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Gustavo de Souza and André Victor D. Ludovice

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REVISED  
March 2023

WP 2022-45

<https://doi.org/10.21033/wp-2022-45>

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# Optimal Unemployment Insurance Requirements\*

Gustavo de Souza<sup>†</sup>

Federal Reserve Bank of Chicago

André Victor D. Luduvicé<sup>‡</sup>

Federal Reserve Bank of Cleveland

This version: March 2023

## Abstract

In the US, workers must satisfy two requirements to receive unemployment insurance (UI): a tenure requirement of a minimum work spell and a monetary requirement of past minimum earnings. Using discontinuity of UI rules at state borders, we find that the monetary requirement decreases the number of employers and the share of part-time workers, while the tenure requirement has the opposite effect. In a quantitative model, the monetary requirement induces workers to stay longer in unemployment because low-paying jobs are not covered by UI. Since it mitigates moral hazard, the optimal UI design has a high monetary requirement.

**Keywords:** Unemployment Insurance, UI Eligibility, Optimal UI

**JEL Codes:** E24, E61, J65

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\*First version: October 2020. We want to thank the participants at the Brazilian Econometric Society, FRB Cleveland, and Washington State University seminars and the SEA 2021, LuBraMacro 2022, and the Midwest Macro Dallas 2022. The views expressed herein are solely those of the authors and do not necessarily reflect the views of the Federal Reserve Bank of Chicago, the Federal Reserve Bank of Cleveland or the Federal Reserve System. All errors are our own.

<sup>†</sup>E-mail: [gustavo@microtomacro.net](mailto:gustavo@microtomacro.net)

<sup>‡</sup>E-mail: [andrevictor.luduvic@cleve.frb.org](mailto:andrevictor.luduvic@cleve.frb.org).

# 1 Introduction

Unemployment insurance (UI) programs have attracted economists' attention both because of their moral hazard component and because of their widespread presence in many modern economies ([Vodopivec and Raju, 2002](#)). The design of such programs is usually characterized by three main elements: a replacement ratio, that is, the percentage of a past wage that the worker receives during the unemployment spell; a limit on how many months the worker can collect such benefits; and some requirement related to the worker's labor market history that deems her eligible to enroll in the program. In this paper, we study empirically and quantitatively how UI requirements in the US affect the labor market and use a model to compute the optimal requirement levels.

We first conduct an empirical analysis to understand the effect of the UI requirements on unemployment, the UI take-up, and labor market dynamics. Gathering data from states' UI policies since 1963, we use discontinuities in the UI requirement at state borders to identify the causal effect of the tenure and monetary requirements on the labor market.<sup>1</sup> We find that the introduction of a tenure requirement decreases unemployment, increases the number of employers and the share of part-time workers, and does not affect the UI take-up rate. On the other hand, the monetary requirement has a negative effect on the number of employers and the share of part-time workers, with a significant and negative effect on the UI recipient rate. These results indicate that both requirements significantly affect the pool of unemployed workers but with opposite effects when it comes to labor market dynamics, a finding that could have different implications for the fiscal burden of the UI as well as its effectiveness in providing insurance for workers.

To understand these effects, we build a quantitative model to rationalize the empirical results and find the optimal level of requirements for UI. We develop an infinite horizon model with incomplete markets, heterogeneous agents, labor market imperfections, and a history-dependent UI program. The program in the model economy has monetary and tenure requirements that closely mimic those of the US design. Workers choose con-

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<sup>1</sup>In our empirical analysis we follow a methodology similar to the one introduced by [Hagedorn et al. \(2016a\)](#).

sumption, savings, and the extensive margin of labor supply. They receive idiosyncratic labor productivity shocks and unemployment shocks. Workers can collect UI benefits after becoming unemployed if they satisfy both the tenure and the monetary requirements. The tenure requirement is a function of workers' past labor supply, while the monetary requirement is a function of workers' past salaries. Therefore, UI is a function of the relevant employment history of workers. Following [Hopenhayn and Nicolini \(2009\)](#), the government cannot perfectly distinguish quits from layoffs, and, with some probability, workers quitting their job can end up receiving UI, thus capturing one of the potential moral hazard components of UI.

To compute the model, we introduce a methodology that reduces the infinite-dimensional state space defined by the sequences of UI reciprocity, labor income, and labor supply histories. By focusing on the relevant part of their allocation and collection history, we can rewrite the workers' problem in a tractable manner while still keeping it history-dependent and rich enough to accommodate the details of the requirements of the UI program and allow the computation of its optimal arrangement.

We show that the model can replicate the qualitative effect of changes in UI requirements on the labor market as found in our empirical analysis. An increase in the monetary requirement reduces workers' incentives to stay at low-paying jobs because these jobs are no longer covered by UI. Therefore, to avoid jobs not protected by UI, workers decide when to take jobs, and when they do so, they are less likely to leave them. Therefore, an increase in the monetary requirement decreases employment transition and the share of workers at low-paying jobs. An increase in the tenure requirement, on the other hand, increases workers' incentives to stay at such jobs. A worker who received an unemployment shock but still does not satisfy the tenure requirement has incentives to stay in a low-paying job until the tenure requirement is satisfied and she is covered by UI. Therefore, an increase in the tenure requirement increases employment transition and the share of workers at low-paying jobs.

We then conduct our quantitative normative analysis and find that the optimal unemployment insurance design has a large monetary requirement and a low tenure require-

ment. Because the monetary requirement reduces the share of workers at jobs for which the monetary threshold is binding, it reduces the share of workers quitting their job and reduces the financial cost of UI. The tenure requirement, on the other hand, induces workers to stay at any job, even ones with low pay and subject to the monetary requirement, and, at a risk, to quit to receive UI. We find that an increase in the monetary requirement from 10 percent to 23 percent of average earnings and a decrease in the tenure requirement from 24 weeks to 12 weeks would increase welfare by 0.99 percent while reducing UI expenditure by half of its benchmark value. We also extended our analysis to include other channels such as general equilibrium effects and changes in job transition probabilities and we find that the main intuition and effect of our optimality results are preserved.

This paper is organized as follows. In the next section, we discuss the related literature. In Section 3, we show the empirical evidence obtained on the effect of UI requirements on employment outcomes. In Section 4, we construct the setting of our quantitative model, provide intuition about the underlying theory, and define all relevant model objects. In Section 5, we describe the calibration used to map the model to the data. Section 6 presents the results for the benchmark economy and the properties of the initial steady state. Section 7 lays out the thought experiment and the results of counterfactual analyses. In Section 8, we conduct a normative analysis and search for the optimal UI policy within the model environment. The last section states our conclusions.

## 2 Related Literature

This paper builds on the literature that assesses numerically the effects of unemployment insurance policies on the labor market. One of the earliest and most influential references is [Hansen and Imrohoroglu \(1992\)](#), who construct a quantitative incomplete markets model with moral hazard to analyze the optimal replacement ratio. In a similar environment but focusing on the search-theoretic component, [Gomes et al. \(2001\)](#) study the welfare cost of business cycles. [Pallage and Zimmermann \(2001\)](#) extend the same model setting to include heterogeneity of skills and study voting preferences toward UI gen-

erosity. [Abdulkadiroğlu et al. \(2002\)](#) move one step further in the canonical framework by making unemployment insurance depend on how much time the agent has been in an unemployed state. The authors find that the optimal UI has to decrease the number of weeks that an agent can collect UI but it should be more extensive if agents are prevented from saving. [Young \(2004\)](#) incorporates search effort in the numerical analysis and finds that the optimal replacement rate should be zero independent of the limits on benefit duration and that eliminating the UI system generates welfare gains, which get smaller if one takes the transition into account. [Lentz \(2009\)](#) further confirms the importance of including transitional dynamics by estimating a search model of optimal UI policy with Danish data.

Moving to job search environments, employment requirements are known to distort job search while employed since early work by [Burdett \(1979\)](#) and [Mortensen \(1977\)](#). [Zhang and Faig \(2012\)](#) study UI eligibility in a Diamond-Mortensen-Pissarides environment and find a Ricardian equivalence type of result in which taxation of risk-neutral households annuls the job creation effect of the employment requirement. A similar approach of quantitatively identifying the UI design in a heterogeneous agents economy but with an endogenization of the labor market in a search and matching framework taken by [Mukoyama \(2013\)](#). [Mazur \(2016\)](#) identifies large welfare gains from a policy that allows quitters to receive UI benefits.

There's a recent strand of the literature focusing specifically on UI requirements in quantitative settings. In a standard search and matching model [Andersen et al. \(2018\)](#) show how the employment requirement strengthens the re-entitlement effects, thus altering the incentives of the optimal UI scheme. Another key reference is [Auray et al. \(2019\)](#), who show that endogeneizing the take-up rate of UI-eligible workers slows the impact of changes in the benefit on the unemployment rate and duration of unemployment. More recently, [Birinci and See \(2019\)](#) analyze the UI eligibility and reciprocity along the wealth distribution and find that in a heterogeneous agents job search model the insurance benefits are larger for wealth-poor workers. In a contemporaneous paper, [Chao et al. \(2021\)](#) study whether paying unemployment insurance affects the value of unemployment. The

authors use a regression discontinuity design to help uncover the causal effect of UI that is confounded by the endogeneity of eligibility. They focus on the lower bound of eligibility and find that UI eligibility has a causal effect on next period earnings that ranges from \$300 to \$900. They use a competitive search model to interpret their results as better match quality and higher rents in light of the endogenous UI take-up. Their results are complementary to ours and in line with our empirical evidence and our model showing the relevance of UI eligibility for workers' labor market outcomes.

We contribute to this branch of the literature by developing a quantitative model of optimal unemployment insurance, incorporating a history-dependent UI program. In our model, to become eligible for UI benefits, agents must satisfy the UI requirements, which test households' labor market history, which needs to be present in the workers' state space. Moreover, we focus on optimizing such requirements, a question that is, to our knowledge, still open in the literature.

Some of the empirical work on UI requirements and eligibility dates back to [Blank and Card \(1991\)](#). The empirical strategy used in our econometric evidence can be tied in with what is now a rich literature that analyzes changes in UI features in the context of recessions. More specifically, the literature studies the extension of UI benefits granted for up to 73 weeks during the Great Recession. We discuss the institutional background details in Subsection 3.1. [Marinescu \(2017\)](#), for example, studies the general equilibrium effects of the extension on job applicants and vacancies. The methodology of using discontinuity in state borders is also present in a sequence of papers that use it to assess the labor market and equilibrium effects of the recession ([Hagedorn et al., 2016a,b, 2019](#)). Recent quantitative and theoretical approaches studying the relationship between UI and recessions are [Mitman and Rabinovich \(2015\)](#) and [Pei and Xie \(2021\)](#). Our main contribution to this branch of the literature is applying this established methodology to the context of UI requirements, a novel approach to the best of our knowledge.

Our paper is also connected to a long tradition of theoretical papers on optimal unemployment insurance design. Two of the earliest contributions can be found in the seminal works by [Shavell and Weiss \(1979\)](#) and [Wang and Williamson \(1996\)](#). In an environment

with a repeated principal-agent problem, [Hopenhayn and Nicolini \(1997\)](#) characterize the optimal contract and lay out a result that is currently well-known in the literature: the optimal payment schedule involves a replacement ratio that decreases during the unemployment spell and a re-employment wage tax that increases with the length of such a period. Other seminal references on the search incentives generated by UI are [Chetty \(2008\)](#) and [Shimer and Werning \(2008\)](#).

In [Hopenhayn and Nicolini \(2009\)](#) the authors amplify the environment in [Hopenhayn and Nicolini \(1997\)](#) to account for multiple unemployment spells with asymmetric information in order to study the optimality of the eligibility condition common in UI programs. The paper's main result is that, if the principal cannot distinguish quits from layoffs, it is optimal for the principal to condition benefit payments on the agent's employment history. A similar idea is present, though not as an endogenous outcome, with an ad hoc formulation of the environment with the experience rating component used by [Wang and Williamson \(2002\)](#) and with the effective entitlement effect erasing the moral hazard in employment flows as in the recent work by [Zhang and Pan \(2019\)](#). [Auray and Fuller \(2020\)](#) expand on experience rated taxes paid by firms and how endogenous UI collection costs slow the impact of changes in the UI policy. In our environment we search for a quantitative design of a UI program that is characterized by an eligibility condition and thus, we follow [Hopenhayn and Nicolini \(2009\)](#) in assuming that the government in our model has the same informational limitation as in their paper.

### **3 Empirical Evidence**

In this section we study empirically how UI requirements affect the labor market in the US. In Subsection [3.1](#) we briefly describe the institutional background of unemployment insurance in the different states. We describe our data in [3.2](#) and the empirical strategy used in [3.3](#). We then outline the results of the econometric exercises in [3.4](#).



### 3.1 Institutional Background

Unemployment insurance in the US is regulated by the federal government, administered by the states, and paid weekly to workers who have lost their jobs through no fault of their own. The eligibility requirements beyond the determination of the reason for the job loss are established by the laws of each state in reference to a base period, which is usually the first four of the last five completed calendar quarters prior to the time the claim is filed. The majority of the states fund the program through a tax imposed on employers.<sup>2</sup>

One of the last substantial revisions to the federal UI law was in 2009 with the American Recovery and Reinvestment Act, which largely extended the duration of benefits due to the Great Recession with the emergency unemployment compensation (EUC) and extended benefits (EB) measures. The baseline period for most of the states was 26 weeks, which the act extended by an additional 13 to 20 weeks. The most recent significant revision was in 2012, which extended the programs from the previous revision and added provisions on self-employment eligibility and the possibility of short-term compensation for employers. The EUC and EB were last extended until 2014. As mentioned previously, these revisions have focused solely on the duration of the payment of benefits and have received due attention in the literature.<sup>3</sup>

### 3.2 Data

We conduct our econometric analysis using data from the IPUMS repository of the Annual Social and Economic Supplement (ASEC) of the Current Population Survey (CPS) between 1963 and 2016 (Flood et al., 2021). We combine the labor market statistics from this sample with data on state unemployment insurance laws taken from the US Department of Labor (USDOL). A more detailed description of the data can be found in Appendix A.

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<sup>2</sup>The US Department of Labor provides further details on the legislation and broader components of the UI regulation. The website can be found via this [link](#).

<sup>3</sup>See our review in Section 2.

### 3.3 Empirical Strategy

We identify the causal effect of UI requirements using changes in state policy. The potential peril of this approach is the possibility of state-level shocks that correlate with such changes in UI policy. For instance, if policymakers refrain from increasing UI requirements during recessions or if they change the tenure requirements according to the state average job duration, a traditional difference-in-difference strategy would be biased. We then would not be able to tease apart the effect of state-level shocks from the effect of policy reforms.

To deal with the potential endogeneity of UI requirements, we use discontinuity of UI requirements at state borders at the MSA level. The idea is that MSAs that span different sides of a state border are subject to the same shock but different UI policies. The specification of our econometric model is:<sup>4</sup>

$$y_{i,m,s,b,t} = \beta_M \mathbb{I}_{s,t} \{\text{Monetary Req.}\} + \beta_T \mathbb{I}_{s,t} \{\text{Tenure Req.}\} + X'_{i,m,s,b,t} \theta + \mu_m + \gamma_{b,t} + \epsilon_{i,m,s,b,t} \quad (1)$$

where  $y_{i,m,s,b,t}$  is a labor market outcome of agent  $i$ , in MSA  $m$  and state  $s$ , which is a member of the border pair identified by  $b$  at time  $t$ .  $\mathbb{I}_{s,t} \{\text{Monetary Req.}\}$  is a dummy taking a value of one if state  $s$  in year  $t$  has a monetary requirement, and  $\mathbb{I}_{s,t} \{\text{Tenure Req.}\}$  is a dummy taking a value of one if state  $s$  has a tenure requirement for UI in year  $t$ . Finally,  $X'_{i,m,s,b,t}$  is a set of controls,  $\mu_m$  is an MSA fixed effect, and  $\gamma_{b,t}$  is a border-year fixed effect. The set of controls used in our regression results are workers' age, years of education, gender, race, and marital status. Standard errors are clustered at the MSA level.

If shocks that lead to changes in UI requirements are continuous over state borders, it should affect the two sides of a border pair  $b$ , and hence are captured by the fixed effect  $\gamma_{b,t}$ . This guarantees the identification of the two coefficients of interest,  $\beta_M$  and  $\beta_T$ ,

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<sup>4</sup>For a similar methodology, see [Dube et al. \(2010\)](#), [Hanson and Rohlin \(2011\)](#), [Hagedorn et al. \(2016a\)](#), and [Hagedorn et al. \(2016b\)](#).

which capture the impact of the monetary and the tenure requirements.

### 3.4 Results

Table 1 shows that UI requirements affect unemployment, unemployment benefit recipient rates, the kinds of jobs individuals take, and number of employers.

Table 1: Effect of UI requirements on the labor market

	(1)	(2)	(3)	(4)
	$\mathbb{I}\{Unemployed\}$	$\mathbb{I}\{UnempBenefit\}$	$\mathbb{I}\{PartTime\}$	$\#Employers$
$\mathbb{I}\{Monetary\ Req.\}$	-0.0191*** (0.000)	-0.0256*** (0.000913)	-0.121*** (0.00167)	-0.0121*** (0.00336)
$\mathbb{I}\{Tenure\ Req.\}$	-0.0531*** (0.000)	-0.000561 (0.00231)	0.0324*** (0.00485)	0.0857*** (0.00586)
$N$	136617	225853	130404	137744
$R^2$	0.051	0.902	0.100	0.051

*Notes:* This table shows the estimated parameters of model (1). Labor data are from the CPS, and UI requirement data are hand collected from reports of the US Department of Labor. The sample is from 1963 to 2016 and the number of observations varies according to variable availability.  $\mathbb{I}\{Unemployed\}$  is a dummy taking a value of one if the worker is employed,  $\mathbb{I}\{UnempBenefit\}$  is a dummy taking a value of one if the worker received UI in the current year,  $\mathbb{I}\{PartTime\}$  is a dummy taking one if the worker worked at a part-time job in the current year, and  $\#Employers$  is the number of employers the worker had in the current year. Standard errors are clustered at the MSA level. See details in Appendix A.

Column 1 of Table 1 shows that the introduction of a monetary requirement reduces unemployment by 1.9 percent, while the introduction of a tenure requirement reduces unemployment by 5.3 percent. Since the introduction of requirements tends to preclude certain workers from accessing unemployment insurance, it is reasonable to expect that removing workers from UI would then give them an incentive to work and cause a decrease in unemployment. The direction of our result holds similarly with the effect of a decline in the unemployment and job finding rates stemming from cuts in the duration of unemployment insurance as in Johnston and Mas (2018) and Karahan et al. (2019). As

shown in Column 2 of Table 1 above, we find that the monetary requirement has a significant and negative effect on UI benefit applications, whereas the tenure requirement has a negative but small and non-significant coefficient. The introduction of a monetary requirement reduces access to UI benefits by 2.5 percent.

The UI requirements also affect the type of jobs workers take and employment dynamics. As depicted in Column 3 of Table 1, the introduction of a monetary requirement leads to a reduction in the share of part-time workers, while the tenure requirement increases part-time jobs. Since the monetary requirement directly establishes a minimum UI eligibility wage, it disincentives workers to take low-paying jobs, such as part-time jobs. The tenure requirement has a positive effect on part-time employment because even low-paying jobs can count toward workers' eligibility. Column 4 shows that the monetary requirement reduces the number of employers that workers had, while the tenure requirement increases it. Therefore, a monetary requirement seems to create longer employment spells, while the tenure requirement contributes to more transitions in employment.<sup>5</sup>

In the next section we use a model to interpret this empirical result. We show that a monetary requirement leads workers to wait longer to accept a job and avoid low-paying jobs. As a consequence, workers do not move across employers and do not stay in part-time jobs. The tenure requirement, on the other hand, leads workers to accept low-paying jobs just so they become eligible for UI. As a consequence, it increases the share of part-time workers and transitions in employment.

## 4 The Model

This section describes the model we use to analyze the optimal degree of unemployment insurance requirements in the US economy. The environment is an infinite horizon economy in partial equilibrium with incomplete markets and individual heterogeneity, discrete labor supply, and UI system that depends on the employment history of workers.

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<sup>5</sup>In Appendix C we show different robustness checks to our main analysis, with the inclusion of controls for other state policy reforms, to running the regressions at the county level, and to the use of marginal variations in a continuous measure of the requirements.

## 4.1 Preferences

The economy is populated by a continuum of households with a time-separable period utility function. Households are risk-averse and maximize their discounted expected lifetime utility from non-durable goods consumption  $c$  and labor supply  $n \in \{0, 1\}$  with  $\beta$  as the discount factor. They have access to incomplete markets and can choose to accumulate assets  $a \geq \underline{b}$  to protect themselves against idiosyncratic shocks, where  $\underline{b}$  is their borrowing limit.

## 4.2 Technology

There is a single good produced in this economy with technology given by a Cobb-Douglas production function that exhibits constant returns to scale,  $Y = F(K_t, N_t) = K_t^\alpha N_t^{1-\alpha}$ , where  $\alpha \in (0, 1)$  is the output share of capital income and  $Y_t$ ,  $K_t$  and  $N_t$  denote, respectively, aggregate output, physical capital, and labor. The final good can be consumed or invested in physical capital on a one-to-one basis. A competitive representative firm uses the technology to produce  $Y_t$  and rents capital at  $r_t$  and labor at  $w_t$ . Since the benchmark model economy is going to be analyzed in a partial equilibrium setting, the interest rate  $r_t$  will be exogenously fixed at the steady state, with value  $r^*$ . From the firm's first-order conditions, we recover  $w^*$ . Details are standard and can be found in [Appendix B.1](#).

## 4.3 Endowments and Labor Income

Agents are born with zero assets and endowed with one unit of time. Households can be either employed or unemployed. In either case, the household receives two types of shocks: an unemployment or employment shock,  $p_u$  or  $p_e$ , respectively, and a productivity shock,  $z$ . There is no aggregate uncertainty. The component  $z$  is persistent and follows an AR(1) process defined by  $z_{t+1} = \rho z_t + \varepsilon_t$ , with  $\varepsilon_t \sim N(0, \sigma_\varepsilon^2)$ . We discretize it in a Markov chain with transition matrix  $\pi_{z,z'} = \Pr(z_{j+1} = z' | z_j = z)$  and stationary distribution  $\Pi(z)$ .

An employed worker with productivity  $z$  in the previous period receives at the beginning of the current period an unemployment shock with probability  $p_u$  and a productivity shock  $z' \in \{z_1, \dots, z_N\}$  with probability  $\bar{\Pi}(z'|z)$ . While an agent is working, individual earnings depend on the competitive wage  $w_t$  and the idiosyncratic persistent component. On the other hand, an unemployed household in the previous period receives at the beginning of the current period an employment shock with probability  $p_e$  and a productivity shock  $z \in \{z_1, \dots, z_N\}$  with probability  $\tilde{\Pi}(z')$ .

We interpret each different shock  $z > 0$  as the given productivity in the same job and assume that if the agent receives an unemployment shock, then  $z = 0$  and the agent is laid off. Hence, in accordance with the current US unemployment insurance code, agents quitting the labor force, i.e.,  $z > 0$  and  $n = 0$ , should not receive an unemployment benefit, while only agents with  $z = 0$  who meet the required eligibility criteria are able to collect it. Without loss of generality, we can collapse all shocks into one vector and rewrite the effective labor income process transition as  $\Pi(z'|z)$ , where  $z' \in \{0, z_1, \dots, z_N\}$ .

#### 4.4 Unemployment Insurance and Moral Hazard

The unemployment insurance program is designed to approximate the UI regulation in the US. It is a function of past labor force participation, the salary of workers, and how long a worker has already received unemployment insurance. Denote  $y_t = w_t z_t n_t$  as the labor income at time  $t$ , and  $n_t$  as the labor supply at time  $t$ , and  $m_t$  is a counter of the number of periods a worker received UI at time  $t$ . We denote  $b^{UI}(\tilde{\mathbf{n}}_t, \tilde{\mathbf{y}}_t, \tilde{\mathbf{m}}_t)$  as the UI benefit of an agent with labor supply history  $\tilde{\mathbf{n}}_t = \{n_0, n_1, \dots, n_t\}$ , labor income history  $\tilde{\mathbf{y}}_t = \{y_0, y_1, \dots, y_t\}$ , and UI history  $\tilde{\mathbf{m}}_t = \{m_0, m_1, \dots, m_t\}$ .<sup>6</sup>

The government pays and monitors UI benefits,  $b^{UI}$ , which amount to a percentage of the average past earnings characterized by a replacement ratio  $\theta \in [0, 1]$ . It does so for a limited number of periods  $\{0, \dots, \mu_b\}$ , with  $\mu_b \in \mathbb{N}$ . It requires a minimum number of

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<sup>6</sup>For the history variables  $\{\tilde{\mathbf{n}}_t, \tilde{\mathbf{y}}_t, \tilde{\mathbf{m}}_t\}$ , we use here the notation with subscript  $t$  in order to facilitate the comprehension of the definition by making explicit the history component. However, throughout the paper, we follow the usual convention that omits the time index for individual-level variables and use it solely for aggregate variables.

consecutive periods of work to be eligible for the program,  $\mu_n \in \mathbb{N}$ , as well as a minimum threshold  $z_{min} \in \mathbb{R}^+$  on the workers' average earnings. Thus, the UI design is defined by the tuple  $\{\theta, z_{min}, \mu_n, \mu_b\}$ . We make the assumption that, in the model economy, every worker satisfying all requirements of the UI program will automatically receive the program benefits.

Workers are also subject to two additional shocks. With probability  $\varphi$ , workers quitting the labor force, i.e., with  $n = 0$  and  $z > 0$ , are not detected by UI authorities and receive the UI benefit if they satisfy the UI requirements. We thus call  $\varphi$  a moral hazard shock. Second, in order for the model to be consistent with the heterogeneity in benefit duration, there is an exogenous loss from the benefit shock: with probability  $\eta$  the unemployed agent loses her UI benefit.

The government monitors the UI system and takes account of workers' labor market history in determining UI eligibility. In the case where a worker is caught defrauding UI, all of her labor market history that counts toward eligibility is erased. The monitoring agency does not keep track of job offers or workers' decisions to take jobs after they enter a UI spell.<sup>7</sup> Finally, following [Hopenhayn and Nicolini \(2009\)](#) we impose an extra informational limitation and assume that the government cannot perfectly distinguish quits from layoffs.<sup>8</sup>

## 4.5 Government

The government runs the UI system and determines its budget. The total revenue and expenditure of the UI system are defined, respectively, by  $Rev_{UI,t}$  and  $Exp_{UI,t}$ . On top of that, the government issues a social security transfer  $T_{u,t}$  paid to all unemployed households. There is an endogenous level of aggregate expenditure  $G_t$ , which is defined residually by what is left to balance the total government's budget. Finally, the government

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<sup>7</sup>The monitoring is conducted via a system of points that the worker accrues toward UI eligibility, which is defined by the way we track labor market history in the state space of the problem. For now we abstract from the notation details for the sake of better exposition of the worker's problem but revisit them in detail in [Appendix B.2](#).

<sup>8</sup>This is a condition similar to the one in [Hopenhayn and Nicolini \(2009\)](#) that guarantees that the eligibility requirement will arise as part of the optimal mechanism in their repeated moral hazard environment.

taxes labor income with an exogenously calibrated flat rate  $\tau$  using the collected revenue to fund all expenses. The government's budget constraint is given by:

$$G_t + T_{u,t} + Exp_{UI,t} = \tau(rK_t + wN_t) + Rev_{UI,t} \quad (2)$$

The universal transfer  $T_u$  in this context is important for two reasons: First, it accounts for the fact that the government has other financial duties beyond its expenditures on unemployment insurance. Second, since the government provides insurance through other welfare and social programs, the transfer  $T_u$  is auxiliary in interpreting the numerical results derived in this paper as accounting for the desire for redistribution and the risk protection provided by UI that exists on top of these other programs. This transfer works then as a reduced-form version of the transfer programs to which households in the US have access via the income security system.

## 4.6 Recursive Household Problem

Households are heterogeneous with respect to their labor income history,  $\tilde{\mathbf{y}} = \{w_j \epsilon_j n_j\}_{j=0}^{t-1} \in \mathcal{Y}^{t-1}$ , labor supply history,  $\tilde{\mathbf{n}} = \{n_j\}_{j=0}^{t-1} \in \mathcal{N}^{t-1}$ , their UI benefit history,  $\tilde{\mathbf{m}} = \{m_j\}_{j=0}^{t-1} \in \mathcal{M}^{t-1}$ , their idiosyncratic productivity shock,  $z \in \mathcal{Z}$ , and their asset holdings  $a \in \mathcal{A}$ . The state space of the economy is then the set  $S = \mathcal{A} \times \mathcal{Z} \times \mathcal{N}^{t-1} \times \mathcal{Y}^{t-1} \times \mathcal{M}^{t-1}$ . The individual state space is  $s = (a, z, \tilde{\mathbf{n}}, \tilde{\mathbf{y}}, \tilde{\mathbf{m}}) \in S$ . Let  $v_n(s)$  be the value function of an agent dependent on the agent's labor supply decision,  $n \in \{0, 1\}$ . Below we define all possible value functions of the worker.

**Value Function and Labor Supply Decision:** Given a certain individual state space  $s$ , we can determine the final value function and the labor supply decision by the following maximization:

$$v_n(a, z, \tilde{\mathbf{n}}, \tilde{\mathbf{y}}, \tilde{\mathbf{m}}) = \max\{v_{n=1}(a, z, \tilde{\mathbf{n}}, \tilde{\mathbf{y}}, \tilde{\mathbf{m}}), v_{n=0}(a, z, \tilde{\mathbf{n}}, \tilde{\mathbf{y}}, \tilde{\mathbf{m}})\} \quad (3)$$



**Value Function if Working:** If an agent works, i.e.,  $n = 1$ , the value function is given by

$$\begin{aligned}
v_{n=1}(a, z, \tilde{\mathbf{n}}, \tilde{\mathbf{y}}, \tilde{\mathbf{m}}) &= \max_{c, a'} u(c, 1) + \beta \left[ p_u v_{n=0}(a', 0, \tilde{\mathbf{n}}', \tilde{\mathbf{y}}', \tilde{\mathbf{m}}') + \right. \\
&\quad \left. (1 - p_u) \sum_{z' \in \mathcal{Z}} \tilde{\pi}(z, z') v_n(a', z', \tilde{\mathbf{n}}', \tilde{\mathbf{y}}', \tilde{\mathbf{m}}') \right] \\
\text{s.t.} & \\
c + a' &= (1 + (1 - \tau)r)a + (1 - \tau)wz \\
\tilde{\mathbf{n}}' &= \{\tilde{\mathbf{n}}, 1\}, \quad \tilde{\mathbf{y}}' = \{\tilde{\mathbf{y}}, wz\}, \quad \tilde{\mathbf{m}}' = \{\tilde{\mathbf{m}}, 0\}, \quad c > 0, \quad a' \geq \underline{b}
\end{aligned} \tag{4}$$

where  $c$  is consumption,  $\tau$  is the income tax, and  $wz$  is labor income.

**Value Function if Laid Off:** If a worker is laid off i.e.,  $z = 0$ , she receives unemployment insurance  $b^{UI}(\tilde{\mathbf{n}}, \tilde{\mathbf{y}}, \tilde{\mathbf{m}})$  if she is eligible. Let  $\mathbb{1}(\tilde{\mathbf{n}}, \tilde{\mathbf{y}}, \tilde{\mathbf{m}})$  be a dummy taking a value of one if the worker is eligible for UI. The value function of a laid-off worker is

$$\begin{aligned}
v_{n=0}(a, 0, \tilde{\mathbf{n}}, \tilde{\mathbf{y}}, \tilde{\mathbf{m}}) &= \max_{c, a'} u(c, 0) + \beta \left[ (1 - p_e) v_{n=0}(a', 0, \tilde{\mathbf{n}}', \tilde{\mathbf{y}}', \tilde{\mathbf{m}}') + \right. \\
&\quad \left. p_e \sum_{z' \in \mathcal{Z}} \tilde{\pi}(z, z') v_n(a', z', \tilde{\mathbf{n}}', \tilde{\mathbf{y}}', \tilde{\mathbf{m}}') \right] \\
\text{s.t.} & \\
c + a' &= (1 + (1 - \tau)r)a + T_u + b^{UI}(\tilde{\mathbf{n}}, \tilde{\mathbf{y}}, \tilde{\mathbf{m}}) \\
\tilde{\mathbf{n}}' &= \{\tilde{\mathbf{n}}, 0\}, \quad \tilde{\mathbf{y}}' = \{\tilde{\mathbf{y}}, 0\}, \quad \tilde{\mathbf{m}}' = \{\tilde{\mathbf{m}}, \mathbb{1}(\tilde{\mathbf{n}}, \tilde{\mathbf{y}}, \tilde{\mathbf{m}})\}, \quad c > 0, \quad a' \geq \underline{b}
\end{aligned} \tag{5}$$

where, differently from the employed worker, a laid-off worker receives welfare transfer  $T_u$  and UI benefit  $b^{UI}(\tilde{\mathbf{n}}, \tilde{\mathbf{y}}, \tilde{\mathbf{m}})$ , which is zero if the worker is not eligible.

**Value Function if Quitting:** If a worker quits, i.e.,  $z > 0$  and  $n = 0$ , with probability  $\varphi$  he receives UI if eligible and with probability  $1 - \varphi$  he does not receive UI. The value function of a worker who quits and receives UI is

$$\begin{aligned}
v_{n=0}^{UI}(a, z, \tilde{\mathbf{n}}, \tilde{\mathbf{y}}, \tilde{\mathbf{m}} | z > 0) &= \max_{c, a'} u(c, 0) + \beta \left[ (1 - p_e) v_{n=0}^{UI}(a', z, \tilde{\mathbf{n}}', \tilde{\mathbf{y}}', \tilde{\mathbf{m}}' | z > 0) + \right. \\
&\quad \left. p_e \sum_{z' \in \mathcal{Z}} \bar{\pi}(z, z') v_n(a', z', \tilde{\mathbf{n}}', \tilde{\mathbf{y}}', \tilde{\mathbf{m}}') \right] \\
\text{s.t.} & \\
c + a' &= (1 + (1 - \tau)r)a + T_u + b^{UI}(\tilde{\mathbf{n}}, \tilde{\mathbf{y}}, \tilde{\mathbf{m}}) \\
\tilde{\mathbf{n}}' &= \{\tilde{\mathbf{n}}, 0\}, \quad \tilde{\mathbf{y}}' = \{\tilde{\mathbf{y}}, 0\}, \quad \tilde{\mathbf{m}}' = \{\tilde{\mathbf{m}}, \mathbf{1}(\tilde{\mathbf{n}}, \tilde{\mathbf{y}}, \tilde{\mathbf{m}})\}, \quad c > 0, \quad a' \geq \underline{b}
\end{aligned} \tag{6}$$

With probability  $1 - \varphi$  the worker is caught by the UI authority and does not receive UI benefits. Moreover, we assume that as punishment for attempting to defraud the UI system, the worker loses her eligibility to receive UI in the following periods. In our notation, this is equivalent to having the worker's labor market history erased. The value function of a worker who quits and does not receive UI is

$$\begin{aligned}
v_{n=0}^{nUI}(a, z, \tilde{\mathbf{n}}, \tilde{\mathbf{y}}, \tilde{\mathbf{m}} | z > 0) &= \max_{c, a'} u(c, 0) + \beta \left[ (1 - p_e) v_{n=0}^{nUI}(a', z, \tilde{\mathbf{n}}', \tilde{\mathbf{y}}', \tilde{\mathbf{m}}' | z > 0) + \right. \\
&\quad \left. p_e \sum_{z' \in \mathcal{Z}} \bar{\pi}(z, z') v_n(a', z', \tilde{\mathbf{n}}', \tilde{\mathbf{y}}', \tilde{\mathbf{m}}') \right] \\
\text{s.t.} & \\
c + a' &= (1 + (1 - \tau)r)a + T_u \\
\tilde{\mathbf{n}}' &= \{0\}, \quad \tilde{\mathbf{y}}' = \{0\}, \quad \tilde{\mathbf{m}}' = \{0\}, \quad c > 0, \quad a' \geq \underline{b}
\end{aligned} \tag{7}$$

Therefore, using (6) and (7) we can write the value function of a worker who quits:

$$v_{n=0}(a, z, \tilde{\mathbf{n}}, \tilde{\mathbf{y}}, \tilde{\mathbf{m}}|z > 0) = \varphi v_{n=0}^{UI}(a, z, \tilde{\mathbf{n}}, \tilde{\mathbf{y}}, \tilde{\mathbf{m}}|z > 0) + (1 - \varphi)v_{n=0}^{nUI}(a, z, \tilde{\mathbf{n}}, \tilde{\mathbf{y}}, \tilde{\mathbf{m}}|z > 0) \quad (8)$$

**Value Function if Receiving UI:** If the worker has already received UI in the last period, with probability  $\eta$  the worker keeps receiving UI and with probability  $(1 - \eta)$ , the worker loses the benefit. The value function of a worker who is already receiving UI and has kept receiving it is defined below

$$v_{n=0}^{UI}(a, z, \tilde{\mathbf{n}}, \tilde{\mathbf{y}}, \tilde{\mathbf{m}}|m = 1) = \max_{c, a'} u(c, 0) + \beta \left[ (1 - p_e)v_{n=0}^{UI}(a', z, \tilde{\mathbf{n}}', \tilde{\mathbf{y}}', \tilde{\mathbf{m}}'|m = 1) + p_e \sum_{z' \in \mathcal{Z}} \tilde{\pi}(z, z') v_n(a', z', \tilde{\mathbf{n}}', \tilde{\mathbf{y}}', \tilde{\mathbf{m}}') \right] \quad (9)$$

s.t.

$$c + a' = (1 + (1 - \tau)r)a + T_u + b^{UI}(\tilde{\mathbf{n}}, \tilde{\mathbf{y}}, \tilde{\mathbf{m}})$$

$$\tilde{\mathbf{n}}' = \{\tilde{\mathbf{n}}, 0\}, \quad \tilde{\mathbf{y}}' = \{\tilde{\mathbf{y}}, 0\}, \quad \tilde{\mathbf{m}}' = \{\tilde{\mathbf{m}}, \mathbb{1}(\tilde{\mathbf{n}}, \tilde{\mathbf{y}}, \tilde{\mathbf{m}})\}, \quad c > 0, \quad a' \geq \underline{b}$$

where we also know that the benefit,  $b^{UI}(\tilde{\mathbf{n}}, \tilde{\mathbf{y}}, \tilde{\mathbf{m}})$ , does not depend anymore on the totality of the worker's labor market history, rather only on the last level of earnings  $y_t$  before the worker started receiving benefits and the benefit recipient's history,  $\tilde{\mathbf{m}}$ . The last level of earnings suffices for the monetary requirement constraint and determines the effective replacement earnings during the entire unemployment spell.

The value function of a worker who is already receiving UI and has been randomly drawn out of the UI benefit pool is given by the problem below

$$v_{n=0}^{nUI}(a, z, \tilde{\mathbf{n}}, \tilde{\mathbf{y}}, \tilde{\mathbf{m}} | m = 1) = \max_{c, a'} u(c, 0) + \beta \left[ (1 - p_e) v_{n=0}^{nUI}(a', z, \tilde{\mathbf{n}}', \tilde{\mathbf{y}}', \tilde{\mathbf{m}}' | m = 1) + p_e \sum_{z' \in \mathcal{Z}} \bar{\pi}(z, z') v_n(a', z', \tilde{\mathbf{n}}', \tilde{\mathbf{y}}', \tilde{\mathbf{m}}') \right]$$

s.t. (10)

$$c + a' = (1 + (1 - \tau)r)a + T_u$$

$$\tilde{\mathbf{n}}' = \{\tilde{\mathbf{n}}, 0\}, \quad \tilde{\mathbf{y}}' = \{\tilde{\mathbf{y}}, 0\}, \quad \tilde{\mathbf{m}}' = \{\tilde{\mathbf{m}}, 0\}, \quad c > 0, \quad a' \geq \underline{b}$$

Therefore, using (9) and (10) we can write the value function of a worker who is already receiving UI:

$$v_{n=0}(a, z, \tilde{\mathbf{n}}, \tilde{\mathbf{y}}, \tilde{\mathbf{m}} | m = 1) = \eta v_{n=0}^{UI}(a, z, \tilde{\mathbf{n}}, \tilde{\mathbf{y}}, \tilde{\mathbf{m}} | m = 1) + (1 - \eta) v_{n=0}^{nUI}(a, z, \tilde{\mathbf{n}}, \tilde{\mathbf{y}}, \tilde{\mathbf{m}} | m = 1) \quad (11)$$

The solution of the dynamic programs (3) to (10) yields the decision rules for the asset holdings  $a : S \rightarrow \mathbb{R}_+$ , consumption  $c : S \rightarrow \mathbb{R}_{++}$ , and labor supply  $n : S \rightarrow \{0, 1\}$ .

In the Bellman equations written above, we have kept the notation initially introduced for exposition purposes and to make it simpler to write down the recursive household problem. Nonetheless, the state space contains the agents' full labor supply, income history, and UI benefit histories,  $(\tilde{\mathbf{n}}, \tilde{\mathbf{y}}, \tilde{\mathbf{m}})$ . Given our infinite time horizon, these become infinite dimensional objects in the steady state of the model. Hence, in the way we have defined the problem so far a numerical solution is, by construction, intractable.

In Appendix B.2 we explain how to reduce the state space to make solving the problem feasible. The principle behind the arithmetic we describe relies on only keeping track of the agents' relevant labor supply history and average earnings. Furthermore, the full definition of the partial equilibrium of the economy, together with the details on the cal-

culations of the aggregates is described in [B.3](#).

## 5 Calibration

### 5.1 Timing, Preferences, and Technology

We define the time period of the model to be equivalent to 6 weeks. The period utility is isoelastic in consumption  $c$  and separable with respect to the labor supply  $n$ :

$$u(c, n) = \frac{c^{1-\gamma}}{1-\gamma} - \chi n \quad (12)$$

where  $\gamma$  is the coefficient of relative risk aversion and  $\chi$  controls the disutility of labor. We calibrate the latter to match the average labor force participation (LFP) of the US economy computed as the average between 1979 and 2014 taken from the Bureau of Labor Statistics data for men 20 years or older. We set  $\gamma = 1$ , hence assuming  $\log(c)$  form throughout our numerical exercises. We endogenously calibrate  $\beta$  to match the average wealth to income ratio in the US, which is taken from our own calculations using the Survey of Consumer Finances (SCF) of 2010 and 2013.

Following [Cooley \(1995\)](#) we set the capital share  $\alpha$  to 0.36, a value already standard in the literature. We exogenously set the partial equilibrium interest rate  $r^*$  to the six-week value that is equivalent to 2 percent per year. For the depreciation rate of capital  $\delta$ , we follow [Gomes et al. \(2001\)](#) and set it to the six-week value that is equivalent to 5 percent per year.

### 5.2 Endowments and Labor Income

We prevent all workers from borrowing; hence, we set  $\underline{b} = 0$ . We follow [Gomes et al. \(2001\)](#) and calibrate the persistence  $\rho$  and the error variance  $\sigma_\varepsilon^2$  of the AR(1) process governing the labor income shock to 0.9 and 0.052, respectively. The probability of finding

a job  $p_e$  is calibrated endogenously to simultaneously match the average duration of UI benefits and the measure exhausting the number of payments of UI benefits. We also calibrate endogenously the probability of losing a job  $p_u$  set to match average job destruction. Our target is based on our calculation of job losers as a share of the population from 1991 to 2014 using data from the US Department of Labor (USDL).<sup>9</sup>

### 5.3 Unemployment Insurance and Government

The values for the parameters governing the UI system in the benchmark economy are calibrated exogenously. The replacement ratio  $\theta$  is set to 0.4641, which is the US average from 1989 to 2011 as provided by the USDL. The monetary requirement  $z_{min}$  is defined exogenously to be 0.5573, which is the numerical value for the 4th largest shock in the grid we use to discretize the AR(1) process in the computation. In the model, this is equivalent to 10 percent of the average of six-weeks' earnings. The maximum number of weeks that workers receive the benefit  $\mu_b$  is 24, which is the closest number consistent with the average of 26 weeks as reported by the USDL. This is equivalent to 4 model periods, which would otherwise amount to 30 weeks, had we considered 5 model periods. The same number of weeks is also required for households to attain the work tenure eligibility requirement  $\mu_t$ .

The remaining parameters are all calibrated endogenously. The universal transfer  $T_u$  is calibrated to match the average transfer to unemployment over average labor income in the data. We calculate the target level for this statistic from the American Community Survey (IPUMS-ACS). The moral hazard shock  $\varphi$  is chosen to target the share of agents receiving UI in the US. The reference value for this moment is, once again, calculated from the average of the USDL data from 1991 to 2014. Last, the loss of benefit shock,  $\eta$ , together with  $p_e$  mentioned previously, targets the average duration of UI benefits and the measure of workers exhausting UI benefits.

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<sup>9</sup>In Appendix D.1 and D.2, we conduct robustness checks on the effect of the changes in the calibrated values of  $p_e$  and  $p_u$  on some of the benchmark aggregate statistics and the optimal policy.

## 5.4 Summary of Calibration

We summarize the information associated with the calibrated parameters in the sequence of tables below. In Table 2, one can find the exogenously calibrated parameters and their sources. Table 3 shows the endogenously calibrated parameters, the targeted moments associated with each of them, the source of such moments for their data counterparts, and the value of such statistics computed for the model economy.

Table 2: Exogenously calibrated parameters

	Parameter	Value	Target / Source
<b>Timing</b>			
Model's period	$t$	$\{1, \dots, \infty\}$	6 weeks ( <a href="#">Hansen and Imrohoroğlu, 1992</a> )
<b>Preferences</b>			
Relative risk aversion	$\gamma$	1.0	Standard
<b>Technology</b>			
Capital share	$\alpha$	0.36	<a href="#">Cooley (1995)</a>
Interest rate	$r$	0.002	$\approx 2\%$ per year
Depreciation of $K$	$\delta$	0.006	$\approx 5\%$ per year ( <a href="#">Gomes et al., 2001</a> )
<b>Labor Income</b>			
Persistence and variance of AR(1)	$\{\rho, \sigma_{\varepsilon}^2\}$	0.900, 0.052	<a href="#">Gomes et al. (2001)</a>
<b>Government and UI</b>			
Replacement ratio	$\theta$	0.4641	US Department of Labor
Monetary requirement	$z_{min}$	0.5573	10% of avg six-weeks earnings
Maximum benefit periods	$\mu_b$	24	US Department of Labor
Eligibility requirement	$\mu_t$	24	US States Data

*Notes:* The table shows model parameters, their numerical values, targeted moments in the model economy, and their data sources.

Table 3: Endogenously calibrated parameters

	Parameter	Value	Target	Data	Model
<b>Preferences and Government</b>					
Discount factor	$\beta$	0.9974	Wealth/Income	2.5	2.5
Labor disutility	$\chi$	0.3343	Labor force participation rate	0.762	0.819
Transfer to unemployed	$T_u$	0.049	Transfer to Unemp/Average Lab. Inc.	0.009	0.009
<b>Labor Market Shocks</b>					
Probability of job offer	$p_e$	0.7977	Weeks receiving UI & shr. exhaust. UI	16 & 0.371	16.1 & 0.371
Probability of losing job	$p_u$	0.0031	Job destruction	0.028	0.028
<b>Moral Hazard Shocks</b>					
Probability of UI benefit w/o being fired	$\varphi$	0.078	Share of agents receiving UI	0.011	0.011
Probability of losing UI exogenously	$\eta$	0.1975	Weeks receiving UI & shr. exhaust. UI	16 & 0.371	16.1 & 0.371

Notes: The table shows model parameters, their numerical values, and targeted moments in the model economy.

## 6 The Benchmark Economy

In Table 3 we have shown that the model is able to successfully match the targeted data moments. In particular, the relevant moments are exactly matched with the only exception being the labor force participation rate, which is about 6 percentage points higher than in the data. This can be rationalized by the fact that the universal transfer  $T_u$  determined by the calibration target is relatively small and households have only UI as a source of income beyond their own return to work. As in the design of the UI, there are explicit incentives for households to work: the structure of the economy is one in which the forces toward labor force participation compete directly with the preference for leisure.

For a better validation of our model, we show in Table 4 some selected non-targeted model moments we consider relevant for our environment to be well specified for the quantitative experiments. We can observe that the model is able to closely replicate the mean unemployment duration and the share of workers excluded by the monetary requirement. Notice that the unemployment duration is around 22 weeks, with an average duration that is 8 years longer than the average period in which workers receive the UI benefit. Hence, the model is able to be precise about the dynamic behavior of the pool of unemployed workers in and out of the labor market and of the insurance system.



The replication of the share of unemployed workers excluded from the benefit by the monetary requirement is key to our analysis as we have exogenously set the requirement  $z_{min}$  to an arbitrarily small level defined by one of the initial points in our discretized shock process. As we match closely the 3.8 percent share of workers who fall in this category, we can be reassured that for the current computation, the monetary requirement has the desired outcome within the model mechanism.<sup>10</sup>

The total expenditure by GDP is also at a level close to what is observed in the US data. This small size of the UI program is also able to be achieved through the existence of the universal unemployment transfer  $T_u$ , which helps households to have the correct amount of income and insurance. Hence, with income, job displacement, and moral hazard shocks, the incompleteness of the market ends up self-selecting workers into the UI program, thus determining the size of the insurance value given to workers through that channel. Finally, the tenure requirement excludes fewer workers than what is observed in the data.

Table 4: Non-targeted moments of the benchmark economy

<b>Statistic</b>	<b>Data</b>	<b>Model</b>
Mean Unemployment Duration	22.50	22.77
UI Expenditure/GDP	0.72%	0.55%
Share Excluded by Mon. Req.	3.8%	3.5%
Share Excluded by Tenure Req.	8.6%	2.9%

*Notes:* The table displays non-targeted moments computed in the data and in the model. The mean unemployment duration is denoted in weeks.

<sup>10</sup>The share of workers excluded by the monetary requirement in the data is calculated using the CPS ASEC, the only part of this survey that has data starting in 1962. For the numbers shown in Table 4, specifically, we take data from 2000 to 2015 and merge them with our collected database for the monetary requirement. We then compare it to workers' weekly earnings and compute the share that is excluded by the threshold. More details on our calculation of the minimum weekly earnings are described in Appendix A.

## 6.1 Connection with the Empirical Evidence

In order to understand the connection of the model with what we measured in the data in our empirical analysis, we also calculate the change in the share of workers who receive the unemployment insurance benefit in our model economy whenever we introduce UI requirements. The idea is to generate an effect similar to that captured in Column 2 of Table 1 for UI take-up. For the monetary requirement, for instance, we calculate the change in the statistic between two model economies, one in which we start it at zero and the one with the initially calibrated level of the monetary requirement. For comparative statics used in these counterfactual changes, we keep the partial equilibrium concept and the initial calibration but vary only the requirement parameters while allowing an extra tax levied on payroll to adjust the unemployment insurance budget.<sup>11</sup>

We show the results in Table 5. In our empirical analysis, we found that there is a decrease of 2.5 percent in the UI beneficiary pool that stems from the introduction of a monetary requirement. In our model, we preserve the same direction and magnitude of the effect, with negative 2.71 percent. For the tenure requirement, the empirical effect measured is null and non-significant; hence, we would expect the model to yield a small effect. This is also true in our benchmark economy if we move the tenure requirement from the minimum period allowed, i.e., 6 weeks, to the initially calibrated period of 24 weeks. This change generates a decrease of -0.06 percent in the share of insured between the two economies.

Table 5: Comparison between the model and the empirical analysis

<b>Statistic</b>	<b>Data</b>	<b>Model</b>
Change in Share Insured with Mon. Req	-2.5%	-2.71%
Change in Share Insured with Tenure. Req	-0.0%	-0.06%

*Notes:* The table displays non-targeted moments computed in our empirical analysis and percent differences in the statistic between a counterfactual economy and the benchmark economy.

<sup>11</sup>This is identical to the thought experiment in 7.1, which we use in the comparative analyses in the next section.

## 7 Counterfactual Analyses

In this section we outline the results of the counterfactual exercises conducted highlighting the impacts on the moral hazard component, job-taking behavior, and exhaustion of UI benefits. First, we describe the thought experiment and the adaptations in the model required to conduct the counterfactuals. Second, we analyze in Subsection 7.2 the effect of all elements of the UI design on different types of employment. In Subsection 7.3, we discuss the effects of the tenure and monetary requirements on the moral hazard component of our economy.

### 7.1 Thought Experiment

The idea behind the counterfactual exercises of changing the design of UI can be described as follows: we vary the value of the policy instrument, say the monetary requirement  $z_{min}$ , while keeping all other parameters of the UI constant. Naturally, the change of regime in this *ceteris paribus* fashion will affect the endogenous spending and revenues of the UI budget. In order to impose discipline on the government's administration of the program, we keep  $T_u$  and  $G$  fixed at their benchmark numerical level. We then add an endogenous payroll tax  $\tau_{UI}$  to finance any residual UI financing needs and close the government's budget. The budget constraint of the household then becomes:

$$c + a' = (1 + (1 - \tau)r)a + (1 - \tau - \tau_{UI})wzn + (1 - n)T_u + (1 - n)b^{UI}(\tilde{\mathbf{n}}, \tilde{\mathbf{y}}, \tilde{\mathbf{m}}) \quad (13)$$

We also need to update the budget constraint of the government under this new regime to add the revenue accrued from the payroll tax  $\tau_{UI}$ . We can compute it as follows:

$$\tau_{UI} = \frac{G + T_u + \int_S b^{UI}(\tilde{\mathbf{n}}, \tilde{\mathbf{y}}) d\Phi(s) - \tau \left( r^*K + w^*L + \int_S b^{UI}(\tilde{\mathbf{n}}, \tilde{\mathbf{y}}, \tilde{\mathbf{m}}) d\Phi(s) \right)}{w^*L} \quad (14)$$

We use the notion of a partial equilibrium of the model economy as described in Appendix B.3 and add  $\tau_{UI}$  as an endogenous equilibrium object in our equilibrium definition. We do so by modifying the condition for the government budget constraint described in Appendix B.3 and substituting it with (14). The solution algorithm to find the partial equilibrium now consists of iterating on the underlying fixed point defined by the budget-clearing rate  $\tau_{UI}$ . In Appendix D, we generalize the thought experiment above, allowing for a full general equilibrium analysis, and compare the results with our main findings.

## 7.2 Effects of the UI Design on Employment

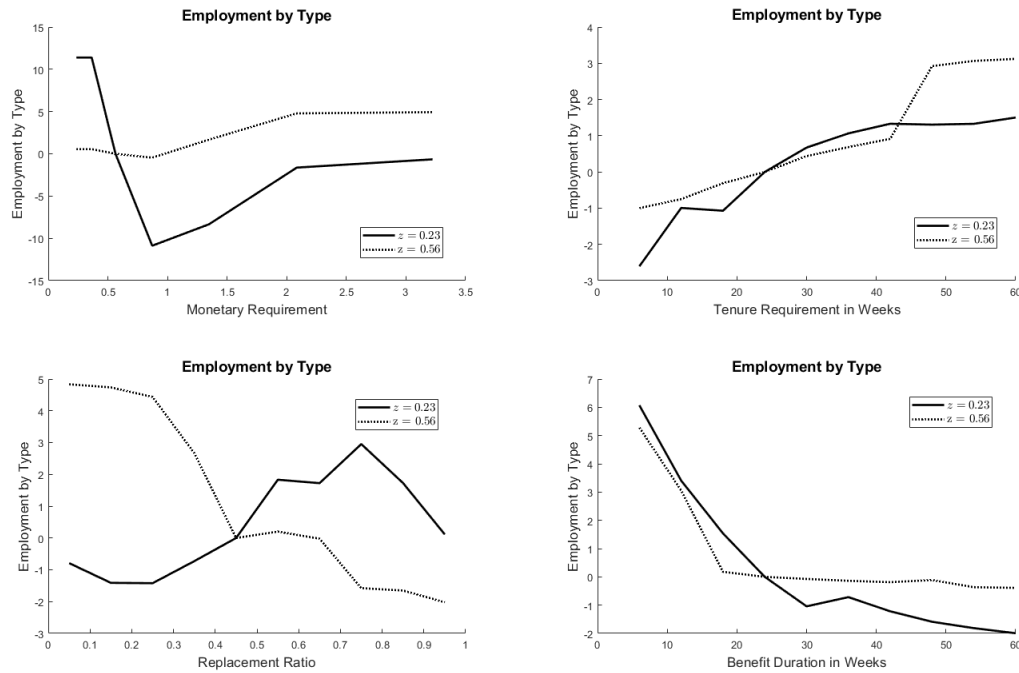
In Figure 1, we show the effect on employment of varying each of the UI design parameters for two of the lowest levels of productivity, namely,  $z = 0.23$ , the lowest positive level, and  $z = 0.56$ , the level for which we calibrated  $z_{min}$  in the benchmark economy. The reason we show only this range is that from the mid-level of the idiosyncratic shock, workers are productive enough so that they basically do not react to changes in the policy instruments in a quantitatively significant manner. The three lowest levels of productivity are where we identify relevant behavioral responses.

First, we observe that the share of employed workers by type changes in a way consistent with what was observed in the empirical correlations shown in Table 1. Both the monetary and the tenure requirement in the model exhibit a sign and magnitude of their impact that are in accordance with what we have measured in our regressions. More specifically, the tenure requirement is positively associated with employment outcomes, whereas the monetary requirement negatively impacts the outcomes. Moreover, the numerical order of magnitude also seems to be preserved, as the tenure requirement has a

smaller effect overall than the monetary requirement when measured for the same statistic.

At the benchmark level, the monetary requirement is approximately 0.56. We can then see in the top left panel that it is exactly where both lines cross the zero level. It is possible to observe that the negative relationship observed in the data also happens in the model, since when the monetary requirement is made stricter or set higher, there is an overall decrease in the employment rate, especially for the lowest level of productivity. Though not monotone, the intuition follows that a looser monetary requirement for a low-productivity worker essentially makes access to the UI benefit easier, which ends up enlarging the option value of working, together with its built-in work incentives, vis-a-vis the cost of supplying labor.

Figure 1: Percent variation in employment by type for different levels of UI instruments



*Notes:* The figure shows the share of employment by type along the ranges considered for each UI policy element. The top panels show the variation for the monetary and tenure requirement, respectively. The bottom panels show the variation for the replacement ratio and the benefit duration, respectively. The solid line shows the employment share for a worker with the lowest level of productivity and the dashed line shows the share for a worker with the third level of productivity. The latter is the level to which the monetary requirement is calibrated in the benchmark economy.

Second, we can find an even clearer correlation when analyzing the relative changes in employment due to the changes in the number of weeks of the tenure requirement. Once again, as we start from 22 weeks, we can see in the top right panel that both lines for each of the productivity levels cross zero at that number. Similarly to what we observed in our empirical evidence, the more demanding the tenure requirement, the higher is the share of employment by type. The intuition for this result is straightforward: with a higher number of weeks required to be able to receive UI benefits, workers have an extra incentive to remain attached to the labor force. Aside from the lower marginal cost of supplying labor, the benefits are based on the average past earnings; hence, the higher

the productivity, even at the very bottom of the distribution, the larger the incentive to work.

Overall, we can observe that the monetary requirement and the replacement ratio have the strongest impact on the employment rate when making changes at the benchmark level. The replacement ratio has different effects depending on workers' productivity. Among the ones depicted, we can observe that the higher the productivity, the more positive the impact of a smaller replacement ratio on the employment share of that type. With higher productivity, a worker has more incentive to actually participate in the labor force if the UI benefit is a smaller fraction of the worker's earnings. Finally, the benefit duration  $\mu_b$  has an unambiguous impact on workers: the longer the duration of the payment stream, the smaller the incentive for households to work.

### 7.3 The Effects of UI Requirements on Moral Hazard

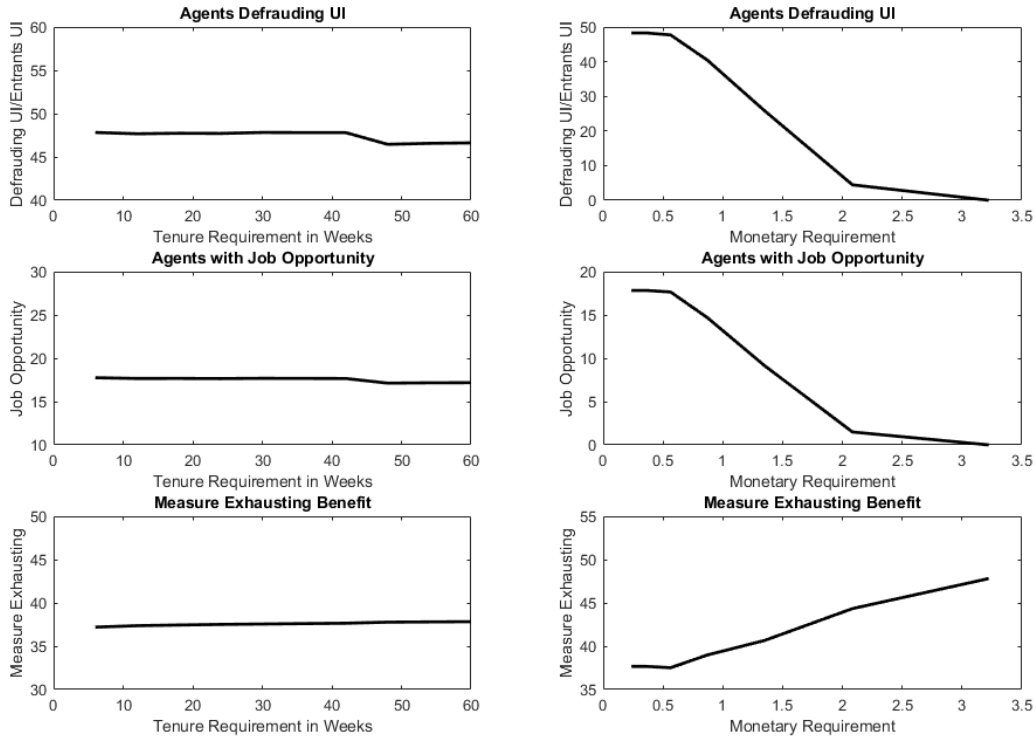
In Figure 2, we show, from top to bottom on the graph, respectively, the effect of changing the value of the tenure and the monetary requirement on workers who are defrauding UI benefits, the job opportunities, and the measure of workers who have exhausted the number of periods for which they are eligible to receive the benefit.

A longer tenure requirement, i.e., a higher  $\mu_t$ , has virtually no effect on all outcomes, which is shown by the small percentage of impact on the shares in the figures. Despite the small quantitative impact, we can see in the bottom graph that the measure of unemployed workers who completely exhaust their UI benefits increases as we require more weeks of work to satisfy the tenure requirement. The intuition for this result is the following: as the requirement gets stricter, unemployed workers seizing their UI benefits realize it is better to stay in that state until the last possible period in which the insurance is paid.

On the top graph, one can verify that a stricter monetary requirement, a higher  $z_{min}$ , overall reduces the share of workers who defraud UI over the share of workers entering the UI program. With the lowest possible requirement, such a share achieves a level in which about 50 percent of the workers receiving UI should not be able to receive such

benefits. Conversely, if we allow that level to be the highest possible level of idiosyncratic productivity, it is possible to decrease this share to zero.

Figure 2: Moral hazard and the tenure and monetary requirement



*Notes:* The figure shows in the top panels the share of workers defrauding UI over entrants into UI, in the middle panels the share of workers with a job opportunity, and in the bottom panels the measure of workers exhausting all available periods of UI reciprocity. All of those are shown along different levels for the tenure requirement in the left column and for the monetary requirement in the right column.

The same inverse relationship happens with the share of workers receiving a job opportunity. With a loose monetary requirement, several workers stay in the unemployment state due to the possibility of collecting undue benefits and thus more than 10 percent of them are receiving opportunities for the lowest values of the requirement. Once again, by choosing the strictest possible value of the requirement, one can reduce such a share to zero. Finally, the monetary requirement is positively correlated with the share of households exhausting UI benefits. But the numerical range of the effect on this measure is



smaller than in the previously reported shares. From the last panel, it is clear that a stricter monetary requirement makes it increasingly worthwhile for workers to use the whole time span in which they are entitled to UI benefits, since the chance of receiving them again is lower.

## 8 Optimal Policy Analysis

We conduct an optimal policy analysis by finding the UI design that maximizes welfare in the economy described. In order to do so, we define a utilitarian social welfare function (SWF) dependent on all relevant policy parameters as follows:

$$W(\theta, \mu_t, \mu_b, z_{min}) = \int v^*(a, z, \bar{n}, m, \bar{y} \mid \theta, \mu_t, \mu_b, z_{min}) d\mu^* \quad (15)$$

where  $\{v^*, \mu^*\}$  are, respectively, the value function and distribution associated with a stationary partial equilibrium.

Essentially, we hold constant the income tax  $\tau$  and the expenditure components  $G$  and  $T_u$ , as if they were fixed by the government at  $t = 0$ , and find the combination of static UI policy parameters that optimize the social welfare function subject to its being consistent with a stationary partial equilibrium. This set of partial equilibria to which the planner restricts her attention will be the one defined by the household's optimization together with the government's budget constraint balanced by  $\tau_{UI}$  as shown in Subsection 7.1.

In light of this reasoning, the restricted social planner's problem is thus defined as:

$$\max_{\{\theta, \mu_t, \mu_b, z_{min}\} \in \Gamma} W(\theta, \mu_t, \mu_b, z_{min}) \quad (16)$$

where  $\Gamma$  is the restricted set of policies for which an associated stationary partial equilibrium exists.

We report the welfare gain in terms of the consumption equivalent variation (CEV).

This measure defines the increment in consumption that we would need to give households in each state of the world so that they would be indifferent between their benchmark level of consumption and their level of consumption in the alternative economies. We do so by calculating the household's *ex-ante* value, hence under the veil of ignorance. The CEV is defined for our environment as follows:

$$CEV(\theta, \mu_t, \mu_b, z_{min}) = 100 * \{ \exp [(1 - \beta) (W(\theta, \mu_t, \mu_b, z_{min}) - W_{bchmk})] - 1 \} \quad (17)$$

where  $W_{bchmk}$  is the SWF associated with the benchmark partial equilibrium parameterized according to Table 2.

We show the results in Table 6 below. When welfare is optimized in each instrument dimension separately, we can notice that the monetary requirement is the one yielding the highest CEV, as shown in the fourth column. The intuition for this result comes from the fact that the monetary requirement prevents households from taking low-wage jobs; otherwise households would have a high incentive to quit their jobs in order to receive the benefit and to defraud the UI program. This is confirmed by the fact that such an optimal outcome exhibits the smallest number of beneficiaries of the program, as shown in the last row of the table, hence diminishing the overall moral hazard faced by the planner.

The second highest level of welfare gain is achieved through a large reduction in the replacement ratio from the initial calibration, as shown by the CEV in the first column of the table. When comparing this equilibrium to the benchmark scenario, it becomes clear that the effect of such a reduction does not have a large impact on the number of workers receiving benefits. However, it sharply decreases the overall cost of the program, with the lowest expenditure/GDP share of all of the other instruments at their optimal level. As we effectively find that the budget-clearing rate  $\tau_{UI}$  is negative, i.e., a transfer, the smaller size of the UI system comes with a lower effective tax rate on payroll when taking into account the wedge already imposed by  $\tau$ .

Table 6: Optimal policies and statistics for each of the UI program instruments

	Benchmark	Replacement Ratio	Benefit Duration	Monetary Requirement	Tenure Requirement	Requirements
<b>Optimal Policies</b>						
Replacement Ratio	0.46	0.15	0.46	0.46	0.46	0.46
Benefit Duration	24	24	6	24	24	24
Monetary Requirement	10%	10%	10%	23%	10%	23%
Tenure Requirement	24	24	24	24	54	12
<b>Statistics</b>						
CEV	0	0.83%	0.58%	.88%	0.26%	0.99%
Expenditure/GDP	0.55%	0.18%	0.42%	0.31%	0.50%	0.22%
Beneficiaries	1.1%	1.07%	0.40%	0.25%	0.93%	0.27%

Notes: The table displays the computed results for the model. The benefit duration and the tenure requirements are denoted in weeks. The monetary requirement is in percentage of six-week average earnings.

We can observe that the tenure requirement yields small welfare gains when considered separately; it needs to be at a level of 50 or more weeks, beyond what we consider in the current computation of the model. Nonetheless, when tenure is combined with the monetary requirement, the planner is able to recover the welfare gains by setting the latter at a level associated with the *ceteris paribus* optimal. At the same time, though, the planner is able to increase the welfare gains by lowering the tenure requirement to half of the benchmark level.

This result happens because with a high monetary requirement and low-wage workers' defrauding behavior ruled out, a lower tenure requirement yields fewer workers who are exhausting their UI benefits, since they anticipate they will be able to benefit from this policy again by taking another job with less restrictive requirements for the program in the future. Since the effective transition probabilities, which otherwise would be endogenous in a standard search and matching environment, are an important component of this mechanism, in Appendix D.2 we allow for small perturbations in the calibrated values of  $p_e$  and  $p_u$  and find that the optimal level of requirements is the same. Also, in Appendix D.3 we show the direction of change in the results under general equilibrium.

## 9 Conclusion

In this paper, we addressed the question of what are the optimal levels of the two types of requirements used in the UI benefits program in the US. We developed an infinite horizon partial equilibrium model with incomplete markets and heterogeneous agents that includes a UI system that closely mimics the rules observed in the data. The model has a rich individual state space that includes workers' assets, idiosyncratic shocks, and labor supply and income histories. Furthermore, the economy has a structure of shocks that allows a moral hazard component akin to the one studied in the theoretical literature about optimal UI design. Our analysis focuses on the impact of changes in the UI policy instruments on workers' labor market outcomes

We conducted an empirical analysis to assess the UI requirements' effects on employment outcomes and obtained stylized facts for our quantitative exercises. We used discontinuities in the UI policies to identify the requirements' causal effect on different labor market outcomes. The monetary requirement has a stronger effect than the tenure requirement on discouraging UI benefit applications and a negative effect on the number of employers and part-time jobs. The tenure requirement has an opposite impact on the latter. The intuition for these results comes from the fact that a tenure requirement does not influence workers to stay at the same job. In contrast, the monetary provision gives workers an incentive to keep high-paying jobs.

We calibrated the model to the US data and conducted a series of counterfactual exercises by following a thought experiment that recovered the balance in the government's budget constraint. We were able to recover the negative correlation between the monetary requirement and the employment outcomes and the associated positive correlation with the tenure requirement. In the results of our exercises, we observe that a stricter monetary requirement significantly reduces the share of workers entering the UI system who are not technically qualified to do so. On the other hand, the tenure requirement has a negligible numerical impact on labor market outcomes subject to moral hazard.

We have maximized a utilitarian social welfare function on a restricted Ramsey prob-

lem and assessed the level of CEV associated with the optimal parametric region for the tuple that characterizes the program. In our results, we found that the highest level of welfare is achieved by a monetary requirement when instruments are evaluated separately. A combination of the tenure and the monetary requirement can achieve a higher welfare level than the *ceteris paribus* optimum.

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# Appendix

## A Data

The time period used in our sample is from 1963 to 2016. The data on the labor market are taken from the IPUMS source for the Annual Social and Economic Supplement (ASEC) of the Current Population Survey (CPS) (Flood et al., 2021). All the data used regarding the unemployment insurance law for the US states are taken from the US Department of Labor (USDOL). We do not perform any sample selection for the current analysis but rely on demographic controls in our regressions. For the county-level data, we are able to identify respondents' county only after 1996, as further discussed in C.2.

### A.1 Construction of Historical UI Requirements

Data on UI requirements are hand-collected and standardized from the USDOL historical archives. The USDOL collects data on unemployment insurance (UI) laws for all US states and publishes it in a document called "Comparison of State Unemployment Laws." This document provides detailed information on the financing schemes, eligibility criteria, employer requirements, and replacement ratios of each state's UI regulation. The USDOL also provides the formula for determining UI eligibility and the minimum earnings required to qualify for UI. We have hand-collected and standardized the data on UI requirements for all states since 1950.

Each state has its eligibility formula and criteria. In many cases, it is a function of total earnings in the 6 months before unemployment (called the base period), the earnings on the quarter with the highest wage, and weeks of employment. But, in general, there are 4 types of eligibility formulas: (i) multiple of high-quarter earnings; (ii) multiple of weekly benefit amount; (iii) flat qualifying amount; or (iv) weeks of employment. On the first eligibility formula, multiple of high-quarter earnings, workers are eligible if their base period earnings are above a multiple of their highest quarter earnings. For instance, for a worker to be eligible for UI in Alabama in 2006, she needs her earnings in the base period to be above 1.5 times her earnings in her highest quarter. On the second type of eligibility formula, the multiple of weekly benefit amount, a worker's earnings in the base period must be higher than a multiple of its weekly benefit amount. For instance, to qualify for UI in Connecticut in 2006, workers would need a base period earning above

40 times their weekly benefit amount. The third type of eligibility formula requires workers to have earnings in the base period above a certain dollar amount. For instance, West Virginia required workers to have earnings above \$2,200 to be eligible for UI. Finally, some states require workers to have a minimum number of employment weeks to be eligible.

Given how complex and diverse the UI requirements are across states and over time, we need to make assumptions to make them compatible. We estimate the tenure requirement by calculating the minimum amount of employment weeks a full-time worker continuously employed and with constant wages would need to become eligible. If a state uses an eligibility formula based on a multiple of high-quarter wages, the minimum amount of weeks a worker has to work is this multiple times twelve.<sup>12</sup> If the state has a requirement based on a minimum number of weeks or hours of work, we can directly calculate the tenure requirement. The tenure requirement is one week if the state is using an eligibility formula based on a flat qualifying amount or a multiple of the weekly benefit amount.

We estimate the monetary requirement by calculating the minimum weekly earnings that a full-time worker continuously employed and with constant wages would need to become eligible. We use three statistics to calculate that: the minimum wages needed to qualify in the highest earning quarter, the minimum wages needed to qualify in the base period, and the minimum weekly wage to qualify, if the state has such a requirement.<sup>13</sup> The monetary requirement is the maximum weekly wage required between the three different requirement types.

## A.2 Statistics of UI Requirements

In this section, we show statistics of the tenure and monetary requirements over time. Table 7 shows that the average tenure requirement in the sample is 16 weeks with considerable variation on it across time and states. The second column shows the monetary requirement in weekly earnings in 2015 dollars. The average weekly monetary requirement is US\$89 with an also large standard deviation.

Figures 3a and 3b show the average tenure and monetary requirements over time. The tenure requirement has been increasing since the 50's and slowing down in more recent years. The mon-

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<sup>12</sup>Twelve is the number of weeks in a quarter. In other words, if a worker needs to have earnings in the base period equal to  $c$  times the earnings in the highest quarter, a worker who has constant weekly earnings needs to work for  $c \times 12$  weeks to become eligible for UI.

<sup>13</sup>These variables are already provided by the USDL.

etary requirement, on the other hand, has fluctuated significantly over time. The stabilization of the increase in the two requirements after the 2000's suggests that the UI eligibility in the US is at an all-time high.

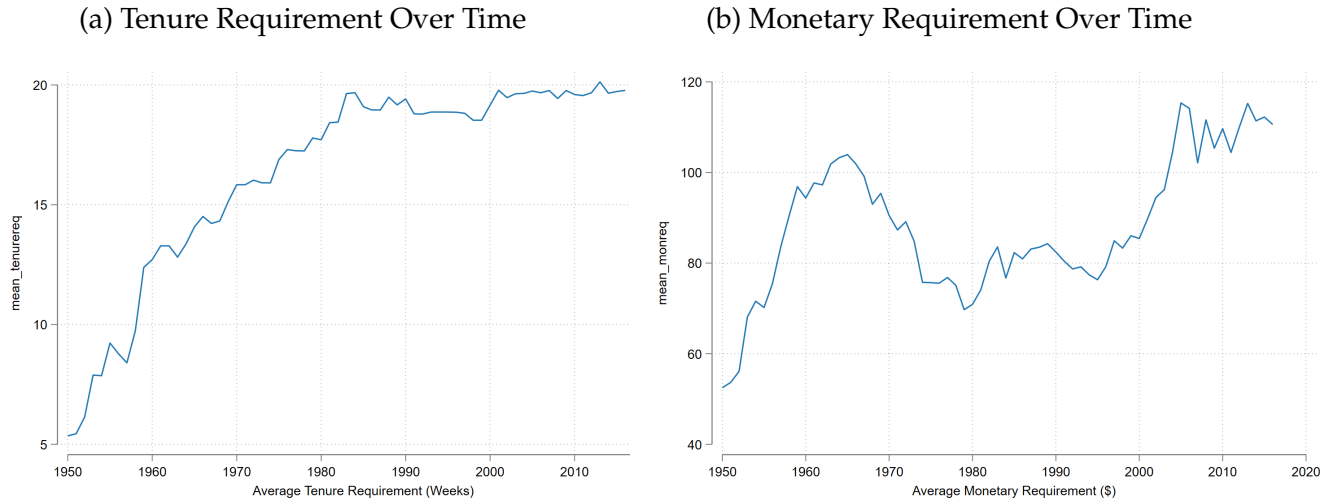
Table 7: Summary statistics of tenure and monetary requirements.

	Tenure Requirement (Weeks)	Monetary Requirement (US\$)
Mean	16.39	89.14
Std. Dev.	7.79	48.93
Median	18.00	82.35
Min	1.00	0.00
Max	36.00	531.45

*Notes:* This table shows statistics of the tenure and monetary requirements. The tenure requirement is in weeks and the monetary requirement in 2015 dollars.

The average tenure and monetary requirements described in Figures 3a and 3b hide a large degree of heterogeneity on UI requirement reforms. Figures 4 and 5 show the tenure and monetary requirements over time for different states, respectively, diving deeper into the variation of the requirements and their reforms. These figures highlight the fact that UI requirements tend to be sticky but exhibit several state-level reforms that introduce large fluctuations in them. Finally, to further highlight the heterogeneity of requirements, Figure 6 plots the histogram of tenure and monetary requirements across our whole sample.

Figure 3: Tenure and monetary requirements over time



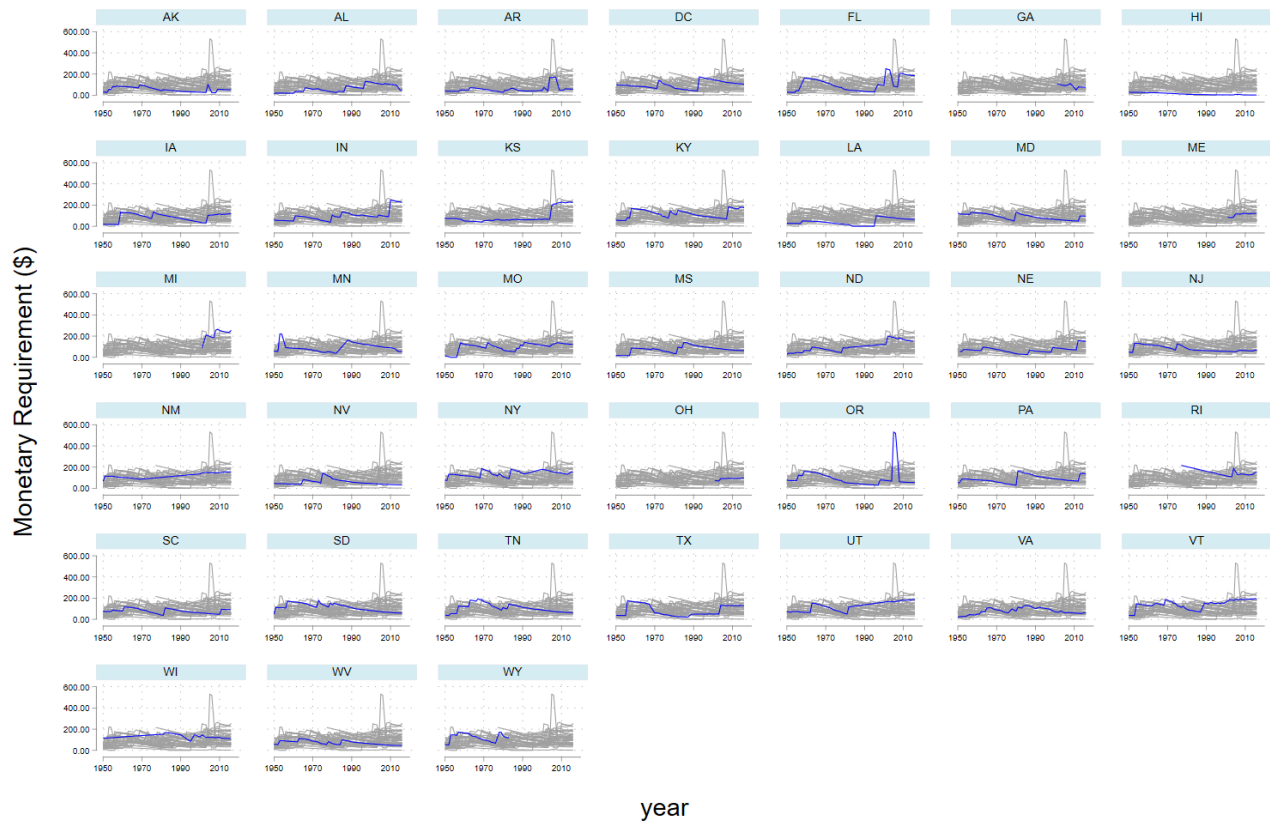
Notes: The figure shows the average tenure and monetary requirements over time. The tenure requirement is in weeks and the monetary requirement in 2015 dollars.

Figure 4: Tenure requirement over time across different states



Notes: The figure shows the tenure in weeks in different states.

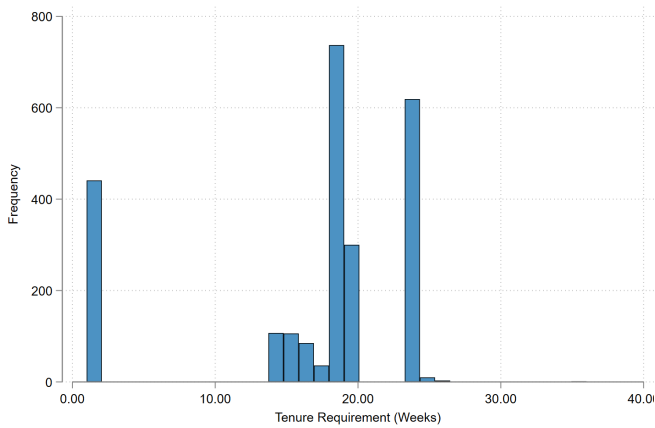
Figure 5: Monetary requirement over time across different states



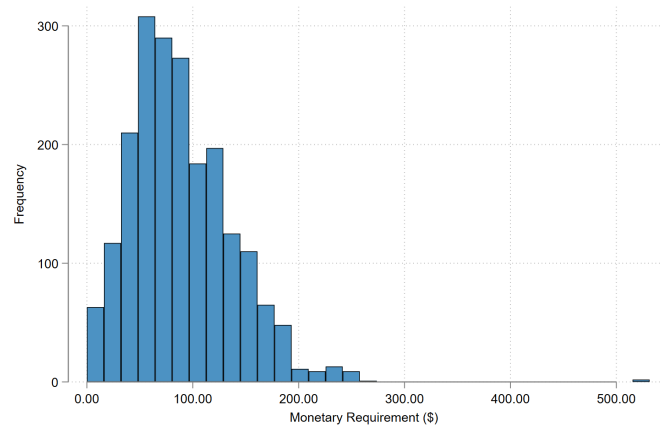
Notes: The figure shows the monetary requirement of different states in 2015 dollars.

Figure 6: Distribution of tenure and monetary requirements

(a) Distribution of tenure requirements in weeks



(b) Distribution of monetary requirements



Notes: The figure plots the histogram of tenure and monetary requirements over the whole sample. The tenure requirement is in weeks and the monetary requirement in 2015 dollars.

## B Details of the Model

### B.1 Firm's Problem

The price of the consumption good is normalized to one and aggregate investment in physical capital,  $I_t$ , is defined by the following law of motion:

$$K_{t+1} = (1 - \delta_k)K_t + I_t, \quad (18)$$

where  $\delta_k$  is the depreciation rate of physical capital.

This technology is used by a representative firm that behaves competitively, maximizing profits at every period  $t$  by choosing labor and capital given factor prices. The profit maximization problem is:

$$\Pi_t = \max_{K_t, N_t} K_t^\alpha N_t^{1-\alpha} - w_t N_t - (r_t + \delta_k)K_t. \quad (19)$$

which yields the following first-order conditions:

$$r_t = \alpha \left( \frac{K_t}{N_t} \right)^{\alpha-1} - \delta_k \quad (20)$$

$$w_t = (1 - \alpha) \left( \frac{K_t}{N_t} \right)^\alpha \quad (21)$$

In the partial equilibrium setting with an exogenously given  $r^*$ , we recover  $K_t/N_t$  via equation (20) and, thus, use equation (21) to determine the associated steady-state wage rate  $w^*$ .

### B.2 Reduction of the State Space

We can start by reducing the size of the agents' labor supply history  $\tilde{\mathbf{n}}$ . Given that the UI program needs to keep track of how many periods the agent has been working, the effective time span needed in the state space at any period  $t$  is completely determined by the minimum tenure requirement  $\mu_t$ . Hence, the agent satisfies this requirement if, at any period  $t$ ,  $n_\ell = 1$  for all  $\ell \in \{t - \mu_t - 1, \dots, t - 1\}$ . Let  $\bar{n}_t \in \{0, \dots, \mu_t\}$  denote the number of periods the worker has been working during her relevant labor supply history  $\{n_\ell\}_{\ell=t-\mu_t-1}^{t-\mu_t}$ . Hence, we can update  $\bar{n}$  with

the following law of motion

$$\bar{n}_{t+1} = (\bar{n}_t + 1)\mathbb{1}_{\{n_t=1\}} \quad (22)$$

where the notation  $\mathbb{1}$  stands for the indicator function, which also takes into account the fact that the worker loses all of her labor history points whenever  $n_t = 0$ .

Analogously, define  $\bar{m} \in \{0, \dots, \mu_t\}$  as the number of periods the worker has been receiving benefits during her relevant UI reciprocity history,  $\{m_\ell\}_{\ell=t-\mu_b-1}^{t-\mu_b}$ . We can then compute the next period's benefit eligibility in terms of periods received using the following law of motion:

$$\bar{m}_{t+1} = (\bar{m}_t + 1)\mathbb{1}_{\{\bar{m}_t \leq \mu_b\}} \quad (23)$$

With the variables introduced above, we then have collapsed all of the relevant information from  $(\tilde{\mathbf{n}}, \tilde{\mathbf{m}})$  into  $(\bar{n}, \bar{m})$ .

In order to tackle the reduction in the dimensionality of the agents' labor income history  $\tilde{\mathbf{y}}$ , we construct the variable  $\bar{y} \in \mathbb{R}_{++}$ . It captures the average labor income history of an agent who has worked for  $t$  consecutive periods:

$$\bar{y}_t = \begin{cases} \sum_{i=1}^t \frac{y_i}{t}, & \text{if } t \leq \mu_t \\ \sum_{i=1}^{t-\mu_t} y_{\mu_t+i} \frac{\mu_t^{t-\mu_t} - i}{(\mu_t + 1)^{t-\mu_t-i+1}} + \frac{\mu_t^{t-\mu_t}}{(\mu_t + 1)^{t-\mu_t+1}} \sum_{i=1}^{\mu_t} \frac{y_i}{\mu_t}, & \text{o.w.} \end{cases} \quad (24)$$

which can be updated recursively as

$$\bar{y}_{t+1} = (1 - \tau)wz_t \frac{1}{t+1} + \bar{y}_t \frac{t}{t+1} \quad (25)$$

With this summary statistic, we can implement a reduction in the state space of the labor income history from  $\tilde{\mathbf{y}}$  to  $\bar{y}$ .



The set  $\{\bar{n} = \mu_t\} \cap \{\bar{m} \leq \mu_b\} \cap \{\bar{y} \geq z_{min}\}$  is thus able to fully determine whether the agent satisfies all requirements to receive UI benefits at a given period and we can then define an indicator function  $\mathbb{1}$  over it. This allows us to write a proper algebraic characterization of the formula for the UI benefits  $b^{UI}(\bar{\mathbf{n}}, \bar{\mathbf{y}}, \bar{\mathbf{m}})$  as it is implemented in the quantitative solution of the model:

$$b^{UI}(\bar{n}, \bar{m}, \bar{y}) = \theta \bar{y} \mathbb{1}_{\{\bar{n}=\mu_t\} \cap \{\bar{m} \leq \mu_b\} \cap \{\bar{y} \geq z_{min}\}} \quad (26)$$

It is important to notice that, following US tax regulations, the benefits are subject to income taxation. Hence, when we update the next period's income  $\bar{y}_{t+1}$  according to the law of motion in (25), we are already including the post-tax income in the state space. Also, the law of motion takes into account that  $\bar{y}_{t+1}$  will be the last relevant earnings level before the worker enters a UI spell, as mentioned in problem (9).

Finally, in order to computationally solve our model, it is possible to further collapse a part of the reduced the state space into one single variable that summarizes the information in  $(\bar{n}, \bar{m})$ . If we take into account that a worker only accrues counts of  $\bar{n}$  whenever she is not accruing counts of  $\bar{m}$ , and vice-versa, we can define a variable  $j \in \{1, \dots, N_c\}$ , where  $N_c = \mu_t + \mu_b$ , that summarizes all possible cases of "points" accrued toward benefits.

### B.3 Partial Equilibrium

Agents are heterogeneous at each point in time in the state  $s \in S$ . The agents' distribution among the states  $s$  is described by a measure of probability  $\Phi$  defined on subsets of the state space  $S$ . Let  $(S, \mathcal{B}(S), \Phi)$  be a space of probability, where  $\mathcal{B}(S)$  is the Borel  $\sigma$ -algebra on  $S$ . For each  $\omega \subset \mathcal{B}(S)$ ,  $\Phi(\omega)$  denotes the fraction of agents who are in  $\omega$ . There is a transition function  $M(s, \omega)$  that governs the movement over the state space from time  $t$  to time  $t + 1$  and that depends on the invariant probability distribution  $\Pi(z)$  and on the decision rules obtained from the household's problem. We define such distributional shares as stationary when  $\Phi_{t+1} = \Phi_t = \Phi$ .

The definition below stands for a stationary equilibrium and we omit the arguments of the distribution for notational convenience. Furthermore, for expositional purposes, the definition

is written using the notation associated with the full state space as initially defined in the description of the model.

**Definition 1** (Stationary Recursive Partial Equilibrium). *Given a UI program  $\{\theta, z_{min}, \mu_t, \mu_b\}$ , a tax  $\tau$ , and exogenous prices  $\{r^*, w^*\}$ , a partial equilibrium for this economy is an allocation of value function  $v$ , policy functions, production plans for the firm  $\{K, N\}$ , residual expenditure  $G$ , and universal transfer  $T_u$ , such that:*

1. *Given prices  $\{r^*, w^*\}$ , the UI program, fiscal policy, and government transfer,  $v$  solves the workers' problems in (4) to (3), and  $\{c, a', n\}$  are the associated policy functions;*
2. *The individual and aggregate behaviors are consistent:*

$$K = \int_S a'(s) d\Phi(s)$$

$$C = \int_S c(s) d\Phi(s)$$

$$N = \int_S z \cdot n(s) d\Phi(s)$$

3. *The government's budget constraint is satisfied:*

$$G + T_u + \int_S b^{UI}(\tilde{\mathbf{n}}, \tilde{\mathbf{y}}, \tilde{\mathbf{m}}) d\Phi(s) = \tau \left( r^* \int_S a'_i(s) d\Phi(s) + w^* \int_S z \cdot n(s) d\Phi(s) + \int_S b^{UI}(\tilde{\mathbf{n}}, \tilde{\mathbf{y}}, \tilde{\mathbf{m}}) d\Phi(s) \right)$$

4. *Given the decision rules,  $\Phi$  satisfies:*

$$\Phi(\omega) = \int_S M(s, \omega) d\Phi, \quad \forall \omega \subset \mathcal{B}(S)$$

*where  $M : (S, \mathcal{B}(S)) \rightarrow (S, \mathcal{B}(S))$ , can be written as follows:*

$$M(s, \omega) = \begin{cases} \pi_{z,z'}, & \text{if } a'(s) \in \mathcal{A}, \tilde{\mathbf{n}}'(s) \in \mathcal{N}^t, \tilde{\mathbf{y}}'(s) \in \mathcal{Y}^t, \tilde{\mathbf{m}}'(s) \in \mathcal{M}^t \\ 0, & \text{otherwise.} \end{cases}$$

## C Robustness of the Empirical Analysis

In this section we show that the main empirical results are robust to the addition of controls, to the variation of requirements at the intensive margin, and to the use of county borders.

### C.1 Controls

If the UI requirements correlate with other policy reforms, the estimates in Table 1 would be biased, capturing the effect of not only UI requirements but also of other policies that correlate with them and are discontinuous at state borders. To ensure that this is not the case, Table 8 adds as controls the UI replacement rate, minimum wage, and welfare transfers. The main results shown in Table 1 are preserved.

Table 8: Effect of UI requirements on the labor market controlling for state policies

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	$\mathbb{I}\{\text{Unemployed}\}$	$\mathbb{I}\{\text{Unemployed}\}$	$\mathbb{I}\{\text{UnempBenefit}\}$	$\mathbb{I}\{\text{UnempBenefit}\}$	$\mathbb{I}\{\text{PartTime}\}$	$\mathbb{I}\{\text{PartTime}\}$	$\#\text{Employers}$	$\#\text{Employers}$
$\mathbb{I}\{\text{Monetary Req.}\}$	-0.0331*** (0.00522)	-0.0326*** (0.00536)	-0.0123*** (0.000305)	-0.0124*** (0.000442)	-0.0744*** (0.00198)	-0.0760*** (0.00207)	0.00803*** (0.00195)	0.00582* (0.00336)
$\mathbb{I}\{\text{Tenure Req.}\}$	-0.0223*** (0.00365)	-0.0244*** (0.00625)	0.0321*** (0.000729)	0.0322*** (0.00232)	0.0799*** (0.00230)	0.100*** (0.00966)	0.116*** (0.00333)	0.140*** (0.0125)
Replacement Rate	X	X	X	X	X	X	X	X
Minimum Wage		X		X		X		X
Welfare Transf.		X		X		X		X
$N$	101062	71853	167712	113393	92774	67006	105484	75484
$R^2$	0.047	0.045	0.013	0.014	0.087	0.090	0.048	0.050

Notes: This table shows the estimated parameters of model 1. Labor data are from the CPS and UI requirement data are hand collected from USDL reports. The sample is from 1963 to 2016, varying according to variable availability.  $\mathbb{I}\{\text{Unemployed}\}$  is a dummy taking a value of one if the worker is employed,  $\mathbb{I}\{\text{UnempBenefit}\}$  is a dummy taking a value of one if the worker received UI in the current year,  $\mathbb{I}\{\text{PartTime}\}$  is a dummy taking the value of one if the worker worked in a part-time job in the current year, and  $\#\text{Employers}$  is the number of employers the worker had in the current year. Columns 1,3,5, and 7 add to the baseline controls the average state UI replacement rate. Columns 2,4,6, and 8 add to the baseline controls the average UI replacement rate, minimum wage, and state-level welfare transfers. Standard errors are clustered at the MSA level.

### C.2 County Discontinuity and Marginal Variation in Requirements

A worker's county is available in the CPS only after 1996. But after 1996, there were no introductions of monetary requirements and only a few states introduced tenure requirements. There-

fore, we cannot identify the effect of the introduction of UI requirements on the labor market using county-level border discontinuity.

To study if our results are robust at the county-level border discontinuity, we exploit the marginal variation in the tenure and monetary requirements after 1996. Due to the smaller variation in requirements in this period, we expect standard errors to be larger. Table 9 displays the estimated effect of UI requirements using county- or MSA-level state border discontinuities. Columns 1 and 2 show that the tenure requirement has a negative effect on unemployment but there is no significant effect from the monetary requirement. Columns 4 and 5 show that the tenure requirement increases the share of part-time jobs, while the monetary requirement reduces it. Columns 7 and 8 show that the monetary requirement reduces employment transition, while the tenure requirement increases it. Therefore, the effect of UI requirements are still robust to the use of the marginal variation in requirements and county-level discontinuity.

Table 9: Effect of UI requirements on the labor market using county and MSA discontinuities

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	$\mathbb{I}\{Unemployed\}$	$\mathbb{I}\{Unemployed\}$	$\mathbb{I}\{UnempBenefit\}$	$\mathbb{I}\{UnempBenefit\}$	$\mathbb{I}\{PartTime\}$	$\mathbb{I}\{PartTime\}$	#Employers	#Employers
$\log(MonetaryReq.)$	0.00395 (0.719)	-0.00306 (0.650)	0.000729*** (0.009)	-0.00119 (0.685)	-0.0323* (0.058)	0.0116 (0.233)	-0.0292** (0.012)	-0.0424*** (0.005)
$\log(TenureReq.)$	-0.00618 (0.509)	-0.00814*** (0.000)	0.0000949 (0.659)	0.0101*** (0.000)	0.0263* (0.062)	0.0233*** (0.000)	0.00697 (0.562)	0.0402*** (0.000)
Region	County	MSA	County	MSA	County	MSA	County	MSA
$N$	108310	77624	193712	129986	124584	71042	111422	80389
$R^2$	0.048	0.044	0.004	0.013	0.073	0.090	0.038	0.040

Notes: This table shows the estimated parameters of model 1. Columns 1, 3, 5, and 7 compare counties that share borders, while the other columns compare the two sides of an MSA. Labor data are from the CPS and UI requirement data are hand collected from USDL reports. The sample is from 1996 to 2016, varying according to variable availability.  $\mathbb{I}\{Unemployed\}$  is a dummy taking the value of one if the worker is unemployed,  $\mathbb{I}\{UnempBenefit\}$  is a dummy taking the value of one if the worker received UI the current year,  $\mathbb{I}\{PartTime\}$  is a dummy taking the value of one if the worker worked at a part-time job in the current year, and #Employers is the number of employers the worker had in the current year. Standard errors are clustered at the MSA level for columns 2, 4, 6, and 8, and at the county level for the other columns.

## D Robustness of the Model

### D.1 Change in Employment Probabilities - Partial Equilibrium

In this robustness exercise we show the change in key model statistics when conducting a 10 percent reduction and increase in the parameters of the probability of a job offer and the probability of losing a job,  $p_e$  and  $p_u$ , respectively. In Table 10 we conduct these changes in our benchmark economy in partial equilibrium to measure the movement in the aggregates relative to the ones of the calibrated benchmark. We can observe that some of our calibration targets as well as the share of unemployed workers are more sensitive to  $p_e$  than to  $p_u$ . This result is not

surprising since most of the different possible statuses of the worker shown in the value functions are affected by exiting unemployment, hence directly by  $p_e$ . This highlights the key role of the unemployment friction, especially when moving out of the unemployed state, created by our augmented productivity process that includes the state in which  $z = 0$ .

Table 10: Comparison of model statistics for different employment probabilities.

Variable	Benchmark	$0.9 * p_e$	$1.1 * p_e$	$0.9 * p_u$	$1.1 * p_u$
Unemployment	100	135.1	85.0	99.2	94.1
Duration Unemp.	100	94.5	101.7	100.0	99.6
Share Exhausting UI	100	88.8	116.8	99.3	99.8
Job Destruction	100	156.9	59.6	99.2	99.9

*Notes:* The table shows model-generated statistics. The column “Benchmark” shows the results of the benchmark model; the column “ $0.9 * p_e$ ” shows the results for the model with 90 percent of the calibrated value for the probability  $p_e$ . All other columns are analogous.

## D.2 Change in Employment Probabilities - Optimal Requirements

In the next robustness check for the model, we repeat the 10 percent changes in  $p_e$  and  $p_u$ , exactly as done in the previous exercise but for the calculation of the optimal unemployment insurance requirements with simultaneous choice of both the tenure and the monetary requirement as shown in the last column of Table 6. As can be seen in Table 11 below, the variation in the unemployment and employment probabilities does not affect the optimal choice of requirements as they remain at their original level with the benchmark calibration, with  $z_{min} = 23\%$  and  $\mu_t = 12$ .

Table 11: Comparison of optimal requirements for different employment probabilities.

Variable	Optimal Benchmark	$0.9 * p_e$	$1.1 * p_e$	$0.9 * p_u$	$1.1 * p_u$
Monetary Requirement	23%	23%	23%	23%	23%
Tenure Requirement	12	12	12	12	12
CEV	0.99%	1.46%	0.42%	0.97%	1.01%
Expenditure/GDP	0.22%	0.26%	0.30%	0.20%	0.24%
Beneficiaries	0.27%	0.34%	0.47%	0.25%	0.30%

*Notes:* The table shows model-generated statistics. The column “Benchmark” shows the results of the benchmark model; the column “ $0.9 * p_e$ ” shows the results for the model with 90 percent of the calibrated value for the probability  $p_e$ . All other columns are analogous.

### D.3 General Equilibrium Effects

In order to understand the potential general equilibrium effects of our welfare analysis, we generalize the partial equilibrium defined in Subsection B.3 and the thought experiment in Subsection 7.1. Our generalization works as follows: (i) we keep the same calibration as in the partial equilibrium analysis shown in Tables 2 and 3; (ii) we start with the initial value of  $\tau_{UI} = 0$  as in the benchmark economy; (iii) as in Subsection 7.1,  $G$  and  $T_u$  are fixed at the benchmark level; and (iv) prices  $r$  and  $w$  vary in each counterfactual, in which we find a fixed point in the capital-labor ratio,  $K/N$ .

We then compute an equilibrium for two variations, one of an increase and another one of a decrease, of each of the UI instruments in the model. In this way, we can understand the direction of a change in welfare in general equilibrium when we vary the instruments and we can see how it compares with the optimal analysis with respect to the benchmark shown in Table 6. The results are in Table 12:

Table 12: Comparison of different UI requirements in general equilibrium

Variable	Benchmark	$\theta = 35\%$	$\theta = 55\%$	$\mu_b = 18$	$\mu_b = 30$	$z_{min} = 6\%$	$z_{min} = 15\%$	$\mu_t = 18$	$\mu_t = 30$
$w$	4.960	4.959	4.961	4.960	4.960	4.960	4.963	4.960	4.960
$\tau_{UI}$	0	-1.46%	-1.23%	-1.40%	-1.29%	-1.33%	-1.40%	-1.31%	-1.36%
CEV	0	-0.007%	0.004%	0.004%	0.012%	0%	0.125%	-0.009%	0.027%
Expenditure/GDP	0.55 %	0.32%	0.52%	0.37%	0.48%	0.43%	0.37%	0.45%	0.42%
Beneficiaries	1.1%	1.15%	1.16%	0.99%	1.27%	1.15%	0.82%	1.21%	1.10%

*Notes:* The table shows model-generated statistics. The column “Benchmark” shows the results of the benchmark model; the column “ $\theta = 35\%$ ” shows the results for the model with a replacement ratio of 35%. All other columns show analogous changes in the UI design instruments. The benefit duration and the tenure requirements are denoted in weeks. The monetary requirement is in percentage of six-week’s average earnings.

The first clear result we can observe across all changes in UI instruments is that the general equilibrium effect shown by the change in the wage rate  $w$  is of a small magnitude. The margin that changes the most is the one captured by the UI budget as shown by the changes in the tax rate  $\tau_{UI}$ . Nonetheless, similarly to our partial equilibrium analysis, the rate is negative in all of our counterfactual equilibria, reflecting the surplus of UI revenues and the need for extra insurance in the form of a payroll subsidy.

Since these characteristics were already present in our analysis with the partial equilibrium

concept, we are able to conclude that the extension to a general equilibrium setting does not bring much action at the aggregate level. Moreover, we can observe that the effect of the change in the instruments is straightforward in terms of the UI budget, as more expansionary policy options, such as a higher replacement rate  $\theta$  or a longer collection duration, induce the system to require a less negative  $\tau_{UI}$ , i.e., more financing needs. Analogously, stricter requirements induce the system to a cheaper rate or a more generous subsidy.

Finally, we can observe that the relative improvement in terms of welfare is preserved in a similar way as shown in our optimality analysis in Table 6, leaving us more reassured of the main approach we proposed. The movement toward stricter requirements shows an improvement not only in welfare but also in the highest levels attained in the exercises considered. The result that the increase in the monetary requirement has the highest gradient is preserved.