Unemployment Insurance, Wage Dispersion and the Re-entitlement Effect

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Monday 20th June, 2022

Abstract

This paper studies how finite duration Unemployment Insurance (UI) benefit payments affect wage dispersion. It also provides a quantification of the implied re-entitlement effect. In a directed on-the-job search model, benefit duration is determined by recent employment history while benefit generosity is a function of a worker's prior wage. As workers approach the expiry of their benefits, they lower their asking wages for two reasons: the impending drop in income makes them eager to get hired and, getting rehired puts them back on the path of benefit re-entitlement. Quantitative exercises evidence a strong interaction between the UI system and on-the-job search in generating wage dispersion. Loss of benefit plays a more important role than re-entitlement per se in the determination of the re-entitlement effect.

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1 Introduction

This paper has two goals. The first is to study the role of the unemployment insurance (UI) system in generating wage dispersion. The second is to quantify the re-entitlement effect – the extent to which expiry of benefits causes workers to lower their application wages.

Hornstein et al. (2011) (henceforth HKV) argued that models that rely on search frictions alone cannot generate the level of wage dispersion observed among homogeneous workers. Since then, a number of papers have attempted to address this shortcoming. Typically, those papers, described in more detail in Section 2, have relied on mechanisms that have made reemployment more desirable than is reflected in the wage alone. Here we explore the extent to which the UI system can act as one such mechanism. Meanwhile, among economists with an interest in UI, there is also a literature on the re-entitlement effect. Despite the clear connection to wage dispersion, the two literatures have remained largely separate. The distinction that we propose is that wage dispersion is a general equilibrium phenomenon while the re-entitlement effect pertains to an individual's search behavior.

While our quantitative focus will be on UI policy in the United States, the salient features for our theoretical analysis are common throughout the OECD (see https://www.oecd.org/social/benefits-and-wages/). Those are that benefits are paid over a finite horizon and that employment (gradually) restores entitlement to future benefits.[1] These features cause workers with longer unemployment durations to lower their wage expectations through two distinct channels. First, the reduction in income (or simply anticipation of the impending reduction in income) sharpens a worker's desire to find a job. Second, that re-employment sets the worker on the path to restore future benefits, makes employment more attractive than is simply reflected in the wage offer. The immediate impact of

[1] For example, in 2022 the New York State UI system benefits use a replacement ratio (50%) up to a maximum payment of around \$500 per week. An unemployed person who is fully entitled to benefits receives them for 26 weeks (6 months). For workers whose benefits have expired, becoming fully re-entitled takes 12 months of continuous employment.

lower wage expectations is to increase both wage dispersion and the re-entitlement effect. The overall impact depends on how the policy change affects job creation which in turn depends on the specific counterfactual being considered. The goal here is to provide an environment which can simultaneously assess the contribution of existing UI policy to wage dispersion and quantify the re-entitlement effect.

We present an otherwise standard Diamond-Mortensen-Pissarides (DMP) model of directed on-the-job search. Jobs are ex ante identical as are workers. Following the typical structure of UI systems across the US, generosity of benefits is determined by the worker's prior wage while the duration of entitlement is determined by the length of their prior employment spell. Consequently, markets are indexed by the workers' employment status, their remaining duration of UI entitlement, and the wage payable to the worker. The equilibrium is block recursive as highlighted by Menzio and Shi (2011). We calibrate the model using simulated method of moments to Survey of Income and Program Participation (SIPP) data from 1996 to 2017.

While we use various measures of wage dispersion, our main focus is on the mean to minimum ratio (MMR) as introduced by HKV. The baseline calibration generates an MMR of 1.117. This is well short of the 1.8 identified by HKV as representative of observed values for homogeneous workers. Indeed, our figure falls short of the 1.16 to 1.27 range that they obtain for a calibrated version of the one-sided on-the-job search model even though we have both on-the-job search and finite duration UI benefits. It is important to recognize, though, that the exercise in HKV is to identify the maximal wage dispersion attributable to search frictions. Our objective is to predict the actual degree of wage dispersion among homogeneous workers and ascertain the extent to which it emerges as a consequence of UI policy implementation. In any case, our figure of 1.117 is significantly larger than 1.04 that HKV argue is the maximum value consistent with sequential search. Meanwhile, we introduce a new metric of the re-entitlement effect – the average percentage drop in the application wage for each month of reduced UI entitlement. We call this the

Wage-Duration Index (WDI) which is 1.44% in the baseline calibration.

Much of the subsequent focus of the paper is on the extent to which the measured MMR and WDI are attributable to the UI system. Shutting down re-entitlement by making benefits indefinite, drops the MMR to 1.043 implying an important role for the UI system.[2] Alternatively shutting down on-the-job search while retaining the 6 month maximum entitlement, however, generates an MMR of 1.010 (and a WDI of 0.32%). These seemingly contradictory results point to a strong interaction between on-the-job search and the UI system. Being able to simultaneously work and look for a better paid job enables unemployed workers with little or no remaining entitlement to lower their immediate wage expectations. They do so because they expect future wage increases and because they resume accrual of UI entitlement. By conducting the same experiments on a small (measure zero) subset of workers, we are also able obtain the partial equilibrium impact of these changes.

The remainder of the paper is organized as follows. Section 2 reviews the related literature. Section 3 provides a summary of the relevant data along with a reduced form analysis of the re-entitlement effect. Section 4 lays out the theoretical model. Section 5 describes our calibration and model estimation strategy. The outcomes from the baseline model calibration are summarized in Section 6. The set of experiments used to quantify the impact of the UI system on wage dispersion and the re-entitlement effect are in Section 7. We explore the impact of various alternative policy arrangements in Section 8. Section 9 considers two possible extensions to the model: incorporating two separation rates and risk-averse workers. Section 10 concludes.

[2]The WDI cannot be measured with indefinite benefits.

2 Literature

As mentioned above, HKV asserts that models incorporating search frictions alone cannot explain the degree of observed wage dispersion among ex ante homogeneous workers. The central intuition for their result is that a worker would not take a low wage when a much higher offer is likely to be received in the near future. Papers motivated to address this shortcoming have typically argued that either unemployment is in fact more pernicious or employment more beneficial than in the standard models. On that basis, workers are more strongly incentivized to accept low offers even when high ones are likely. Of course, Burdett and Mortensen (1998), which predates HKV, falls into the second group of models. There, workers continue to receive job offers after getting hired, so accepting a low wage offer while unemployed does not carry the same opportunity cost. HKV, however, maintains that an accurate calibration of the Burdett and Mortensen (1998) model still generates insufficient wage dispersion.[3] Burdett et al. (2011) and Ortego-Marti (2016) enhance the baseline on-the-job search model to increase equilibrium wage dispersion. The former makes employment per se more beneficial by incorporating learning-by-doing, the latter makes unemployment more pernicious due to concomitant skill decay. By comparison (relative to a system paying benefits indefinitely), the UI system, as modelled in the current paper, lowers reservation wages through both channels. First, the impending termination of benefits reduces the present value of unemployment. Second, workers anticipate that their reemployment will (gradually) restore their entitlement to future benefits.

Coles and Masters (2007) identified the role of finite duration benefit payments in helping stabilize labor demand over the business cycle. Essentially, by lowering hiring wages more in recessions than in booms, the re-entitlement effect induces inter-temporal transfers from firms that hire in future booms to firms that hire in current recessions. On

[3] Indeed, in our own calibration when wage dispersion relies on on-the-job search alone, the MMR is only 1.043

that basis, it is important to quantify the re-entitlement effect. However, in Coles and Masters (2007) workers become fully re-entitled to benefits as soon as they get hired. In fact, re-entitlement typically takes a year or more which should reduce the strength of the effect. Our quantification is carried out for a UI system that, while still stylized, is much closer to observed policy implementations.[4]

Ortega and Rioux (2010) recognizes that benefits take time to accrue and provides a simple model in which workers can either be receiving UI, which is subject to termination, or a less generous unemployment assistance that can be received indefinitely. The termination of UI benefits for the unemployed and re-entitlement to UI for the employed are assumed to follow Poison processes. Andersen et al. (2018) extends Ortega and Rioux (2010) to incorporate endogenous search intensity. As such it exhibits both sources of moral hazard associated with the UI system: the policy maker is unable to make benefit payments contingent on either the worker's search effort or his propensity to reject job offers. In both papers, the simplicity of the UI system implies a 2-point equilibrium wage distribution which could be used to provide a simple measure of the re-entitlement effect. By comparison, our model provides for a much richer set of labor market histories from which to impute the effect.

Andersen and Ellermann-Aarslev (2020) considers how the rules governing re-entitlement to UI shape the distribution of employment durations. They provide a random search model in which all jobs offer the same wage but differ according to their expected duration. It is shown that when re-entitlement to UI depends on prior employment history, the labor market endogenously moves towards a "dual-market" (see e.g. Dickens and Lang (1985)) in which those with a weak employment history take short duration jobs and those with strong histories take longer duration jobs. A re-entitlement effect therefore emerges in the model along the employment duration dimension. As such we see this paper as complementary to our own.

[4]Indeed, we have consciously abstracted from certain common features of the US system such as delayed benefit collection, the implications of which are analysed in Xie (2019).

The paper perhaps closest to ours in structure, is Chaumont and Shi (2022) they provide a directed on-the-job search model of the labor market. Workers are ex ante homogeneous but can differ ex post through accumulation of wealth. UI benefits expire stochastically as in Ortega and Rioux (2010) but, as wealthier workers search for higher wages, wealth provides an additional source of wage dispersion.

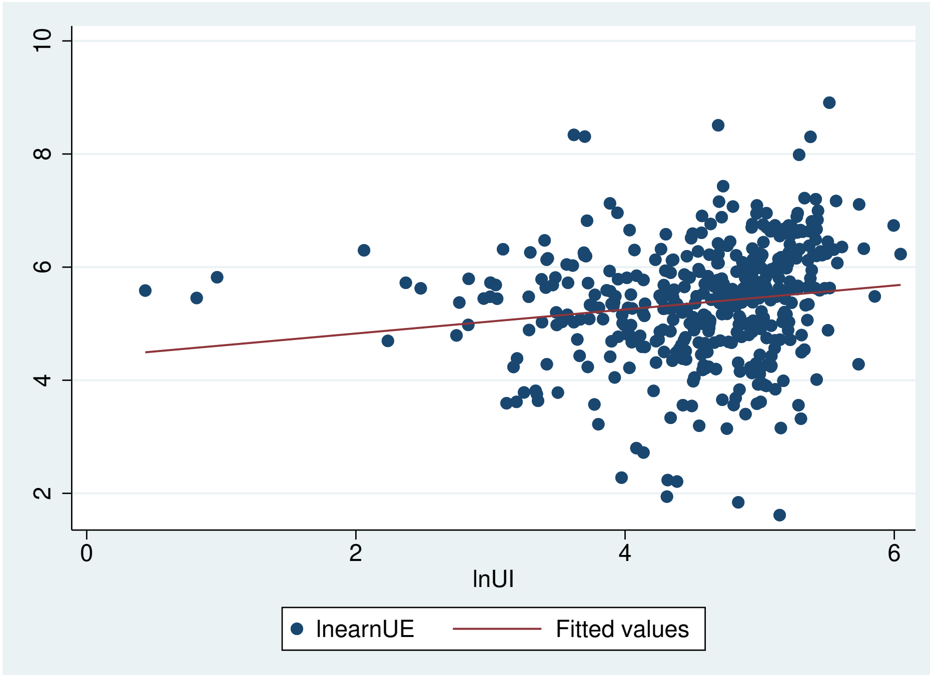
3 Data and reduced-form quantification

With reduced-form modelling we cannot provide all of the counterfactuals needed to provide a comprehensive perspective on the re-entitlement effect. Still it is helpful to identify the extent to which the effect is apparent in the data. These results will then be used to discipline the theory.

We use the Survey of Income and Program Participation (SIPP) as the main data source. In the SIPP each respondent is surveyed for up to 48 consecutive months. This longitudinal feature enables us to track labor force activities at the individual level. As our structural model will not include savings, to identify the relevant effects from the data we will need to control for wealth. Fortunately, the SIPP also includes information on on respondents' asset holdings.

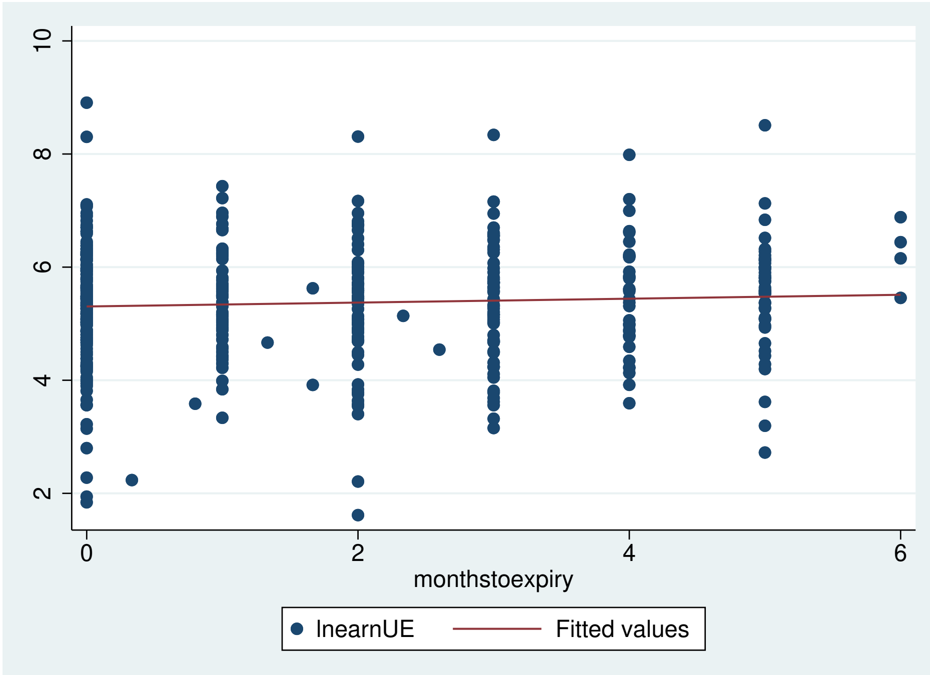
In the US the UI system is administered through the states and each state has its own eligibility rules. However, they generally have a similar structure in which the magnitude of the payments is a function of the recipient's last wage and the duration is a function of the the recipient's recent employment history. To capture any impact of re-entitlement, then, we need both the worker's last wage and duration of entitlement when laid-off. Data on wages is readily available in the SIPP but UI entitlement is not. We recover this value by using UI policy rules across states and time. We use this proxy as the key independent variable and control for benefit amounts, states, time, wealth and other demographic variables.

Figure 1: Earnings of re-employed workers and UI amounts



First we perform bi-variate analyses to explore correlations between monthly earnings of re-employed workers and UI benefit variables using the SIPP data. Figure 1 plots a positive correlation between unemployment-to-employment (UE) wages for re-employed workers and the weekly benefit payments received during their last unemployment spell. Figure 2 shows a slightly positive relationship between the UE earnings and the number of months of UI remaining. As benefits approach expiry, unemployed workers tend to search for jobs with lower wages.

Figure 2: Earnings of re-employed workers and UI months remaining



$$
\begin{aligned}
\log UEwage = & \beta_1 * (1_{\text{1st quartile of benefit}} * 1_{\text{networth}<0} * \log UIbenefit) \\
& + \beta_2 * (1_{\text{higher quartile of benefit}} * 1_{\text{networth}<0} * \log UIbenefit) \\
& + \beta_3 * (1_{\text{1st quartile of benefit}} * 1_{\text{networth}>0} * \log UIbenefit) \\
& + \beta_4 * (1_{\text{higher quartile of benefit}} * 1_{\text{networth}>0} * \log UIbenefit) \\
& + \gamma_1 * (1_{\text{1st quartile of benefit}} * 1_{\text{networth}<0} * MonthstoExpiry) \\
& + \gamma_2 * (1_{\text{higher quartile of benefit}} * 1_{\text{networth}<0} * MonthstoExpiry) \\
& + \gamma_3 * (1_{\text{1st quartile of benefit}} * 1_{\text{networth}>0} * MonthstoExpiry) \\
& + \gamma_4 * (1_{\text{higher quartile of benefit}} * 1_{\text{networth}>0} * MonthstoExpiry) \\
& + \text{controls} \qquad (1)
\end{aligned}
$$

Equation 1 regresses the logarithm of monthly earnings for those unemployed workers who find a job during the month ($\log UEwage$) on the logarithm of benefit amounts

Table 1: Estimations on Out-of-Unemployment Wages

	Coef.	Est.	Std. Dev.
$1_{\text{1st quartile of benefit}} * 1_{\text{networth}<0} * \log UIbenefit$	β_1	0.405**	0.167
$1_{\text{higher quartile of benefit}} * 1_{\text{networth}<0} * \log UIbenefit$	β_2	0.290**	0.119
$1_{\text{1st quartile of benefit}} * 1_{\text{networth}>0} * \log UIbenefit$	β_3	0.167	0.137
$1_{\text{higher quartile of benefit}} * 1_{\text{networth}>0} * \log UIbenefit$	β_4	0.250*	0.120
$1_{\text{1st quartile of benefit}} * 1_{\text{networth}<0} * MonthstoExpiry$	γ_1	0.031	0.120
$1_{\text{higher quartile of benefit}} * 1_{\text{networth}<0} * MonthstoExpiry$	γ_2	-0.040	0.089
$1_{\text{1st quartile of benefit}} * 1_{\text{networth}>0} * MonthstoExpiry$	γ_3	0.100	0.079
$1_{\text{higher quartile of benefit}} * 1_{\text{networth}>0} * MonthstoExpiry$	γ_4	0.103*	0.055
Observations	309		

Linear regression using SIPP 1996 to 2017. The sample size is small because few respondents report the amount of government UI benefits they receive.

($\log UIbenefit$), number of months before UI benefits expire ($MonthstoExpiry$), and other controls including individual age, education, occupation, state, months. We use 1996-2017 data, and reduce the sample using the similar strategy to Huggett et al. (2011) to include male, unemployed workers of prime age, receiving UI benefits and not on layoff expecting a recall. We split our sample by individuals' net worth and UI benefit in order to identify the UI entitlement impact on groups with different characteristics.

We interpret γ_1 to γ_4, the coefficients on the imputed number of moths until benefit expiry[5], as the impact of one month closer to UI benefit exhaustion on the wage unemployed workers search for. The overall effect of losing one month of benefits reduces wages the unemployed workers apply for. These estimates are not statistically significant possibly because of sample size or measurement error. However, the combined estimates of γ's is 5% (although not statistically significant) which reveals that individuals one more month closer to UI expiration are willing to take wages more than 5% lower.

The coefficient β_1 is statistically significant and is also of interest. It shows how fast the application wages rise with the magnitude of benefits. For the poorest group, those

[5] This variable is calculated as the eligible length of UI benefits minus the number of months the worker has received benefits for. The eligible UI duration is approximated by applying the UI policy to the most recent employment spell of the worker.

with lowest benefit and negative wealth, the wage elasticity with respect to benefits (β_1) is 0.4. This number will be used for calibration.

4 Model

4.1 Environment

The model is set in discrete time with an infinite horizon. There is a mass 1 of workers who are ex ante identical and live forever. There is a large mass of firms that create ex ante identical individual jobs that start out as vacancies. The number of jobs will be controlled by a free entry condition. Each period, jobs are subject to destruction with probability λ. Both workers and firms are risk-neutral and discount the future at the rate r per period. All unemployed workers receive z units of the consumption good per period from non-market activities. Vacancies cost c units of the consumption good per period to maintain.

In addition to their non-market activities, unemployed workers can be entitled to UI benefits, $b(w) = \min\{\phi w, \bar{b}\}$, per period where w is the worker's prior wage. The parameter $\phi \in [0,1]$ is referred to as the replacement rate and $\bar{b}$ is the maximum benefit. The benefit is constant throughout the worker's entitlement term. The length of the term depends on the length of the last employment spell and the amount of unused time from the previous unemployment spell.

The earlier literature (e.g., Coles and Masters (2007)) found that the non-stationary nature of the unemployed worker's search problem had important implications for the path of their reservation wage over the unemployment spell. Consequently, we do not allow the benefits to expire according to a Poisson process. Instead, we expand the state space to incorporate the exact time to benefit expiry for the unemployed and the duration of eligibility for the employed.

Thus, we let $i \in \mathcal{I} = \{0, 1, .., I\}$ represent the number of periods of a worker's UI entitlement. Then, while unemployed,

$$i_{t+1} = \begin{cases} \max\{i_t - 1, 0\} & \text{with probability } q_u \in [0,1] \\ i_t & \text{with probability } 1 - q_u \end{cases},$$

where t represents calendar time. Analogously, while employed,

$$i_{t+1} = \begin{cases} \min\{i_t + 1, I\} & \text{with probability } q_e \in [0,1] \\ i_t & \text{with probability } 1 - q_e \end{cases}.$$

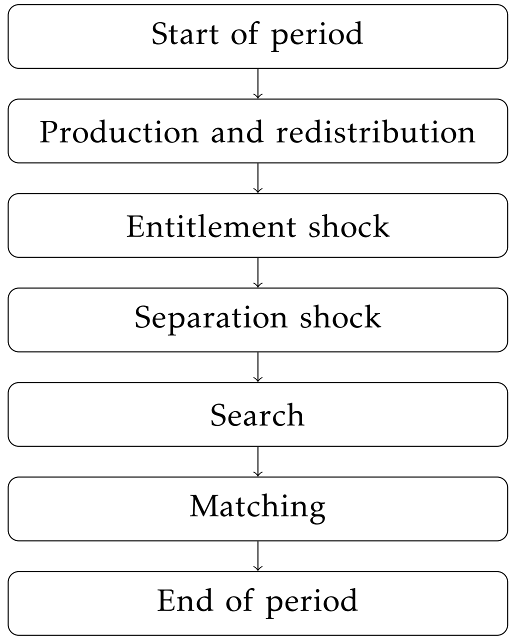
An employed worker who looses his job becomes unemployed (or, if lucky, re-employed) next period with an entitlement of $i_{t+1} = i_t$. The introduction of the probabilistic components, q_e and q_u, allows for re-entitlement to take longer than its expiry without having to further expand the state-space. In the typical UI system across the US, re-entitlement to benefits takes twice as long as expiry. Consequently, for the leading parameterization of the model, q_e is set to 0.5 while q_u is set to 1. [6] The UI system is paid for by a proportional pay-roll tax, τ, on wages that is nominally paid by the firms.

A matched pair of job and worker produces output p per period. Vacant jobs and workers meet in a large number of submarkets indexed by the wage posted by the firm, w, the level of worker entitlement, i, and the ratio, θ, of vacancies to job seekers in that submarket – the market tightness. Unemployed workers in any submarket with tightness θ contact a vacancy with probability $m(\theta)$ while employed workers in that submarket contact a vacancy with probability $\gamma m(\theta)$ where $\gamma \geq 0$.[7] The function m is twice continuously differentiable, increasing and concave with $m(0) = 0$, and $\lim_{\theta\to\infty} m(\theta) = 1$. Consequently, vacancies meet with workers in the market at the rate $m(\theta)/\theta$ which is assumed to be decreasing.

[6]The only reason q_u is included in the model specification is to provide the flexibility required for the policy experiments conducted below.

[7]Job seeking workers are heterogeneous in terms of their "wage" (current wage for employed and former wage for unemployed), their employment status, and their current entitlement period. However, all that maters to firms, given the wage being offered, is their entitlement level.

Figure 3: Timing within a period



Each period is divided into five stages: production, entitlement, separation, search and matching (see Figure 3). In the production stage, all output is produced, taxes are levied and benefit payments are made. In the entitlement stage, workers' entitlement shocks are realized. Any separations due to job destruction occur in the separation stage. In the search stage, depending on their current employment status, wage (or benefit) and benefit entitlement status, workers decide which market to enter. Unlike Menzio and Shi (2011), we do permit those laid-off this period to search. Of course, for such individuals, their search strategy will reflect the fact that they are destined to be unemployed next period if they do not get a job. In the matching stage, new matches for next period are realized. In the case of currently employed workers, matching means their existing employment relationships are dissolved.

We seek a block-recursive directed search equilibrium. Firms enter markets in such numbers as to ensure that no vacancy makes positive profits ex ante. The focus throughout is on steady-state.

4.2 Value functions

4.2.1 Workers

Workers take the wages and associated levels of market tightness as given and enter the market that is optimal for them based on their current state, (y, i, w) where $y \in \{e, u\}$ is employment status, $i \in \mathcal{I}$ is UI benefits entitlement status and $w \in [0, p]$ is their current wage if employed or their former wage if unemployed. Let $V_y^i(w)$ represent the value to being a worker of type (y, i, w). Then, for the unemployed workers with some remaining entitlement, $i > 0$,

$$V_u^i(w) = \frac{1}{1+r}\Big\{b(w) + z + q_u \max_{\tilde{w},\tilde{\theta}}\Big\{m(\tilde{\theta})V_e^{i-1}(\tilde{w}) + (1 - m(\tilde{\theta}))V_u^{i-1}(w)\Big\} + (1 - q_u)\max_{\tilde{w},\tilde{\theta}}\Big\{m(\tilde{\theta})V_e^{i}(\tilde{w}) + (1 - m(\tilde{\theta}))V_u^{i}(w)\Big\} \quad (2)$$

For unemployed workers with expired benefits, $i = 0$, any dependence on their old wage is lost. So that

$$V_u^0 = \max_{\tilde{w},\tilde{\theta}} \frac{1}{1+r}\Big\{z + m(\tilde{\theta})V_e^0(\tilde{w}) + (1 - m(\tilde{\theta}))V_u^0\Big\}. \quad (3)$$

For employed workers with less than full entitlement, $i = 0, \ldots, I - 1$

$$\begin{aligned} V_e^i(w) = \frac{1}{1+r}\Bigg\{w + q_e\Bigg[&\lambda \max_{\tilde{w},\tilde{\theta}}\Big\{m(\tilde{\theta})V_e^{i+1}(\tilde{w}) + (1 - m(\tilde{\theta}))V_u^{i+1}(w)\Big\} \\ &+(1-\lambda)\max_{\tilde{w},\tilde{\theta}}\Big\{\gamma m(\tilde{\theta})V_e^{i+1}(\tilde{w}) + (1 - \gamma m(\tilde{\theta}))V_e^{i+1}(w)\Big\}\Bigg] \\ &+ (1 - q_e)\Bigg[\lambda \max_{\tilde{w},\tilde{\theta}}\Big\{m(\tilde{\theta})V_e^{i}(\tilde{w}) + (1 - m(\tilde{\theta}))V_u^{i}(w)\Big\} \\ &+(1-\lambda)\max_{\tilde{w},\tilde{\theta}}\Big\{\gamma m(\tilde{\theta})V_e^{i}(\tilde{w}) + (1 - \gamma m(\tilde{\theta}))V_e^{i}(w)\Big\}\Bigg]\Bigg\} \quad (4) \end{aligned}$$

For employed workers with full entitlement, $i = I$,

$$V_e^I(w) = \frac{1}{1+r}\left\{w + \lambda \max_{\tilde{w},\tilde{\theta}}\left\{m(\tilde{\theta})V_e^I(\tilde{w}) + (1-m(\tilde{\theta}))V_u^I(w)\right\}\right.$$
$$\left. + (1-\lambda)\max_{\tilde{w},\tilde{\theta}}\left\{\gamma m(\tilde{\theta})V_e^I(\tilde{w}) + (1-\gamma m(\tilde{\theta}))V_e^I(w)\right\}\right\} \quad (5)$$

It will be convenient to use $(\tilde{\theta}_e^i(w), \tilde{w}_e^i(w))$ as the market tightness and wage that solves the preceding problem for the employed worker with current wage w. Similarly, we will use $(\tilde{\theta}_u^i(w), \tilde{w}_u^i(w))$ as the market tightness and wage that solves the preceding problem for the unemployed worker with former wage w.

That the unemployed search more effectively raises the possibility that workers might want to quit a low wage job once their entitlement for benefits is fully restored. These equations do not allow for that possibility because, consistent with all the UI systems we explored, people who quit are ineligible for benefits. Once they quit they face the same problem as any one who has zero entitlement to benefits. Those workers always choose the lowest wage that has positive density – quitting cannot make them better off.

4.2.2 Firms

Firms take the search strategies of the workers as given and create vacancies to target those workers. Because firms do not care about their current worker's former employment status, filled jobs are characterized by the pair (i, w), where i is the UI entitlement status of the worker and w is the wage paid to that worker. Let $V_f^i(w)$ represent the present expected discounted profits accruing from such a filled job. As free-entry drives the value to holding a vacancy in every active market to zero, for the job occupied by a worker with less than full entitlement, $i = 0..I-1$,

$$V_f^i(w) = \frac{1}{1+r}\Big\{p - w(1+\tau) + (1-q_e)(1-\lambda)(1-\gamma m(\tilde{\theta}_e^i(w)))V_f^i(w) + q_e(1-\lambda)(1-\gamma m(\tilde{\theta}_e^{i+1}(w)))V_f^{i+1}(w)\Big\}. \quad (6)$$

For a job occupied by a worker with full entitlement, $i = I$,

$$V_f^I(w) = \frac{1}{1+r}\Big\{p - w(1+\tau) + (1-\lambda)(1-\gamma m(\tilde{\theta}_e^I(w)))V_f^I(w)\Big\}. \quad (7)$$

Free-entry of vacancies determines the tightness in each submarket so that

$$\frac{m(\theta)}{\theta}V_f^i(w) \leq c \text{ and } \theta \geq 0 \quad (8)$$

with complementary slackness. We will focus on equilibria in which there is a unique value of the market tightness, $\theta(i,w)$ that solves equation (8) for each entitlement and wage level.

Notice that while employment status, $y \in \{e,u\}$, does matter for which market the worker enters, the market tightness function, $\theta(i,w)$, is not indexed by y. This is because the the firms doing the hiring do not care about current employment status. They only care about UI entitlement and the wage they will pay. In general, for a given level of worker entitlement, i, firms offering higher wages will attract employed workers while those offering low wages attract unemployed workers. That latter set of markets will have commensurately higher market tightnesses.

4.3 Steady State

Worker optimal search policies, $(\tilde{\theta}_e^i(w), \tilde{w}_e^i(w))$ and $(\tilde{\theta}_u^i(w), \tilde{w}_u^i(w))$, imply Markovian transition dynamics which further imply an ergodic distribution of workers across states. We denote by $e^i(w)$ the steady state measures of employed workers whose current eligibility status is i and whose current wage is w. We similarly denote by $u^i(w)$ the steady state measures of unemployed workers whose current eligibility status is i and whose previous wage was w. So that

$$e = \sum_{i \in \mathcal{I}} \int_0^p e^i(w)dw \quad \text{and} \quad u = \sum_{i \in \mathcal{I}} \int_0^p u^i(w)dw \tag{9}$$

are the aggregate steady state measures of employed and unemployed workers respectively. As the total population is normalized to 1, they also represent the employment and unemployment rates.

4.4 Government Budget constraint

Because we focus on steady states, the government budget constraint is always balanced,

$$\sum_{i \in \mathcal{I}} \int_0^p \tau w e^i(w)dw = \sum_{i \in \mathcal{I} \setminus \{0\}} \int_0^p b(w)u^i(w)dw. \tag{10}$$

4.5 Equilibrium

Definition 1 *A steady state, free-entry, directed search equilibrium consists of a pair of worker policy functions, $\tilde{w}_y^i : \mathcal{I} \times \{e, u\} \times [0, p] \rightarrow [0, p]$ and $\tilde{\theta}_y^i : \mathcal{I} \times \{e, u\} \times [0, p] \rightarrow \mathbb{R}_+$, a set of active submarkets, $\mathcal{A} \subset \mathcal{I} \times [0, p]$, a market tightness function, $\theta : \mathcal{A} \rightarrow \mathbb{R}_+$, the steady state population measures, $e^i(w)$ and $u^i(w)$, and a pay-roll tax rate, τ such that:*

1. *Given the set of active markets, the market tightness function and pay-roll tax rate, the worker policy functions emerge from optimal search and matching; equations (2), (3), (4) and (5).*
2. *The set of active markets, $\mathcal{A}$, is determined where $\frac{m(\theta)}{\theta} V_f^i(w) = c$ and $\theta > 0$*
3. *The tightness function determines $\theta(i, w)$ from (8) for all $(i, w) \in \mathcal{A}$.*

4. *The steady state population measures, $e^i(w)$ and $u^i(w)$ represent the ergodic distribution that emerges from the worker policy functions.*

5. *The balanced budget condition, (10), holds.*

This type of block-recursive equilibrium (see Menzio and Shi (2011)) builds on two key modeling choices. The first is the use of directed search instead of random search. In a directed search setup, firms and workers do not need to forecast wages because wages are choice variables, which do not depend on who they meet. However, in such an environment, workers and firms still need to forecast the market tightness in each market. The second modelling choice is free-entry of vacancies into any submarket. It implies that each submarket is self-contained. Since the cost of opening a vacancy is constant, the free-entry condition pins down the value of the market tightness as a function of the value of a new job independently from the distribution of firms. Therefore it is possible to construct a block-recursive equilibrium in which neither the value functions nor the market tightness depend on the distribution of firms or workers across wage levels.

5 Calibration

The list of parameters and their preferred values is provided in Table 2.

5.1 External parameters and functional forms

The time period is set to one month. Our only externally obtained structural model parameter is the discount rate which is based on an annual risk-free interest rate of 5% and implies $r = 0.004$. The matching function is chosen to be Cobb-Douglas, $m(\theta) = \min\{m\theta^{\eta}, 1\}$. Because the parameter m moves one-to-one with the cost of holding a vacancy, c, it can be chosen to avoid the matching rate hitting it's upper value of 1 without otherwise impacting the results. We use $m = 0.1$. The match productivity, p, is normalized to 1.

Table 2: Parameters

	Symbol	Values
Number of months for eligibility	I	6
Monthly discount factor	$1/(1+r)$	0.996
Value of leisure	z	0.494
Matching function TFP	m	0.1
Tightness elasticity	η	0.653
Vacancy cost	c	0.121
Replacement ratio	ϕ	50%
On-the-job search efficiency	γ	0.834
Separation rate	λ	1.5%

5.2 Policy parameters

While the specific details of UI policy vary across states, some features as reported by the US Department of Labor (DoL) are essentially uniform across the country. Standard UI eligibility extends to 26 weeks which implies $I = 6$. However, it takes a full year of working to restore full eligibility for a worker who had exhausted benefits prior to getting hired. On that basis we set $q_u = 1$ and $q_e = 0.5$. Our replacement ratio, $\phi = 0.5$, reflects a consensus across state rules and is common in the literature.

The benefit cap, $\bar{b}$, varies more widely across states but here will be moot. With ex ante homogeneous workers, the wage dispersion that emerges in the model is insufficient to warrant its use. Depending on the group we are trying to capture, the cap would typically either bind on all of them or none of them. Because our focus is on lower income workers we assume $\bar{b} > p$ so that it does not bind on anyone.

5.3 Calibrated parameters

The remaining targeted moments were obtained from the SIPP sample constructed in Section 3. The separation rate, $\lambda = 1.5\%$, comes directly from the data. The remaining parameters are: the elasticity of the matching function, η, the on-the-job search efficiency

Table 3: Moments Calibration results

	Model	Data
Unemployment rate	6.37%	6.5%
$\varepsilon_{w,b}$ for low benefit recipients	0.365	0.405
On-the-job transition rate (all)	1.72%	1.6%
On-the-job transition rate ratio (upper half vs lower half)	4.09%	2.72%

parameter, γ, the value of leisure, z, and the vacancy holding cost, c. These were all obtained simultaneously using simulated method of moments (SMM). The target moments are reported in Table 3.

Clearly, γ, is readily identified from the overall employment-to-employment movement rate. Then, η is identified from differential matching rates between workers searching for higher and lower wages. In all active submarkets, firms have to expect the same return from creating vacancies. Because they will earn lower expected profits in high wage submarkets, they have to be compensated by higher matching rates.[8] Consequently, workers will have lower matching rates in those markets and that is something we can observe. As higher values of η generate higher differential matching rates between workers searching for high and low wages, identification comes from the relative matching rates across submarkets.

Identification of z comes from the impact it has on the elasticity of the wages unemployed workers apply for with respect to their current benefit receipt, $\varepsilon_{w,b}$. To a worker in the model, the value of leisure and UI benefits are interchangeable. Because p represents an upper bound on wages, the higher is z the lower is the impact of any given change in benefits on the wage that worker will apply for. This is depicted in Figure 4. Value of leisure level $z1$ (left panel) is lower than $z2$. The application wage is less responsive to changes in b when $z = z2$. Finally, as the cost of maintaining a vacancy, c, is the main variable that determines market tightness, it is pinned down by the overall unemployment

[8] See Delacroix and Shi (2006)

rate.

Figure 4: Identification of z

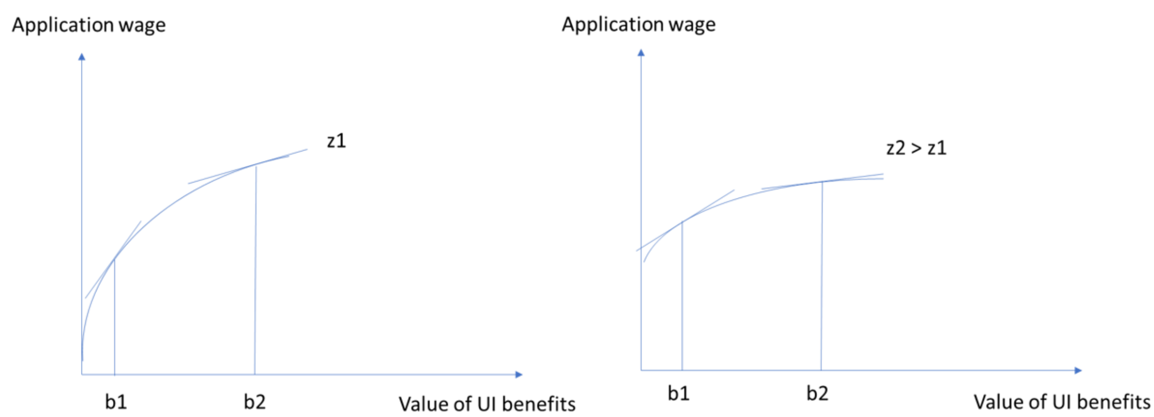
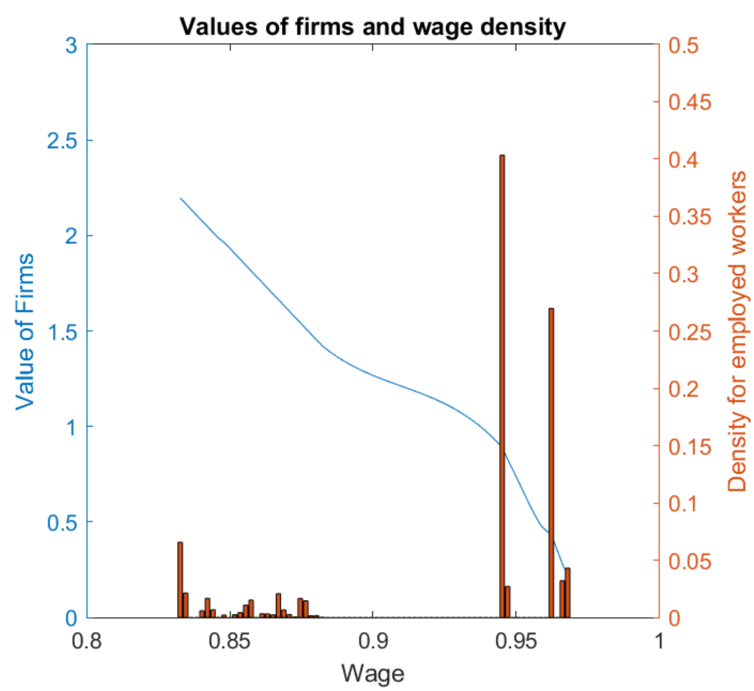


Figure 5: Matched Firm Values and the Wage Distribution



6 Baseline model outcomes

Figure 5 superimposes the match values for firms on the equilibrium wage distribution. An implication of directed search is that wages emerge in blocks. The unemployed generally apply for the jobs in the lowest wage block centered around 0.85. Its wide dispersion reflects the importance of UI entitlement to the unemployed. As will become clear below, once they get a job, duration of entitlement is not as important to them so the subsequent blocks of wages in the ladder are increasingly concentrated. While firms are indifferent across which of the the active markets to enter, their realized profits from hiring a worker decrease in the wage. This is offset for the newly created vacancies by the increased matching rates in higher wage markets.

For both employed and unemployed workers, Figure 6 plots worker values against the wage for each level of entitlement. The match values of employed workers increase noticeably with the wage but cluster close together with respect to UI entitlement. This is because the chance of being made unemployed is relatively low and what matters to them most is their current wage and its implications for future wage increases. It is apparent from the cluster of curves near the bottom of the figure that for the unemployed, entitlement is relatively more important than their former wage. This is driven by the immediacy of the impending loss of benefits to them. As identified by Coles and Masters (2007) termination of relatively generous benefits after a fixed period of time allows for income maintenance while still incentivizing job search.

Figure 7 plots the wage search strategies for unemployed workers across entitlement levels. Again the general implication is that entitlement matters more than does former earnings.[9] Here we see, though, that this effect itself does depend on entitlement. Workers with a lot of remaining UI entitlement and whose last wage was high will apply for high wages. As UI entitlement declines, the former wage becomes less important in determining application wages. Ultimately, for workers who have exhausted their benefits, their former wage has no impact on the jobs they apply for. On average, one-month closer to UI expiration causes unemployed workers to search for wages 1.44% lower. This is our central

[9]One concern here might be that in equilibrium anyone earning the highest wage cannot be ineligible for benefits. To earn that highest wage the worker must have ascended the wage ladder which takes several months even if the worker receives an offer at every possible occasion. However, from the model we can still identify the wage such an hypothetical worker would apply for.

Figure 6: Values of workers with different entitlements versus the wage

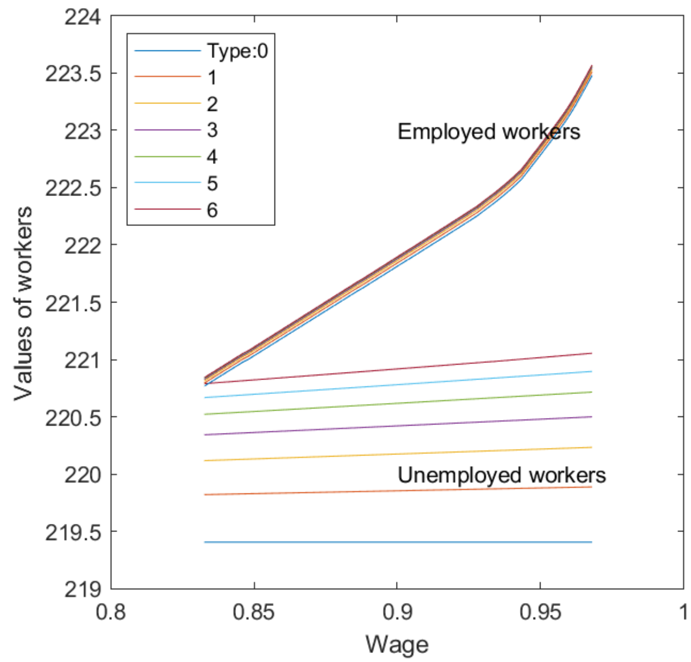


Figure 7: Application wages for unemployed workers

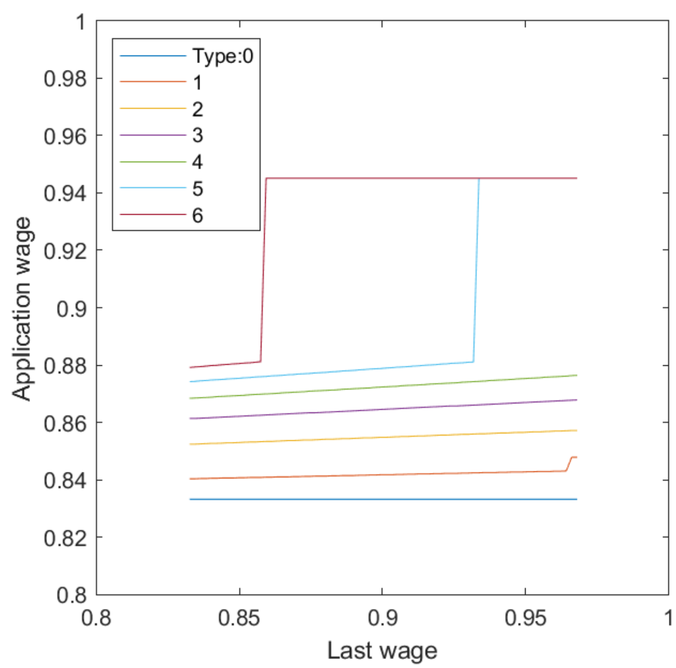
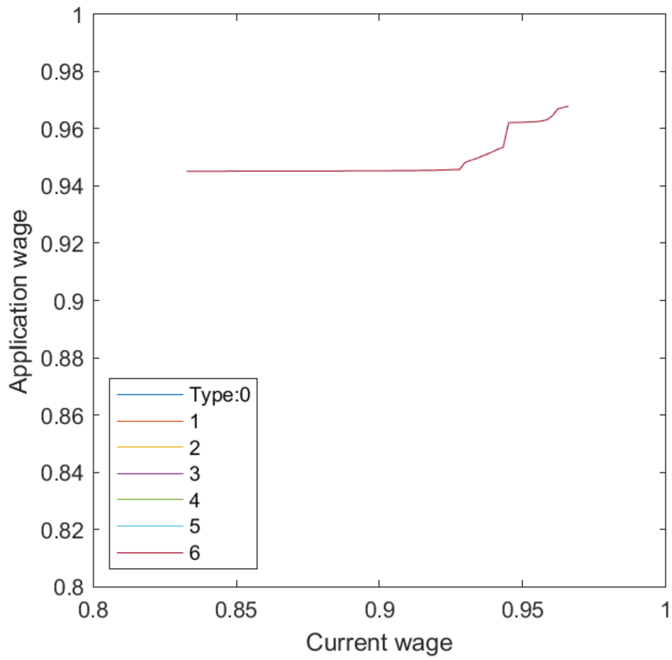


Figure 8: Application wages for employed workers



measure of the re-entitlement effect which we will call the Wage-Duration Index (WDI). This is considerably lower than the 5% reported in Section 3 which likely reflects our inability to fully control for individual characteristics in that exercise.

Figure 8 shows the wage ladder for employed workers. For example, a worker starting (regardless of UI entitlement) with a wage lower than 0.94 will search for a wage of 0.945, then 0.962, then 0.967, and finally settling in at 0.968. The 0.968 wage is the highest across all active submarkets.[10] Meanwhile the ladders for each entitlement level lie on top of each other because there is no impact of UI entitlement on the employed workers' search strategy. It could matter, but it does not due to the relatively low probability of losing a job in any given month.

[10]Regardless of their matching probability, firms will not pay more than 0.968 because above that level they cannot recover their vacancy posting costs.

7 Wage dispersion and re-entitlement effects

The baseline calibration generates an MMR of 1.1169 and a WDI of 1.44%. The objective here is to assess the contribution of the UI system to wage dispersion and to the re-entitlement effect. To do so we consider various counterfactual scenarios in both general and partial equilibrium contexts.

7.1 General equilibrium exercises

The general equilibrium exercises compare outcomes across scenarios when vacancy creation is endogenous.

7.1.1 Indefinite benefits

Here the baseline model is compared with a version in which UI eligibility never expires. Wage dispersion still arises because of on-the-job search (see Delacroix and Shi (2006)). UI can still interact with the distribution of wages because benefit payments depend on the worker's last wage. Entitlement type is moot so submarkets are indexed by wage alone. After dropping the i superscript from the previous notation, we have

$$V_u(w) = \max_{\tilde{w},\tilde{\theta}} \frac{1}{1+r}\Big\{b(w) + z + m(\tilde{\theta})V_e(\tilde{w}) + (1-m(\tilde{\theta}))V_u(w)\Big\}, \tag{11}$$

$$V_e(w) = \frac{1}{1+r}\Bigg\{w + \lambda \max_{\tilde{w},\tilde{\theta}}\Big\{m(\tilde{\theta})V_e(\tilde{w}) + (1-m(\tilde{\theta}))V_u(w)\Big\} \tag{12}$$

$$+ (1-\lambda)\max_{\tilde{w},\tilde{\theta}}\Big\{\gamma m(\tilde{\theta})V_e(\tilde{w}) + (1-\gamma m(\tilde{\theta}))V_e(w)\Big\}\Bigg\}, \text{ and} \tag{13}$$

$$V_f(w) = \frac{1}{1+r}\Big\{p - w(1+\tau) + (1-\lambda)(1-\gamma m(\tilde{\theta}_e(\tilde{w})))V_f(w)\Big\}. \tag{14}$$

And, the free-entry condition becomes,

$$\frac{m(\theta)}{\theta}V_f(w) \le c \text{ and } \theta \ge 0 \tag{15}$$

Table 4: Re-entitlement effects

	Baseline model	Indefinite benefits
Replacement ratio	50%	26.5%
Unemployment rate	6.37%	9.28%
Tax rate	2.88%	2.74%
Mean wage	0.9301	0.9382
Minimum wage	0.8327	0.8992
Wage Mean-Min ratio	1.1169	1.0434
Wage standard deviation	0.0444	0.0260
Wage Gini coefficient	0.0228	0.0146
Mean value for workers	222.4389	220.7633

with complementary slackness.

An issue with any of these policy variations is making the correct comparisons. If we simply keep the benefit payment profile, $b(w)$, unchanged and impose an indefinite payment scheme, the present value of benefits will increase and push all wages up towards p. We have therefore chosen to make the change revenue neutral by adjusting the replacement rate, ϕ, downwards. The new values are reported along with the baseline calibration results in Table 4. The remaining wage dispersion in the counter-factual model comes entirely from on-the-job search. The Wage-Duration Index is not reported here because it has no relevance when benefits are paid indefinitely.

Imposing indefinite benefit payments significantly reduces wage dispersion even though workers are free to look for jobs while employed and the benefit level still depends on the worker's last wage. Absent the impending loss of benefit payments, the unemployed look for higher wage jobs which reduces job creation and increases unemployment. Given the need to balance the UI budget, this forces government to lower the replacement rate. The resulting (balanced budget) equilibrium still exhibits higher application wages for the unemployed which drives the reduction in wage dispersion. Also, notice that under indefinite benefit payments, workers' average present value of being in the market is lower. This comes from the higher level of unemployment – there is simply not as much output to go around.

7.1.2 Fixed and indefinite benefits

Here we replace the benefit payment profile, $b(w)$, with a wage invariant and indefinite payment, $b = 0.3109$. Again, the value is chosen to maintain revenue neutrality. The results are provided in the second column in Table 5 alongside those of the baseline calibration.

Comparison of these results with those in Table 4 points to the role of wage dependent benefits in exacerbating wage dispersion. The results are very similar but, contrary to what might have been expected, the degree of wage dispersion across all measures is slightly higher when benefits are invariant to the prior wage. This comes from the impact on the lowest wage in the economy. When benefits are invariant to the prior wage, workers with exhausted benefits have a reduced incentive to hold out for a high wage.

Column 3 of Table 5 shows the outcomes for a wage invariant benefit which expires in 6 months. The experiment harkens back to the earlier literature on UI (see e.g. Coles and Masters (2007)) by incorporating immediate re-entitlement upon reemployment. The results are very close to the baseline calibration in which full re-entitlement is expected to take 12 months. This suggests that the re-entitlement effect is driven more by the expiry of current benefits than by the rapidity of re-entitlement per se.

7.1.3 Sequential search

In this model there are two basic engines of wage dispersion: the UI scheme and on-the-job search. It was shown above that shutting down benefit expiry had a significant impact. The question here is what happens when, instead, we shut down on-the-job search. To achieve that we simply set γ, the effectiveness of search while employed, to zero.

The second column in Table 6 shows that the elimination of on-the-job search almost entirely eliminates wage dispersion: the mean-min wage ratio drops to 1.01 and the wage variation is extremely small. Without the wage ladder, all unemployed workers with some

Table 5: Fixed and indefinite benefits on re-entitlement effects

	Baseline model	Fixed and indefinite benefit	Immediate re-entitlement
Benefit	50% of wage	0.3109	0.44
Unemployment rate	6.37%	7.93%	6.17%
Tax rate	2.88%	3.01%	2.65%
Mean wage	0.9301	0.9354	0.9321
Minimum wage	0.8327	0.8915	0.8342
Wage Mean-Min ratio	1.1169	1.0492	1.1173
Wage standard deviation	0.0444	0.0287	0.0438
Wage Gini coefficient	0.0228	0.0157	0.0227
Wage-Duration Index	1.44%	0%	1.48%
Mean value for workers	222.4389	221.8833	222.58

remaining UI entitlement search for the same relatively high wage. The mean wage at 0.94, however, is not much higher than in the baseline model at 0.93 but there is no wage ladder.

Recall, though, that wage dispersion was also much diminished when benefits were set to be fixed and indefinite (see Table 5). What the results point to, therefore, is an interaction between these two sources of wage dispersion – each reinforces the other. In the full model, unemployed workers with low or zero entitlement are prepared to accept low reemployment wages because being employed makes them eligible for both future pay raises and restoration of their UI entitlement. As workers move up the wage ladder, the generosity and expected duration of future benefits increase in unison.

7.2 Partial equilibrium exercises

As we alter the UI system (even under the constraint of revenue neutrality) it has feedback effects through the unemployment rate that is determined in general equilibrium. The idea here is to understand how important those feedback effects can be for the impact of UI on the wage structure. We introduce a small (measure zero) group of artificial workers into our model whose behavior does not affect the rest of the economy.

Table 6: On-the-job search on re-entitlement effects

	OTJ search(baseline)	No OTJ search
Replacement ratio	50%	53.86%
Unemployment rate	6.37%	5.67%
Tax rate	2.88%	2.71%
Mean wage	0.9301	0.9388
Minimum wage	0.8327	0.9293
Wage Mean-Min ratio	1.1169	1.0102
Wage standard deviation	0.0444	0.0074
Wage Gini coefficient	0.0228	0.0045
Wage-Duration Index	1.44%	0.32%
Mean value for workers	222.44	225.09

Mirroring the work above, our first partial equilibrium experiment is to have benefits extend indefinitely for the small group of workers and look at how it affects their wage choices. For comparability we use the benefit profile reported in Table 4 for those workers. They have the same meeting rates with vacancies but value those meetings differently to the other workers. Despite the fact that their indefinite benefits still depend on their former wages through the replacement ratio, when unemployed, they all apply for the same wage of 0.968. That is, they all hold out for the highest wage in the market and experience no wage dispersion even from on-the-job search. What happens here is that workers receive a fixed share of their prior wage as benefits. When we make those benefits indefinite, it pushes up the wages they apply for which then pushes up the the benefit payments they receive after losing their job and so on. This mechanism is present in the general equilibrium exercise but it is tempered in that case by the impact on unemployment. By making the prospect of continued unemployment less attractive, the general equilibrium effect, therefore, works against the direct effect of eliminating the termination of benefits on wage dispersion.

Our next experiment is to create a measure zero group of workers who receive fixed but indefinite benefits when unemployed. The benefit amount is set at the calibrated value

0.3109 from Table 5. This group of workers has wage mean-min ratio 1.064, and search for a lowest wage of 0.878 while unemployed. They subsequently move to 0.945, 0.9622 and finally 0.968. Consistent with the earlier comparison under general equilibrium, these workers experience higher wage dispersion than those whose benefits depend on their prior wage. Fixing the benefit level ex ante breaks the feedback loop that pushes benefits higher as wages rise which, in turn, push up wages. Instead, their application decisions simply reflect the availability of on-the-job search.

As an alternative, we also looked at a one-time indefinite extension of UI benefit for a small group of unemployed workers. Specifically, the government announces unexpectedly that these unemployed workers can receive endless benefits of the same amount as they do during the current unemployment spell, and they will not lose or gain entitlement until they find a new job. This experiment is designed to measure the short term effect of removal of the termination of benefits. Here there is some narrow dispersion in their application wages between 0.950 and 0.968. The feedback loop that pushes up wages and then pushes up benefits does not occur in this scenario either because the workers go back to their old entitlement levels on getting a job. Still, they are reluctant to take a job at low wages because they are not subject to the impending termination of their current benefits.

Another experiment is to assume that a measure zero group of workers are not able to search on the job but still face entitlement expiry. This group has wage mean-min ratio 1.0204. Unemployed workers without benefits apply for a wage of 0.8803. All other unemployed workers with unexpired UI search for wage = 0.9451 jobs. Wage dispersion among this group is therefore much lower than among the general population. Deprived of the opportunity to search on the job, these workers hold out for higher wages while unemployed. The wage dispersion among them is, however, still higher than when on-the-job search is unavailable to everyone (see Table 6). In the latter scenario, vacancy creation is higher because of the reduced possibility of losing a worker. This pushes up the lowest wage acceptable to the unemployed.

8 Alternative UI policy design

Here we consider some alternative policy arrangements. First, we look at changing the maximum number of months of benefit entitlement, I. We set $q_e = I/12$ to ensure that anyone who has expired benefits needs to work for about 12 months to recover full entitlement. The other parameters are kept unchanged. Table 7 shows what happens as the maximum entitlement increases from 4 to 7 months. All else equal, a longer, but still finite benefit period might be expected to increase wage dispersion. With a longer entitlement period, the newly unemployed are more incentivized to search for high-wage jobs with low finding probabilities. Meanwhile, a worker whose benefits have expired, recognizing the higher reward associated with the potential for re-entitlement, lowers their reservation wage. Indeed, this effect does show up in the MMR measure of wage dispersion but the effects are small. This is because as we extend the benefit period, the tax rate rises which stems vacancy creation. The ensuing higher level of unemployment tempers the optimism of the fully entitled. Of course, as we have seen above, the MMR will be lower when benefits are paid indefinitely. In that scenario, there are no workers with expired benefits and so no one will apply for very low wages.

The Wage-Duration Index peaks at 5 months of maximum entitlement. This is where the benefit expiry scheme has the strongest impact in terms of incentivizing workers to lower their wage expectations while still providing some income to the unemployed. With risk-neutral workers, however, shorter benefits always give higher levels of welfare (Total Values) to the workers because of the fiscal externality coming from the pay-roll tax.[11] We consider risk-aversion in Section 9.2

Table 8 demonstrates the impact of changing the replacement ratio between 0.43 and 0.57. A more generous replacement ratio does not alter the wage MMR but does reduce employment and consumption. As we saw above, when benefits are made proportional to

[11] When they create a vacancy, firms do not internalize the benefit to other firms of a lower expected tax rate.

Table 7: Re-entitlement effects across lengths of UI benefit in months

Maximum benefit	4	5	6	7	8
Unemployment rate	4.66%	5.51%	6.37%	7.23%	8.07%
Tax rate	1.83%	2.31%	2.88%	3.31%	3.79%
Mean wage	0.9369	0.9339	0.9301	0.9275	0.9245
Min wage	0.8398	0.8366	0.8327	0.8298	0.8285
Wage MMR	1.1156	1.1163	1.1169	1.1177	1.1159
Wage-Duration Index	1.14%	2.00%	1.44%	1.39%	1.20%
Mean value for workers	223.65	223.13	222.44	221.94	221.35

Table 8: Re-entitlement effects across replacement rate, ϕ

	$\phi = 0.43$	$\phi = 0.47$	$\phi = 0.50$	$\phi = 0.53$	$\phi = 0.57$
Unemployment rate	5.24%	5.85%	6.37%	6.54%	7.06%
Tax rate	2.05%	2.47%	2.88%	3.00%	3.35%
Mean wage	0.9363	0.9332	0.9301	0.9292	0.9250
Min wage	0.8383	0.8354	0.8327	0.8319	0.8302
Wage MMR	1.1169	1.1170	1.1169	1.1170	1.1142
Wage-Duration Index	0.78%	1.75%	1.44%	1.60%	1.55%
Mean value for workers	223.38	222.91	222.44	222.53	221.88

wages, there is a feedback effect that raises all wages thereby reducing wage dispersion. The higher is the replacement ratio, the stronger is this effect. The implied reduction in wage dispersion is, however, offset here by the increase in unemployment that makes workers with expired benefits more inclined to accept low wages. For the same reason, there is also no discernible pattern to the Wage-Duration Index across replacement ratios (above 0.47). For the lowest value of $\phi = 0.43$, the Wage-Duration Index is notably lower. This because the range of wages unemployed workers apply for is narrower so the decline in their application wages is not so responsive to the duration of UI entitlement.[12]

[12] For $\phi = 0.45$, WDI = 1.21%. For $\phi = 0.40$, WDI = 0.70%

Table 9: Parameters for the two separation rates model

	Symbol	Values
Tightness elasticity	η	0.637
Vacancy cost	c	0.309
On-the-job search efficiency	γ	0.654
Value of leisure	z	0.338
Separation rate switch rate	q_λ	0.25
High Separation rate	λ_h	10.0%
Low Separation rate	λ_l	1.0%
Combined Separation rate	λ	1.61%

9 Extensions

9.1 Two separation rates

In our baseline calibration the fraction of workers who are ineligible for UI (Type 0) is 17.6%. Meanwhile, Auray et al. (2019) find that in US data this figure is closer to 50%. To improve our model in this respect we introduce two separations rates: a high rate λ_h for all workers starting new jobs, and a low rate λ_l switching from λ_h with probability q_λ as long as workers don't change jobs. This shock on separation rates occurs at the same stage in the time period as the entitlement eligibility shock. The model is detailed in Appendix A.

To calibrate the model with two separation rates, λ_h is set to the empirical separation rate for workers in their first month of employment, λ_l is set to the empirical rate for those who work more than 12 months (stable job), and q_λ is calibrated to let the overall separation rate in the model match the data. Other parameters are obtained using the same procedure as for the baseline calibration. The parameter values are shown in Table 9.

The outcomes appear in Table 10. As shown there, the introduction of heterogeneous separation rates increases the share of UI ineligible unemployed workers from 17.6% to 35.4%. Overall wage dispersion by all measures is higher with two separation rates while the Wage-Duration Index is lower. This apparent contradiction emerges because the range of wages that the unemployed apply for is much smaller with two separation rates. Even

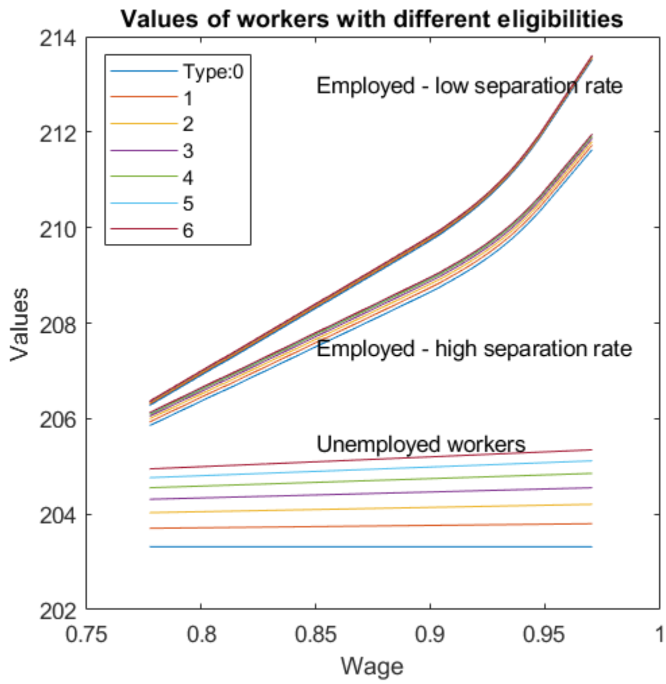
Table 10: Two separation rates

	Baseline	Two λ's
% of U pop with exhausted UI	17.6%	35.4%
Replacement ratio	50%	50%
Unemployment rate	6.37%	6.80%
Tax rate	2.88%	2.31%
Mean wage	0.9301	0.8919
Minimum wage	0.8327	0.7777
Wage Mean-Min ratio	1.1169	1.1469
Wage standard deviation	0.0444	0.0743
Wage Gini coefficient	0.0228	0.0414
Wage-Duration Index	1.44%	0.90%
Mean value for workers	222.44	209.65

those with high prior wages and full entitlement just need to find a job that they can keep for long enough to establish a stable match. This tends to both lower and compress the range of wages the unemployed apply for.

Figure 9 plots expected present values of workers for each state against the current wage (employed workers) or previous wage (unemployed workers). The flatter but more separated set of curves near the bottom of the figure represents the unemployed workers. Again, duration of remaining benefits matters relatively more to them than does their former wage. There are two other groups of curves in Figure 9. The lower and more separated of the two corresponds to the high separation rate employed workers while the other group corresponds to the low separation rate employed workers. Despite a ten fold difference in their separation rates, worker values are quite similar at low wages (i.e. close to the lowest acceptance wage of 0.7777). This comes from the well known result in search theory that at the reservation wage, workers are indifferent to the separation rate since they are equally well off in employment as unemployment. Consequently, at low wages both the high and low separation rate workers climb the wage ladder quickly. At higher wages, however, because what matters to the worker is the present value of the employment relationship, low separation workers will only apply for new jobs with considerably higher

Figure 9: Values of workers with different separation rates versus the wage



wages. The horizontal distance between the corresponding low and high separation rate curves in Figure 9 represents the amount of current income a high separation rate worker would be prepared to give up in order to become a low separation rate worker. As they give up their low separation rate status to take a new job, that distance also represents a lower bound on the wage increase sought by low separation rate workers as they search on the job.

9.2 Risk aversion

Up to this point, a maintained assumption has been worker risk-neutrality so that UI has no actual insurance role. To see how risk aversion impacts the behavior of the model we introduce CRRA utility with the coefficient of relative risk aversion set to 2. The calibration procedure is the same as above but with one exception. Here, we target the empirical wage volatility (standard deviation of the logarithm of the wage) rather than the elasticity of

Table 11: Re-entitlement effects with risk aversion and neutrality

	CRRA=2	Linear Utility(Baseline)
Unemployment rate	9.35%	6.37%
Tax rate	3.14%	2.88%
Mean wage	0.6863	0.9301
Minimum wage	0.4904	0.8327
Wage Mean-Min ratio	1.3893	1.1169
Log of Wage standard deviation	0.1945	0.0444
Wage-Duration Index	2.53%	1.44%
Wage Gini coefficient	0.1006	0.0228

application wages with respect to current benefits.[13]

Table 11 compares the results for risk averse workers with those of the baseline model. The outcomes are are qualitatively similar. Risk aversion exaggerates the degree of wage dispersion and increases the Wage-Duration index.[14] Risk averse workers are are eager to avoid the drop in consumption that occurs when benefits expire and so target low wages to improve their prospects of re-employment. By assuming risk-neutrality the foregoing analysis, therefore, underestimates the degree of wage dispersion that is attributable the UI system. Allowing workers to self-insure through saving would mitigate the impact of risk aversion somewhat and bring the economy back closer to the risk neutral version. Incorporating savings, however, goes beyond the scope of this paper and is left for future work.

10 Conclusion

This paper has provided a framework for simultaneously assessing the role of the UI structure in the determination of the wage distribution and quantifying the re-entitlement

[13]It is not feasible to match $\varepsilon_{w,b}$ as a large block of unemployed workers search for the lowest wage and $\varepsilon_{w,b} = 0$.

[14]The different calibration strategies between the risk aversion and risk neutrality models may be causing some of the increase in wage dispersion. However, various experiments with different calibration strategies and parameters values produce the similar results.

effect. Our baseline calibration of the directed on-the-job search and matching model generates an MMR of 1.117. The analysis points to a high degree of interaction between the termination of benefits and on-the-job search in the determination of wage dispersion. Shutting down each source lowers the MMR to 1.043 and 1.010 respectively. Because they recognize that moving up the wage ladder simultaneously increases the generosity and expected duration of future benefits, workers are especially eager to get back onto it.

Our metric of the re-entitlement effect is the Wage-Duration Index (WDI), the extent to which workers lower their asking wage for each month of reduced entitlement. Our main calibration yields a WDI of 1.44%. Essentially, the re-entitlement effect represents the component of wage dispersion attributable to the search behavior of the unemployed. As such the WDI generally moves in lockstep with the MMR. The one exception to that pattern occurs when the model was extended to incorporate two separation rates. New matches were assumed to separate at 10 times the rate of older ones. While overall wage dispersion increased (MMR=1.147), the re-entitlement effect fell (WDI=0.9%). What matters to the unemployed workers here, almost independently of their current UI eligibility status, is getting any job. We also saw that allowing for immediate re-entitlement, rather than the baseline policy in which full re-entitlement is expected to take a full calendar year, did not have much impact on the re-entitlement effect (WDI=1.48%). This tells us that it is the expiry of benefits rather than re-entitlement per se that is the most powerful driver of wage dispersion emerging from the UI system.

While we do briefly consider risk-aversion among workers in this model, we do not allow them to self-insure through savings. While access to savings might allow workers to smooth their consumption, the impending loss of benefits has a more powerful impact on risk-averse workers. Incorporating savings along with risk-aversion is left for future work.

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A The model for two separation rates

In this environment, the problem for unemployed workers is not affected. For employed workers with less than full entitlement, $i = 0,\dots,I-1$, and with long tenure (low separation rate), λ_l

$$
\begin{aligned}
V_{e,l}^{i}(w) = \frac{1}{1+r}\Bigg\{ w + q_e \Bigg[& \lambda_l \max_{\tilde{w},\tilde{\theta}} \Big\{ m(\tilde{\theta}) V_{e,s}^{i+1}(\tilde{w}) + (1 - m(\tilde{\theta})) V_{u}^{i+1}(w) \Big\} \\
& + (1-\lambda_l) \max_{\tilde{w},\tilde{\theta}} \Big\{ \gamma m(\tilde{\theta}) V_{e,s}^{i+1}(\tilde{w}) + (1 - \gamma m(\tilde{\theta})) V_{e,l}^{i+1}(w) \Big\} \Bigg] \\
& + (1-q_e) \Bigg[\lambda_l \max_{\tilde{w},\tilde{\theta}} \Big\{ m(\tilde{\theta}) V_{e,s}^{i}(\tilde{w}) + (1 - m(\tilde{\theta})) V_{u}^{i}(w) \Big\} \\
& + (1-\lambda_l) \max_{\tilde{w},\tilde{\theta}} \Big\{ \gamma m(\tilde{\theta}) V_{e,s}^{i}(\tilde{w}) + (1 - \gamma m(\tilde{\theta})) V_{e,l}^{i}(w) \Big\} \Bigg] \Bigg\}. \quad (16)
\end{aligned}
$$

For employed workers with less than full entitlement, $i = 0,\dots,I-1$, and with short tenure (high separation rate), λ_h, the value of being employed is

$$
\begin{aligned}
V_{e,s}^{i}(w) = (1-q_\lambda) \frac{1}{1+r}\Bigg\{ w + q_e \Bigg[& \lambda_h \max_{\tilde{w},\tilde{\theta}} \Big\{ m(\tilde{\theta}) V_{e,s}^{i+1}(\tilde{w}) + (1 - m(\tilde{\theta})) V_{u}^{i+1}(w) \Big\} \\
& + (1-\lambda_h) \max_{\tilde{w},\tilde{\theta}} \Big\{ \gamma m(\tilde{\theta}) V_{e,s}^{i+1}(\tilde{w}) + (1 - \gamma m(\tilde{\theta})) V_{e,s}^{i+1}(w) \Big\} \Bigg] \\
& + (1-q_e) \Bigg[\lambda_h \max_{\tilde{w},\tilde{\theta}} \Big\{ m(\tilde{\theta}) V_{e,s}^{i}(\tilde{w}) + (1 - m(\tilde{\theta})) V_{u}^{i}(w) \Big\} \\
& + (1-\lambda_h) \max_{\tilde{w},\tilde{\theta}} \Big\{ \gamma m(\tilde{\theta}) V_{e,s}^{i}(\tilde{w}) + (1 - \gamma m(\tilde{\theta})) V_{e,s}^{i}(w) \Big\} \Bigg] \Bigg\} + q_\lambda V_{e,l}^{i}(w). \quad (17)
\end{aligned}
$$

For employed workers with full entitlement, $i = I$, and with long tenure (low separation rate), λ_l,

$$
\begin{aligned}
V_{e,l}^{I}(w) = \frac{1}{1+r}\Bigg\{ w + & \lambda_l \max_{\tilde{w},\tilde{\theta}} \Big\{ m(\tilde{\theta}) V_{e,s}^{I}(\tilde{w}) + (1 - m(\tilde{\theta})) V_{u}^{I}(w) \Big\} \\
& + (1-\lambda_l) \max_{\tilde{w},\tilde{\theta}} \Big\{ \gamma m(\tilde{\theta}) V_{e,s}^{I}(\tilde{w}) + (1 - \gamma m(\tilde{\theta})) V_{e,l}^{I}(w) \Big\} \Bigg\}. \quad (18)
\end{aligned}
$$

For employed workers with full entitlement, $i = I$, and with short tenure (high separation rate), λ_h,

$$V_{e,s}^{I}(w) = (1-q_\lambda)\frac{1}{1+r}\left\{w + \lambda_h \max_{\tilde{w},\tilde{\theta}}\left\{m(\tilde{\theta})V_{e,s}^{I}(\tilde{w}) + (1-m(\tilde{\theta}))V_{u}^{I}(w)\right\}\right.$$
$$\left. +(1-\lambda_h)\max_{\tilde{w},\tilde{\theta}}\left\{\gamma m(\tilde{\theta})V_{e,s}^{I}(\tilde{w}) + (1-\gamma m(\tilde{\theta}))V_{e,s}^{I}(w)\right\}\right\} + q_\lambda V_{e,l}^{I}(w). \quad (19)$$

For the job occupied by a worker with less than full entitlement, $i = 0..I-1$, and long tenure (low separation rate), λ_l,

$$V_{f,l}^{i}(w) = \frac{1}{1+r}\left\{p - w(1+\tau) + (1-q_e)(1-\lambda_l)\left[(1-\gamma m(\tilde{\theta}_e^{i}(w,\theta)))V_{f,l}^{i}(w)\right]\right.$$
$$\left. +q_e(1-\lambda_l)\left[(1-\gamma m(\tilde{\theta}_e^{i+1}(w,\theta)))V_{f,l}^{i+1}(w)\right]\right\} \quad (20)$$

where $\tilde{\theta}_e^{i}(w,\theta)$ is the tightness of the market that the worker currently employed in this job will search in. For the job occupied by a worker with less than full entitlement, $i = 0..I-1$, and short tenure (high separation rate), λ_h,

$$V_{f,s}^{i}(w) = (1-q_\lambda)\frac{1}{1+r}\left\{p - w(1+\tau) + (1-q_e)(1-\lambda_h)\left[(1-\gamma m(\tilde{\theta}_e^{i}(w,\theta)))V_{f,s}^{i}(w)\right]\right.$$
$$\left. +q_e(1-\lambda_h)\left[(1-\gamma m(\tilde{\theta}_e^{i+1}(w,\theta)))V_{f,s}^{i+1}(w)\right]\right\} + q_\lambda V_{f,l}^{i}(w). \quad (21)$$

For a job occupied by a worker with full entitlement, $i = I$, and long tenure (low separation rate), λ_l,

$$V_{f,l}^{I}(w) = \frac{1}{1+r}\left\{p - w(1+\tau) + (1-\lambda_l)\left[(1-\gamma m(\tilde{\theta}_e^{I}(w,\theta)))V_{f,l}^{I}(w)\right]\right\}. \quad (22)$$

For a job occupied by a worker with full entitlement, $i = I$, and short tenure (high separation rate), λ_h,

$$V^I_{f,s}(w) = (1-q_\lambda)\frac{1}{1+r}\left\{p - w(1+\tau) + (1-\lambda_h)\Big[(1-\gamma m(\tilde{\theta}^I_e(w,\theta)))V^I_{f,s}(w)\Big]\right\} + q_\lambda V^I_{f,l}(w). \quad (23)$$

The free-entry condition is the same as before.