement rate from the 45% in place in the US to 90%. Since unemployment is more attractive with a higher replacement rate, job-finding rates decrease in all three model calibrations. Moreover, all of these calibrations are consistent with the elasticity of the job-finding rate to UB estimated in section 2; therefore, they all predict similar reductions in job-finding rates.[14]

The calibration with no MHOJ predicts no change in the separation rate, thus underestimating the impact of higher replacement rates on the level of unemployment. In contrast, the benchmark calibration and the calibration with no output loss predict an increase in the firing rate of 41% and 51%, respectively. These two calibrations match the same elasticity of the separation rate to UI benefits at the replacement rate of 45%; therefore, for small changes in the replacement rate, they predict the same change in the firing rate. For large increases in the replacement rate, though, such as the one considered in this experiment, the effects on workers' effort and, therefore, on firing rates are mitigated under larger output losses as illustrated in figure 3. The reason is that lower effort is more costly to firms if output losses are higher, so firms optimally respond to larger increases in the replacement rate by increasing wages to prevent sharper reductions in workers' effort.

[14] The reduction in job-finding rates is slightly smaller in the model with no MHOJ though. The reason is that the tax rate was held constant to calculate the elasticity of job-finding rates to UI benefits in the calibration, and the increase in the tax rate required to preserve budget balance is lower in the model with no MHOJ because separation rates do not respond. With a lower increase in the tax rate, vacancy posting reacts less, and job finding rates react less as well

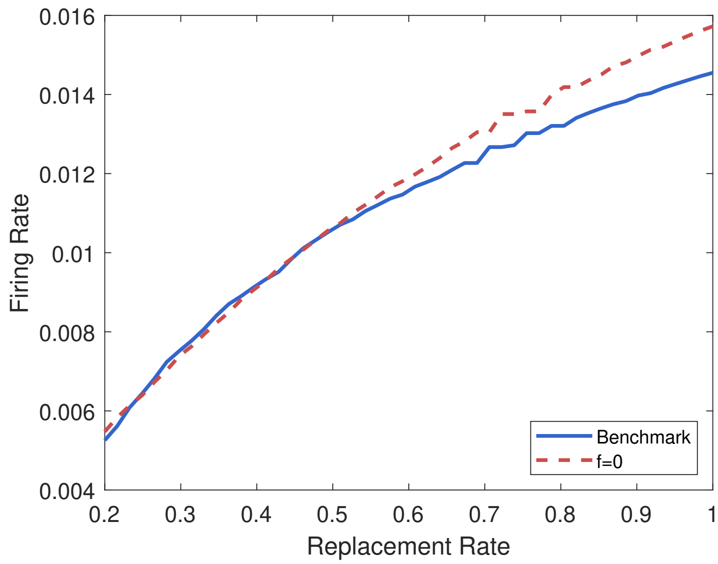

Figure 3: Separation Rates Across Calibrations

Notes: Firing rates in the simulated models with benchmark calibration (solid line) and no output loss calibration (dashed line) for different UI replacement rates.

Finally, only the benchmark calibration identifies the effect of higher UI benefits on output per employed worker. In particular, this version attributes not only firing but also wage cuts to MHOJ and uses wage cuts patterns to back out the output losses for matches that remain active after the policy change. Output per employed worker (net of losses due to negative events) goes down by 2.1%. Finally, the implications of increasing UI benefits for output are composed of changes in the employment rate and output per employed worker. Aggregate output decreases in all three calibrations, but in the calibration with no MHOJ only by 0.6% due to lower job finding rates, suggesting mild costs of increasing UI benefits. The calibration with MHOJ but no output loss, though, predicts a substantially larger drop in aggregate output of 3.4% due to lower job-finding rates but also more frequent firing. Finally, the benchmark calibration accounts for all three channels: lower job-finding rates, more frequent firing, and lower output per employed worker. Although it predicts a lower increase in the unemployment rate with respect to the calibration with no output loss, this is more than compensated by a decrease in output per employed worker, resulting in a larger predicted decrease in aggregate output of 4.8%. A larger drop in aggregate output implies a higher cost of generous UI and leads to a lower optimal replacement rate.

7 Conclusions

UI policy trades off insurance provision with incentives distortion for unemployed and employed workers. Although most of the literature has focused on the adverse effects of UI on the incentives of unemployed workers, I show empirically that UI also has sizable implications for the frequency of firing. Modeling the incentives problem of employed workers to replicate this empirical finding makes quantitatively a large difference in assessing the implications of UI policy for labor market outcomes. For example, a naive calibration of my model where MHOJ is ignored would predict that doubling the UI replacement rate is roughly optimal because it produces only a modest reduction in aggregate output of 0.6%. However, the benchmark calibration accounts for MHOJ, and it indicates that the current generosity of UI in the US is already roughly optimal and that doubling the replacement rate would actually lead to a large reduction in aggregate output of 4.8% via reduced job-finding rates, increased firing rates, and lower output per employed worker.

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Appendix

A Proof of Proposition 4.1

To prove 4.1 I proceed in several steps. First, I show that the optimal effort on the job is a differentiable function of promised values in Lemma A.1. Then I derive tidy versions of the first-order conditions associated with the optimal contract with respect to V_i^H and V_i^L in lemmas A.2 and A.3. In Lemma A.4, I derive a crucial inequality that allows me to compare future to current promised values. Lemma A.5 establishes that promised values are higher than current values if no negative events occur, and lower than current values if negative events occur. Then to prove the proposition, the only step left is to show that wages are increasing in promised values.

Lemma A.1 *Let V_i^H and V_i^L be the promised values to the worker if the outcome of the lottery is i, and assume that at least one of these promised values is higher than V^U. Then there is a unique effort level x_i^e that satisfies the incentives constraint in 7. Moreover, the optimal effort level is a differentiable function of $V_i^H - (\mu V^U + (1-\mu)V_i^L)$.*

Proof. Uniqueness follows directly from strict concavity of u and strict convexity of ψ_e. Moreover, the effort levels of 0 and 1 can be ruled out by the limiting properties of $\psi_e'(x)$, which converges to 0 as $x \to 0$ and to infinity as $x \to \infty$. Then the optimal effort level is interior and satisfies the first-order condition

$$\psi'(x_i^e) = \beta(1-\delta)(V_i^H - (\mu V^U + (1-\mu)V_i^L)).$$

Solving for x_i^e gives a differentiable function of the optimal effort level as a function of $(V_i^H - (\mu V^U + (1-\mu)V_i^L))$. ■

Lemma A.2 *Fix the current value of an employed worker V. The optimal promised values V_i^H and V_i^L satisfy*

$$(1-\mu)(1 - x(V_i^H - \tilde{V_i^L}))(\Pi'(V_i^L) - \Pi'(V)) = \tag{A.1}$$
$$x'(V_i^H - \tilde{V_i^L})[\Pi(V_i^H) - (1-\mu)(-f + \Pi(V_i^L))] - \left(\frac{\lambda_{PCFL}\Pi'(V_i^L) + \lambda_{PCWL}}{\beta(1-\delta)\pi_i}\right)$$

where $\tilde{V_i^L} \equiv \mu V^U + (1-\mu)V_i^L$, $x(\cdot)$ *is the optimal effort level function given by* A.1, λ_{PCFL} *is the lagrange multiplier associated with the participation constraint of the firm* $\Pi(V_i^L) \geq 0$, *and* λ_{PCWL} *is the lagrange multiplier associated with the participation constraint of the worker* $V_i^L \geq V^U$.

Proof. Consider the contracting problem 7 where the incentives constraint has been used to solve for the optimal level of effort as a function of $V_i^H - \tilde{V_i^L}$, and denote this function by $x(\cdot)$. The first order condition with respect to V_i^L is

$$\begin{aligned}
&\pi_i\beta(1-\delta)[-x'(V_i^H - \tilde{V_i^L})\Pi(V_i^H) + x'(V_i^H - \tilde{V_i^L})(1-\mu)(-f + \Pi(V_i^L))] + \\
&\pi_i\beta(1-\delta)[\Pi'(V_i^L)(1-\mu)(1 - x(V_i^H - \tilde{V_i^L}))] + \\
&\lambda_{PK}\pi_i\psi_e'(x(V_i^H - \tilde{V_i^L}))x'(V_i^H - \tilde{V_i^L}) + \\
&\lambda_{PK}\pi_i\beta(1-\delta)[-x'(V_i^H - \tilde{V_i^L})V_i^H + x'(V_i^H - \tilde{V_i^L})\tilde{V_i^L} + (1 - x(V_i^H - \tilde{V_i^L}))(1-\mu) + \\
&\lambda_{PCFL}\Pi'(V_i^L) + \lambda_{PCWL} = 0
\end{aligned}$$

where λ_{PK} is the lagrange multiplier associated with the promise keeping constraint. Using the envelope condition $\lambda_{PK} = -\Pi'(V)$ and rearranging terms gives

$$\begin{aligned}
&\beta(1-\delta)(1-\mu)(1 - x(V_i^H - \tilde{V_i^L}))(\Pi'(V_i^L) - \Pi'(V)) = \\
&\beta(1-\delta)x'(V_i^H - V_i^L)[\Pi(V_i^H) - (1-\mu)(-f + \Pi(V_i^L))] - \frac{\lambda_{PCFL}\Pi'(V_i^L)}{\pi_i} - \frac{\lambda_{PCWL}}{\pi_i} + \\
&\Pi'(V)x'(V_i^H - \tilde{V_i^L})[\underbrace{\psi_e'(x(V_i^H - \tilde{V_i^L})) - \beta(1-\delta)(V_i^H - \tilde{V_i^L})}_{=0}]
\end{aligned}$$

where the last term equals zero by first-order condition of the workers' problem. ■

Lemma A.3 *Fix the current value of an employed worker* V. *The optimal promised values* V_i^H *and* V_i^L *satisfy*

$$\begin{aligned}
&x(V_i^H - \tilde{V_i^L})(\Pi'(V_i^H) - \Pi'(V)) = \\
&\qquad x'(V_i^H - V_i^L)[-\Pi(V_i^H) + (1-\mu)(-f + \Pi(V_i^L))] - \left(\frac{\lambda_{PCFH}\Pi'(V_i^H) + \lambda_{PCWH}}{\pi_i\beta(1-\delta)}\right)
\end{aligned} \tag{A.2}$$

where $\tilde{V_i^L} \equiv \mu V^U + (1-\mu)V_i^L$, $x(\cdot)$ *is the optimal effort level function given by* A.1, λ_{PCFH} *is the Lagrange multiplier associated with the participation constraint of the firm* $\Pi(V_i^H) \geq 0$, *and λ_{PCWH} is the Lagrange multiplier associated with the participation constraint of the worker $V_i^H \geq V^U$.*

Proof. Consider the contracting problem 7 where the incentives constraint has been used to solve for the optimal level of effort as a function of $V_i^H - \tilde{V_i^L}$, and denote this function by $x(\cdot)$. The first order condition with respect to V_i^H is

$$
\begin{aligned}
&\pi_i \beta(1-\delta)[x'(V_i^H - \tilde{V_i^L})\Pi(V_i^H) + x\Pi'(V_i^H)] - \\
&\pi_i \beta(1-\delta)[x'(V_i^H - \tilde{V_i^L})(1-\mu)(-f + \Pi(V_i^L))] - \\
&\lambda_{PK}\pi_i \psi_e'(x(V_i^H - \tilde{V_i^L}))x'(V_i^H - \tilde{V_i^L}) + \\
&\lambda_{PK}\pi_i \beta(1-\delta)[x'(V_i^H - \tilde{V_i^L})V_i^H + x(V_i^H - \tilde{V_i^L}) - x'(V_i^H - \tilde{V_i^L})V_i^L] + \\
&\lambda_{PCFH}\Pi'(V_i^H) + \lambda_{PCWH} = 0
\end{aligned}
$$

where λ_{PK} is the Lagrange multiplier associated with the promise keeping constraint. Using the envelope condition $\lambda_{PK} = -\Pi'(V)$ and rearranging terms gives

$$
\begin{aligned}
&\beta(1-\delta)x(V_i^H - \tilde{V_i^L})(\Pi'(V_i^H) - \Pi'(V)) = \\
&\beta(1-\delta)x'(V_i^H - V_i^L)[-\Pi(V_i^H) + (1-\mu)(-f + \Pi(V_i^L))] - \frac{\lambda_{PCFH}\Pi'(V_i^H)}{\pi_i} - \frac{\lambda_{PCWH}}{\pi_i} + \\
&\Pi'(V)x'(V_i^H - \tilde{V_i^L})[\underbrace{-\psi_e'(x(V_i^H - \tilde{V_i^L})) + \beta(1-\delta)(V_i^H - \tilde{V_i^L})}_{=0}]
\end{aligned}
$$

where the last term equals zero by first-order condition of the workers' problem. ■

Lemma A.4 *Let V_i^H and V_i^L be the promised values to the worker if the outcome of the lottery is i. The following inequality must be satisfied*

$$\Pi(V_i^H) \geq (1-\mu)(-f + \Pi(V_i^L)). \tag{A.3}$$

Proof. I analyze different cases depending on which of the participation constraints bind.

1. If $\lambda_{PCWL} > 0$. In this case, $V_i^L = V^U$ by complementary slackness. Therefore the left-hand side in A.2 must be zero. Since the last term in parenthesis in the right hand side is strictly positive, then $\Pi(V_i^H) - (1-\mu)(-f + \Pi(V_i^L)) > 0$.

2. <u>If $\lambda_{PCWH} > 0$.</u> In this case, $V_i^H = V^U$ by complementary slackness, implying $V_i^H \leq V_i^L$. Then $\Pi(V_i^H) \geq \Pi(V_i^L)$ and $\Pi(V_i^H) \geq (1-\mu)(-f+\Pi(V_i^L))$.

3. <u>If $\lambda_{PCFL} > 0$.</u> Then $\Pi(V_i^L) = 0$, and $V_i^L \geq V_i^H$. Then $\Pi(V_i^H) \geq \Pi(V_i^L)$ and $\Pi(V_i^H) \geq (1-\mu)(-f+\Pi(V_i^L))$.

4. <u>If $\lambda_{PCWL} = 0$, $\lambda_{PCWH} = 0$, and $\lambda_{PCFL} = 0$.</u> Towards a contradiction, suppose $\Pi(V_i^H) < (1-\mu)(-f+\Pi(V_i^L))$. Then the right-hand side in A.2 is strictly negative; therefore, by concavity of $\Pi(\cdot)$, we must have $V_i^H \leq V$. Similarly, the right-hand side in A.3 is strictly positive; therefore, by concavity of $\Pi(\cdot)$, we must have $V_i^L \geq V$. But then $\Pi(V_i^H) \geq (1-\mu)(-f+\Pi(V_i^L))$, a contradiction.

■

Lemma A.5 *Let V_{max} satisfy $\Pi(V_{max}) = 0$. If $V \in [V^U, V_{max}]$, then:*

1. $V_i^H(V), V_i^L(V) \in [V^U, V_{max}]$.
2. $V_i^H \geq V$.
3. $V_i^L \leq V$.

Proof. That $V_i^H(V), V_i^L(V) \in [V^U, V_{max}]$ follow from the participation constraints.

To show that $V_i^H \geq V$, the case where $\Pi(V_i^H) \geq V^U$ binds is trivial because then $V_i^H = V_{max}$. Suppose $\Pi(V_i^H) \geq V^U$ does not bind, so that $\lambda_{PCWH} = 0$. Then by lemma A.4, the right-hand side in lemma A.3 is weakly negative. Then by concavity of $\Pi(\cdot)$, we have $V_i^H \geq V$.

Finally to show that $V_i^L \leq V$, notice that if the participation constraint $V_i^L \geq V^U$ binds, the result holds trivially. Suppose $V_i^L \geq V^U$ does not bind so that $\lambda_{PCWL} = 0$. Then by lemma A.4, the right-hand side of lemma A.2 is weakly positive. Then by concavity of $\Pi(\cdot)$, we have $V_i^L \leq V$. ■

Proof of Proposition 4.1: It suffices to show that $w_i(V)$ is increasing in the promised value V. Consider the FOC of problem 7 with respect to w_i:

$$-\pi_i + \lambda_{PK}\pi_i u'(w_i(1-\tau))(1-\tau) = 0$$

Using the envelope condition $\lambda_{PK} = -\Pi'(V)$ and rearringing gives

$$u'(w_i(1-\tau)) = \frac{1}{-\Pi'(V)(1-\tau)}.$$

The result follows from the concavity of $\Pi(\cdot)$ and $u(\cdot)$. ■

B Empirical Results: Robustness

B.1 Alternative Specifications

Table A.1: Elasticities to Unemployment Benefits

	Discharge or layoff rate
Benchmark	0.69**
	(0.34)
Exclude 2008 and 2009	0.73**
	(0.36)
Up to 2007	2.24***
	(0.77)
Use part-time workers	0.28
	(0.32)
HQ spline control	0.70**
	(0.35)
Ages 20 to 60	0.49
	(0.32)
Use HQ earnings variation	0.87***
	(0.31)

Notes: Estimates of β in the Cox regression (3) using different specifications, where the left-hand side variable h_{it} is the rate of fire due to discharge or layoff.

* Significant at 10% level.

** Significant at 5% level.

*** Significant at 1% level.

B.2 Placebo Tests

I use the UB that workers would be entitled to if they were located in a different state as a placebo treatment. The rationale is as follows: In the empirical strategy, the treatment received by unemployed workers is the UB they collect, and the treatment received by employed workers is the UB they could collect if they were fired from their jobs. These UB are determined by workers' state of residence, but the UB that workers would receive if they were in a different state should not alter workers' incentives; therefore, they should not have an effect on job finding and firing rates.

Estimating 3 using the benchmark specification with 100 different placebo UI benefits yields a distribution of estimates for β centered around zero as shown in A.1.

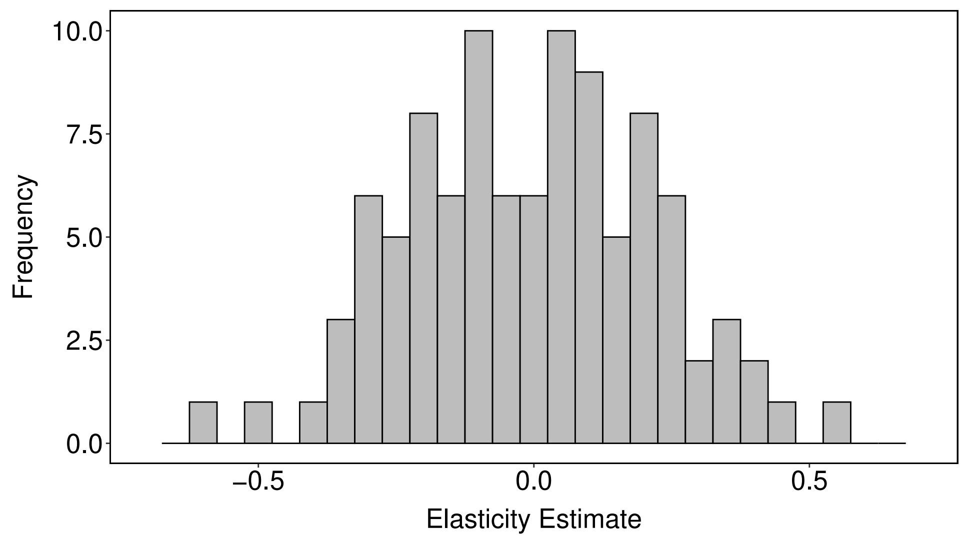

Figure A.1: Distribution of Coefficients in Placebo Test

C Stationarity Conditions

Stationary distribution. Letting u^c and u^e denote the share of workers with current and expired benefits respectively, the following two conditions give stationarity of workers across employment states:

$$(1-u^c-u^e)\left[\delta+(1-\delta)\int(1-x_e(V))\mu g(V)dV\right]=u^c(x^u+(1-x^u)\lambda). \tag{A.1}$$

$$u^c(1-x_u^c)\lambda = u^e x^u_{expired} \tag{A.2}$$

where x^u and $x^u_{expired}$ are the optimal search policies of unemployed workers with current and expired benefits respectively. In equation *A.1*, the left hand side of equation shows the inflows into unemployment with current benefits, namely all employment-to-unemployment transitions, whereas the right hand side shows the outflows, namely the workers with current benefits who either found a job or their benefits expired. Similarly, equation A.2 shows inflows into the pool of unemployed workers with expired benefits in the left hand side, composed of unemployed workers whose benefits just expired, and the outflows from this pool in the right hand side, composed of unemployed workers with expired benefits who found a job.

Finally, the following condition for a stationary distribution of workers across promised values must be satisfied

$$\begin{aligned}(1-u^c-u^e)g(V) =& u^c x^u \mathbb{1}(V=V_0)+u^e x^u_{expired}\mathbb{1}(V=V_{0,\text{expired}})\\ &+(1-u^c-u^e)(1-\delta)\sum_{i=1,2}\left[\int_{\hat{V}:V_i^H(\hat{V})=V}\pi_i(\hat{V})x_i^e(\hat{V})g(\hat{V})d\hat{V}\right.\\ &\left.+\int_{\hat{V}:V_i^L(\hat{V})=V}\pi_i(\hat{V})(1-x_i^e(\hat{V}))(1-\mu)g(\hat{V})d\hat{V}\right],\end{aligned} \tag{A.3}$$

where V_0 and $V_{0,\text{expired}}$ are the initial values where unemployed workers with current and expired benefits search; $\pi_i(\cdot)$ is the lottery policy; $V_i^L(\cdot)$ and $V_i^H(\cdot)$ are the policy functions for promised values conditional on negative event and no negative event respectively conditional on the outcome of the lottery i. The left hand side of *A.3* can be interpreted as the outflows from value V.