

# Worker Selectivity and Fiscal Externalities from Unemployment Insurance\*

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## Abstract

A robust prediction of job search models is that unemployment insurance (UI) makes workers more selective about which jobs they accept, thereby raising average accepted wages and thus generating a positive fiscal externality. We provide a sufficient-statistics formula for evaluating the size of this selectivity effect and argue theoretically that it is likely to be small. In a standard sequential search model, the effect of UI on wages is linked to its effect on the job-finding hazard; the slope of the relationship between these elasticities depends on a small number of estimable statistics, key among them observed worker flows. Plausible calibrations of the model imply that the magnitude of the wage elasticity is small relative to the job-finding elasticity. Although ignoring the wage effect of UI would over-estimate its fiscal cost and under-estimate its welfare benefit, the model-implied formula predicts the magnitude of this bias to be small.

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# 1 Introduction

A key theoretical prediction of labor market search theory (McCall (1970), Mortensen (1970)) is that, by raising unemployed workers’ reservation wages, unemployment insurance (UI) affects not only their re-employment probabilities but also their re-employment wages. The purpose of this paper is to shed light on the magnitude of the latter effect, which we term the *selectivity effect*. Such a wage-enhancing effect of UI has profound policy implications, which have long been recognized (see e.g. Marimon and Zilibotti (1999)). In particular, it adds an additional dimension to the insurance-incentives tradeoff that has guided the analysis of optimal UI. In this paper we show that labor market search theory disciplines the magnitude of the selectivity effect, and assess how much it matters quantitatively.

We show that the standard search model not only implies the *existence* of a selectivity effect, but also places quite particular restrictions on its *magnitude*, given the values of other observables. We consider a classic framework: workers sample wage offers sequentially, decide to accept or reject, and search on the job while employed. The central insight is that, in such a framework, workers face a tradeoff between the rate at which they expect to find an acceptable job and the wage that they expect to receive. Unemployment insurance alters this tradeoff by making workers more selective about the wages they accept, thereby raising the average accepted wage and lowering the job-finding probability. We confirm that intuition by deriving a simple sufficient statistics formula that links the effect of UI on average wages (henceforth the *wage elasticity*) to its effect on the job-finding probability (*job-finding elasticity*). In other words, our formula gives the *slope* of the tradeoff between the average accepted wage and the job-finding probability.

We show analytically that two channels determine the slope of this tradeoff. The first determinant is the dispersion of wage offers. If wages are very dispersed, a small increase in the worker’s reservation wage can generate a large increase in the average accepted wage without a large accompanying drop in the job-finding rate. The opposite occurs when wages are very concentrated. Our formula shows, in fact, that the slope of the wage/job-finding tradeoff is directly linked to the *mean-min ratio* of wages highlighted by Hornstein *et al.* (2011). This is important for our subsequent analytical characterization, because, as shown in Hornstein *et al.* (2011), this particular measure of wage dispersion itself admits a simple sufficient statistics formula, depending on the replacement rate of UI and easily estimable worker flows. In fact, these values put an upper bound on the model-implied mean-min ratio. In our setting this implies, all else equal, an upper bound on the wage elasticity for a given job-finding elasticity. Intuitively, workers find jobs rather quickly in the data. Disciplined by this statistic, the model implies that workers do not have much to be selective about. Hornstein *et al.* (2011) use this “unpleasant search arithmetic” to argue that frictional wage dispersion cannot be very large. We show that this logic has important implications for the effects of unemployment insurance, which, to our knowledge, have not been pointed out previously.

The second determinant of the slope of the wage/job-finding tradeoff is the efficacy of

on-the-job search. Unemployment insurance raises *initial* re-employment wages through increased worker selectivity, but its impact on the average wage is muted by the speed with which workers subsequently progress up the job ladder. If on-the-job search is fast relative to separations from unemployment - as is the case in the data - the model predicts that initial wages for workers have a rather small effect on their steady-state wage. This second channel (on-the-job search) is of crucial importance because of how it interacts with the first (wage dispersion). Our formula implies that all else equal, the wage elasticity is larger (i) the larger is wage dispersion, and (ii) the smaller is the efficacy of on-the-job search. As was shown by [Hornstein \*et al.\* \(2011\)](#), on-the-job search goes a long way in helping the model generate larger wage dispersion. Our result implies that this *does not* translate into a larger wage elasticity, precisely because faster on-the-job search also generates the second, offsetting effect. On-the-job search allows for higher wage dispersion, hence a higher effect of UI on accepted wages, but it also mutes the long-term effect of higher initial wages. On net, therefore, our formula implies that the wage elasticity cannot be too large, regardless of whether on-the-job search is fast or slow.

We next apply our result to the normative analysis of unemployment insurance. Our approach extends the canonical Baily-Chetty ([Baily \(1978\)](#), [Chetty \(2006\)](#)) formula, which expresses the welfare gain from an increase in UI in terms of two sufficient statistics: the consumption-smoothing benefit of UI and its fiscal cost. The selectivity effect of UI alters the fiscal cost relative to the conventional Baily-Chetty analysis. In the absence of a wage effect of UI, the fiscal cost of UI would be determined by the job-finding elasticity. However, when UI affects wages and is financed by proportional taxes, it also generates a positive fiscal externality through the selectivity effect. As a consequence, the fiscal cost of UI now depends on both the job-finding elasticity and the wage elasticity, but our main result shows that the latter can be expressed in terms of the former. The selectivity effect of UI, and hence its positive fiscal externality, thus shows up simply as a wedge on the job-finding elasticity; this wedge depends on a number of estimable statistics but does *not* require estimating the wage elasticity directly.

We numerically assess the importance of this wedge. In doing so, we seek to answer the following hypothetical question. Suppose that a researcher computed the fiscal cost of UI and its resulting welfare benefit by applying the Baily-Chetty formula, but mistakenly assumed that UI had no effect on wages. By how much would they overstate the fiscal cost of UI, and thereby understate its welfare benefit? For a plausible range of parameter values, we find that the wage elasticity is about 1/10 of the job-finding elasticity. As a result, ignoring the wage effect of UI would overestimate the fiscal cost of increasing UI by 3-6%, and underestimate the welfare gain from increasing UI by 1-7%. Our results suggest that the wage effect, while non-trivial under some parameter values, is of limited impact for optimal UI. Moreover, our numerical results imply that worker ability to search on the job dampens the magnitude of the wage effect, by making initial job placement less consequential for average wages.

## 1.1 Relationship to literature

The theoretical insight that UI affects not only re-employment probabilities but also re-employment outcomes has long been recognized in the labor search literature (see e.g. [Marimon and Zilibotti \(1999\)](#), [Acemoglu and Shimer \(1999, 2000\)](#), [Lagos \(2006\)](#)). This is a natural implication of the rudimentary sequential search model ([McCall \(1970\)](#), [Mortensen \(1970\)](#)) and environments building on it, since unemployed workers have a tradeoff between the average wage they accept and their job-finding rate. The challenge, which we take up in this paper, is to put quantitative discipline on the magnitude of this channel. The insight we uncover is that the rudimentary search model in fact puts quite a tight restriction on the wage elasticity given the magnitude of job-finding elasticity. To put it differently, our result implies that the standard search model cannot be consistent with arbitrary combinations of the two elasticities.

Our result establishes a clear connection between the fiscal externality from UI and the characterization of frictional wage dispersion in [Hornstein \*et al.\* \(2011\)](#): a connection that, to our knowledge, is new to the literature. [Hornstein \*et al.\* \(2011\)](#) showed that the mean-min ratio of wages admits a sufficient-statistics characterization in the standard sequential search model; moreover, this characterization implies that the model-implied mean-min ratio cannot be too large, given plausible values for observed worker flows. Our result uncovers a direct role for the mean-min ratio in disciplining the slope of the wage/job-finding tradeoff, which pins down the wage elasticity for any given job-finding elasticity. If wages are not very dispersed, then workers do not have much to be selective about; as a consequence, little can be gained by making workers more selective. Thus, the same “unpleasant search arithmetic” that led [Hornstein \*et al.\* \(2011\)](#) to conclude that frictional wage dispersion is not very large also implies that the wage gains from UI are not very large.

Importantly, however, a low mean-min ratio is only a part of our argument. [Hornstein \*et al.\* \(2011\)](#) and the subsequent literature identify a natural mechanism for enabling the model to generate larger wage dispersion: on-the-job search. If workers can continue to search on the job even while employed, they will be willing to accept jobs quickly even if there are much better jobs available. As a result, a high rate of on-the-job search can reconcile a high job-finding rate with high wage dispersion. However, in spite of this, we show that a high rate of on-the-job search *does not* imply a high wage elasticity. This is because a high rate of on-the-job search also has an independent, offsetting effect: it mutes the importance of initially accepted wages for average steady-state wages. So, while wage dispersion is of crucial importance for the magnitude of the wage elasticity, a high value of the former is not sufficient for a high value of the latter. In fact, as we confirm numerically, a sequential search framework with risk-averse workers and on-the-job search is consistent with a sizable mean-min ratio but implies an only modest wage elasticity.

This last point is important precisely because some of the most successful papers addressing the [Hornstein \*et al.\* \(2011\)](#) wage dispersion conundrum rely exactly on the efficacy of on-the-job search. In particular, [Faberman \*et al.\* \(2022\)](#) show in novel survey data

that the employed are more effective at job search, and receive better wage offers, than the unemployed; these findings suggest that the workhorse model, with exogenous job offer rates and identical wage distributions for the employed and unemployed, is overly simplistic. Once their empirical findings are accounted for in the model, they show that the model can be consistent with a large degree of wage dispersion. Our result implies that this feature need not, and in fact likely would not, imply a larger wage effect of UI. The same force that enables the model to generate large wage dispersion - the high efficacy of search by the employed compared to the unemployed - implies that employed workers are able to escape the adverse effects of a poor initial job placement relatively fast. As a result, even if higher UI improves the initial job placement, this is not very consequential for average wages. This intuition is, in fact, further corroborated by the finding of [Faberman \*et al.\* \(2022\)](#) that on-the-job search is particularly intensive at the bottom of the job ladder.

Our analysis is also highly complementary to the empirical literature that seeks to estimate the wage effect of UI in the data. This literature has obtained widely varying and often conflicting results. For example, [Nekoei and Weber \(2017\)](#) and [Griffy \(2021\)](#) find significant positive effects of UI on re-employment wages; [Card \*et al.\* \(2007\)](#), [Lalive \(2007\)](#), and [Van Ours and Vodopivec \(2008\)](#) estimate wage effects of UI close to zero; on the other hand, [Schmieder \*et al.\* \(2016\)](#) estimate negative wage effects. Using cross-state data in the Great Recession, [Hagedorn \*et al.\* \(2013\)](#) find a positive effect of UI extensions on wages, though they attribute it to Nash bargaining rather than a selectivity effect. Moreover, a growing literature has empirically investigated the effect of UI on proxies for re-employment match quality other than wages, such as job tenure ([Centeno \(2004\)](#), [Tatsiramos \(2009\)](#), [Caliendo \*et al.\* \(2013\)](#)) and occupational switching ([Lyshol \(2020\)](#), [Houstecka and Parkhomenko \(2020\)](#)). We complement the empirical literature by studying the effects of UI theoretically, asking what magnitudes of the wage elasticity can plausibly be expected according to the standard model. Our approach expresses the model-implied wage effect of UI in terms of other statistics and thus does not require estimating the wage elasticity directly. Our results also help interpret the existing empirical estimates. As mentioned above, empirical studies have reached conflicting results. One compelling explanation, as suggested by [Schmieder \*et al.\* \(2016\)](#) and [Nekoei and Weber \(2017\)](#), is that UI may also affect wages through channels other than the selectivity effect: in particular, UI increases unemployment duration, which *itself* may have an adverse effect on average wages, e.g. through human capital depreciation ([Ortego-Martí \(2016\)](#)). Our results imply that, even without such adverse effects through duration dependence, one should not be surprised by an absence of large positive wage effects, because the selectivity effect itself is not very large. This discussion also highlights, more broadly, that empirical studies may find a wage effect of UI for a variety of reasons, not only the selectivity effect. Our theoretical approach enables isolating the magnitude of the selectivity effect.

More broadly, our paper contributes to the agenda trying to quantify the importance of search frictions in the labor market (see e.g. [Gautier and Teulings \(2015\)](#) and the recent work by [Martellini and Menzio \(2020, 2021\)](#)), and their impact on optimal UI (for recent

work, see e.g. [Braxton \*et al.\* \(2020\)](#), [Chao \(2021\)](#), [Chao \*et al.\* \(2021\)](#), [de Souza \*et al.\* \(2022\)](#), among many others). The wage/job-finding tradeoff can be conceived as a measure of how costly (in terms of reduces job-finding probability) it is to slightly increase the average wage. Our approach to calculating the slope of this tradeoff, has applicability beyond UI: at a fundamental level, it relies on the fact that a change in the worker’s reservation wage (itself due to some exogenous event, such as UI) affects the average wage and the job-finding rate in a particular proportion.

This paper proceeds as follows. In section 2, we lay out the basic model environment. Section 3 contains our main result. Section 4 draws its implications for welfare gains from UI, and section 5 describes our parameter calibration and numerical results. Section 6 concludes and discusses the implications of our results in context of the existing literature.

## 2 Environment and preliminaries

In this section we lay out the model environment, which largely follows the conventional sequential search model.<sup>1</sup> Time is continuous, and the time horizon is infinite. There is a continuum of workers, each of whom evaluates consumption streams according to

$$\mathbb{E} \int_0^\infty e^{-rt} v(c(t)) dt \quad (1)$$

where  $r > 0$  is the discount rate, and the flow utility of consumption  $v$  satisfies  $v' > 0$ ,  $v'' \leq 0$ . When unemployed, the worker receives wage offers at Poisson rate  $\lambda_u$ , which are drawn from a cumulative distribution  $F$  with density  $f$ . When employed, the worker receives wage offers at Poisson rate  $\lambda_e < \lambda_u$ , which are also drawn from  $F$ . An employed worker becomes unemployed at Poisson rate  $\delta$ . Workers do not save or borrow. An unemployed worker receives government-provided unemployment benefits  $b$ . Employed workers are taxed at a proportional rate  $\tau$ , so that a worker employed at wage  $w$  receives consumption  $(1 - \tau)w$ . Note that risk aversion and proportional taxes on wages are not essential for our main result: we introduce them because they will be relevant for the welfare analysis that follows it.

Let  $U$  be the value of an unemployed worker, and let  $W(w)$  be the value of a worker employed at wage  $w$ . These values are given, respectively, by the Bellman equations

$$rU = v(b) + \lambda_u \int_0^\infty \max\{W(w) - U, 0\} dF(w) \quad (2)$$

and

$$(r + \delta)W(w) = v((1 - \tau)w) + \delta U + \lambda_e \int_0^\infty \max\{W(w') - W(w), 0\} dF(w') \quad (3)$$

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<sup>1</sup>All the derivations are included in the Appendix to make the analysis self-contained, but these derivations are standard in the literature.

It is standard to show that  $W(w)$  is increasing in  $w$ , and therefore an employed worker switches jobs whenever  $w' > w$ , and the unemployed worker's job acceptance decision rule is characterized by a reservation wage, denoted by  $w_R$ . This reservation wage is the solution to  $W(w_R) = U$ . We show in Appendix A.1 that this reservation wage satisfies

$$v((1-\tau)w_R) = v(b) + (\lambda_u - \lambda_e) \int_{w_R}^{\infty} \frac{(1-\tau)v'((1-\tau)x)(1-F(x))}{r + \delta + \lambda_e(1-F(x))} dx \quad (4)$$

Given  $w_R$ , we can proceed to define several key equilibrium objects. First, the job-finding rate, denoted by  $h_u$ , is equal to

$$h_u = \lambda_u(1 - F(w_R)) \quad (5)$$

and the steady-state unemployment rate is then given by

$$u = \frac{\delta}{\delta + \lambda_u(1 - F(w_R))} \quad (6)$$

Next, define  $G$  to be the steady-state cumulative distribution of wages among employed workers. We show in Appendix A.2 that  $G$  is given by

$$G(w) = \frac{\delta}{\delta + \lambda_e(1 - F(w))} \cdot \frac{F(w) - F(w_R)}{1 - F(w_R)} \quad (7)$$

The average steady-state wage across employed workers, denoted  $\bar{w}$ , is then given by

$$\bar{w} = \int_{w_R}^{\infty} wdG(w) \quad (8)$$

### 3 The wage/job-finding tradeoff: a sufficient statistic

Our main result concerns the comparative statics of  $\bar{w}$  and  $h_u$  with respect to  $b$ . Define the elasticities

$$\epsilon_{h,b} \equiv \frac{\partial \ln h_u}{\partial \ln b}; \quad \epsilon_{w,b} \equiv \frac{\partial \ln \bar{w}}{\partial \ln b}$$

Differentiation of (5) and (8) then gives

**Proposition 1** *The elasticities of the job-finding rate and average wage with respect to  $b$  satisfy*

$$\epsilon_{w,b} = -\frac{1}{1 + \kappa_e} \left( \frac{\mu - 1}{\mu} \right) \epsilon_{h,b}, \quad (9)$$

where  $\mu = \bar{w}/w_R$  is the mean-min ratio of wages, and  $\kappa_e = \lambda_e(1 - F(w_R))/\delta$ .

**Proof.** See Appendix A.3. ■

**Interpretation of the result.** While simple, the formula in (9) is rich in economic intuition. To start with, it shows that the positive elasticity  $\epsilon_{w,b}$  is tightly linked to the negative elasticity  $\epsilon_{h,b}$ . This indicates that the worker faces a wage/job-finding tradeoff: to the extent that an increase in  $b$  raises the accepted wage, it must also lower the job-finding probability. In turn, the ratio between the wage elasticity  $\epsilon_{w,b}$  and the job-finding elasticity  $\epsilon_{h,b}$  is shown to depend on two key statistics. First, it depends on how dispersed wages are, as captured by the mean-min ratio  $\mu$ . All else equal, if wages are very concentrated, a given increase in  $b$  would lead to a lower job-finding rate without much of an increase in the average accepted wage; the opposite is true if wages are very dispersed. Second, it depends on the efficacy of on-the-job search relative to the job separation rate, as captured by the quantity  $\kappa_e$ . After an unemployed worker finds a job, they climb the job ladder via on-the-job search, a process interrupted by job separations. If  $\kappa_e$  is large, upward job switches are frequent relative to separations back into unemployment; in this case, the average steady-state wage is not very sensitive to the initially accepted re-employment wage, and hence not very sensitive to unemployment insurance.

**Discussion of assumptions.** It is instructive to note that the formula (9) relies on a rather minimal set of assumptions. In particular, it uses the fact that workers follow a reservation-wage rule, but not the fact that the reservation wage satisfies (4) (which we do, however, use below to characterize  $\mu$ ). In essence, equation (9) follows from the mathematical link between the objects  $Prob(w \geq w_R)$  and  $\mathbb{E}(w|w \geq w_R)$ , which implies that the comparative statics of these two objects are also linked.

The crucial assumption is that unemployment benefits affect both  $\bar{w}$  and  $h_u$  only through the reservation wage. In the discussion below, we consider the most prominent violations of this assumption in the literature (e.g. endogenous search effort). Most of them would imply that UI has an adverse (or, at least, less positive) effect on average wages given the same effect on job-finding probabilities. If this is the case, our formula is likely to provide an upper bound on the wage elasticity, given the job-finding elasticity. Since we will ultimately argue that the wage elasticity implied by (9) cannot be very large, such violations of our main assumption are likely to only strengthen this argument.

**Characterizing the mean-min ratio.** To make further progress, we derive an expression for  $\mu$  following the procedure in [Hornstein \*et al.\* \(2011\)](#). That paper shows that, in a sequential search setting, the mean-min ratio of wages is tightly linked in equilibrium to several estimable statistics, notably the replacement rate of non-market activity and the magnitudes of worker flows. [Hornstein \*et al.\* \(2011\)](#) derive their formula for  $\mu$  for a model with risk-neutral workers, as well as for a model with risk-averse workers and no on-the-job search. Fortunately, their technique extends in a straightforward way to the environment with both risk aversion and on-the-job search, which yields the following result.



**Lemma 1** Assume that utility takes the CRRA form,

$$v(x) = \frac{x^{1-\gamma} - 1}{1-\gamma}, \quad \gamma \geq 0 \quad (10)$$

If  $r \approx 0$ , then the mean-min ratio  $\mu = \bar{w}/w_R$  satisfies

$$\mu \approx \left[ \frac{1 + \frac{\kappa_u - \kappa_e}{1 + \kappa_e}}{\rho^{1-\gamma} + \frac{\kappa_u - \kappa_e}{1 + \kappa_e} \left(1 + \frac{1}{2}\gamma(\gamma - 1)\xi^2\right)} \right]^{\frac{1}{1-\gamma}}, \quad (11)$$

where  $\rho = b/((1 - \tau)\bar{w})$ ,  $\kappa_u = \lambda_u(1 - F(w_R))/\delta$ ,  $\kappa_e = \lambda_e(1 - F(w_R))/\delta$ , and

$$\xi = \frac{\sqrt{\text{var}(w)}}{\bar{w}}$$

is the coefficient of variation of wages.

**Proof.** See Appendix A.4. ■

As in [Hornstein \*et al.\* \(2011\)](#), the key lesson from the expression in (11) is that observed worker flows put a lot of discipline on the model-implied mean-min ratio. If workers find jobs relatively quickly (as would be represented by a high  $\kappa_u$ ), this indicates that they do not have much to be selective about, which implies that wages are not very dispersed. In turn, if this is the case, our formula (9) would imply that making workers slightly more selective would not raise their wages much, or in other words, a given decrease in  $h_u$  would be associated with only a modest increase in  $\bar{w}$ .

On-the-job search, as captured by  $\kappa_e$ , works in the opposite direction: if workers can continue to search on the job even while employed, they will be willing to accept jobs quickly even if there are much better jobs available. As a result, a higher  $\kappa_e$  can reconcile a high  $\kappa_u$  with a high  $\mu$ . Importantly, however, while fast on-the-job search, all else equal, implies a higher mean-min ratio, it does not imply a higher  $\epsilon_{w,b}$ . This is precisely because, as shown in (9), a higher  $\kappa_e$  also has an independent, offsetting effect on the wage elasticity. It allows the model to be consistent with wider wage dispersion, but it also mutes the importance of initially accepted wages for average steady-state wages. So, while wage dispersion is of crucial importance for the magnitude of the wage elasticity, a high value of the former is not sufficient for a high value of the latter.

## 4 Fiscal cost and welfare gain from UI

In this section, we apply the formula derived above to quantify the fiscal externality from an increase in unemployment insurance and, consequently, its effect on welfare. We follow the approach of [Baily \(1978\)](#) and [Chetty \(2006\)](#) by expressing local welfare effect from a small

increase in  $b$  in terms of a small set of easily estimable statistics, key among them the two elasticities  $\epsilon_{h,b}$  and  $\epsilon_{w,b}$ .<sup>2</sup> We then assess the quantitative importance of  $\epsilon_{w,b}$ .

Consider a worker who starts out unemployed. A benevolent government is maximizing the discounted expected utility  $U$  of the worker by choosing  $\tau$  and  $b$ , subject to the worker's optimal behavior, captured by (4), and subject to the budget constraint. The budget constraint states that the present discounted value of taxes collected from the worker must equal in expectation to the present discounted value of unemployment benefits paid to the worker. When  $r \approx 0$ , this problem is equivalent to maximizing the average steady-state flow utility,

$$uv(b) + (1 - u) \int_0^\infty v((1 - \tau)w) dG(w) \quad (12)$$

subject to the steady-state budget constraint

$$(1 - u) \tau \bar{w} \approx ub \quad (13)$$

and subject to (4), (7), and (8). We show this equivalence formally in Appendix A.5. The approximation holds because the present discounted utility of an individual worker is approximately equal to steady-state average flow utility; similarly, the value of wages the worker expects to receive over the lifetime is approximately the same as the average wage in the cross-section in steady state.<sup>3</sup> From the expression (6) for the steady-state unemployment rate, (13) can further be rewritten as

$$h_u \tau \bar{w} \approx \delta b \quad (14)$$

We are interested in calculating  $\frac{dU}{db}$ , the welfare gain from an increase in  $b$ , taking into account that  $\tau$  is a function of  $b$  through (14) and  $w_R$  is a function of  $b$  and  $\tau$  through (4). In Appendix A.6, we show that the welfare gain per unemployed worker satisfies

$$\frac{1}{u} \frac{dU}{db} \approx v'(b) - \epsilon_{\tau,b} \int_{w_R}^\infty \left(\frac{w}{\bar{w}}\right) v'((1 - \tau)w) dG(w) \quad (15)$$

where the elasticity  $\epsilon_{\tau,b} = \frac{b}{\tau} \frac{d\tau}{db}$  is obtained by treating  $\tau$  as a function of  $b$  in (14). This formula, similar to the prior literature, shows that the welfare gain from increasing UI equals to its consumption benefit minus its average consumption cost to the employed due to increased taxes. To get a welfare metric in consumption terms that is comparable across calibrations, we normalize by the average marginal utility of the employed, defining the

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<sup>2</sup>The sufficient statistics formula derived here is, as usual in the literature, a local result; therefore, we are making local statements about the effects of a UI increase rather than statements about the globally optimal UI level.

<sup>3</sup>In particular, this means that focusing on a worker who is initially unemployed is without loss of generality.

normalized welfare gain as

$$\mathcal{W}_b = \frac{v'(b) - \epsilon_{\tau,b} \int_{w_R}^{\infty} \left(\frac{w}{\bar{w}}\right) v'((1-\tau)w) dG(w)}{\int_{w_R}^{\infty} v'((1-\tau)w) dG(w)} \quad (16)$$

In order to compute  $\mathcal{W}_b$ , we must first compute  $\epsilon_{\tau,b}$ , the fiscal cost of an increase in UI. We note from (14) that

$$\epsilon_{\tau,b} = 1 - \epsilon_{h,b} - \epsilon_{w,b} \quad (17)$$

Rather than separately estimate both  $\epsilon_{h,b}$  and  $\epsilon_{w,b}$  directly, we can now take advantage of the fact that  $\epsilon_{h,b}$  and  $\epsilon_{w,b}$  are linked analytically by (9). It follows that we can rewrite (17) as

$$\epsilon_{\tau,b} = 1 - (1 - \Phi) \epsilon_{h,b}, \quad (18)$$

where  $\Phi = \frac{1}{1+\kappa_e} \left(\frac{\mu-1}{\mu}\right)$  from Proposition 1, and  $\mu$  is furthermore described by the characterization in Lemma 1. The key components necessary for computing the wedge  $\Phi$  are the replacement rate of unemployment benefits and measures of worker flows, as well as the coefficient of variation of wages, all of which can be calibrated from available data. With regard to elasticities, only  $\epsilon_{h,b}$  needs to be estimated.

## 5 Numerical analysis

We now proceed to implement the formulas in (18) and (16) numerically in order to evaluate the two key objects of interest: the marginal fiscal cost of UI, measured by  $\epsilon_{\tau,b}$ , and the marginal welfare gain from UI, measured by  $\mathcal{W}_b$ . We then use our numerical results to conduct the following counterfactual thought experiment. Suppose that a researcher computed the marginal fiscal cost and marginal welfare gain from UI by directly using equation (17) for  $\epsilon_{\tau,b}$ , but mistakenly assumed that  $\epsilon_{w,b} = 0$ . Such a calculation would overstate the marginal fiscal cost of UI and understate its marginal welfare benefit. How large would the magnitude of this bias be?

We assume, as above, that the utility function  $v$  is of the CRRA form (10), with risk-aversion parameter  $\gamma$ . A Taylor expansion procedure standard in the literature<sup>4</sup> gives

$$\mathcal{W}_b \approx 1 + \gamma(1 - \rho) - \epsilon_{\tau,b} \quad (19)$$

where  $\rho = b/((1-\tau)\bar{w})$  is the replacement rate of UI with respect to the average after-tax wage. As explained above,  $\epsilon_{\tau,b}$  can be computed according to the formula (18). We then compute, for the same parameter values, the “mis-specified” welfare gain

$$\widetilde{\mathcal{W}}_b \approx 1 + \gamma(1 - \rho) - \tilde{\epsilon}_{\tau,b} \quad (20)$$

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<sup>4</sup>See e.g. Baily (1978), Gruber (1997), Chetty (2006, 2009). Appendix A.6 contains the derivation of the approximate expression (19).

where  $\tilde{\epsilon}_{\tau,b}$  is the fiscal externality a researcher would compute if ignoring the effect of UI on wages, i.e. if they used the same  $\epsilon_{h,b}$  but setting  $\epsilon_{w,b} = 0$ :

$$\tilde{\epsilon}_{\tau,b} = 1 - \epsilon_{h,b} \tag{21}$$

We then measure the importance of the wage effect by inspecting the magnitudes of  $\epsilon_{\tau,b}/\tilde{\epsilon}_{\tau,b}$  for the fiscal cost, and  $\mathcal{W}_b/\tilde{\mathcal{W}}_b$  for the welfare gain.

## 5.1 Calibration

Our choices of parameter values come from estimates of observed worker flows in the US, as well as other consensus statistics used in the empirical literature. We conduct several robustness exercises below in order to assess the sensitivity of the results to the key parameters. For the baseline value of the replacement rate, we adopt the commonly used value of  $\rho = 0.4$ .<sup>5</sup> We set the elasticity of unemployment duration with respect to UI to the standard estimate from [Chetty \(2008\)](#): a 10% increase in unemployment benefits is associated with a 5% decrease in the job-finding hazard, so that  $\epsilon_{h,b} = -0.5$ . Our baseline value for the risk aversion parameter is  $\gamma = 2$ . The coefficient of variation of wages,  $\xi$ , is set to 0.5, consistent with the upper bound of the range of estimates in [Hornstein \*et al.\* \(2007\)](#).

The remaining key parameters,  $\kappa_u$  and  $\kappa_e$ , are calculated from estimates of average worker flows at a monthly frequency: the job-finding rate  $h_u$ , the job separation rate  $\delta$ , and the job-to-job transition rate  $h_{ee}$ . In [Appendix B](#), we describe in detail how  $\kappa_u$  and  $\kappa_e$  are calculated given these worker flow rates. A consensus estimate of the job-finding rate is  $h_u = 0.43$ , which we maintain throughout. Estimates of  $\delta$  range from as low as 0.013 ([Krolkowski, 2017](#)) and 0.02 ([Fujita and Ramey, 2012](#)) to 0.03 ([Hornstein \*et al.\*, 2011](#)) and 0.035 ([Hall, 2017](#)), and estimates of  $h_{ee}$  range from 0.022 to 0.032 (see e.g. [Hornstein \*et al.\* \(2011\)](#)). We follow [Hornstein \*et al.\* \(2011\)](#) and take  $\delta = 0.03$  and  $h_{ee} = 0.022$  as our baseline calibration, and examine the sensitivity of the results to these choices below.

## 5.2 Numerical results

For our baseline parameter calibration described above, we obtain a model-implied mean ratio of  $\mu = 1.53$  and a wedge of  $\Phi \equiv -\epsilon_{w,b}/\epsilon_{h,b} = 0.1$ , implying a wage elasticity equal to  $\epsilon_{w,b} = 0.05$ . This then implies a fiscal elasticity of  $\epsilon_{\tau,b} = 1.45$  and a welfare gain of  $\mathcal{W}_b = 0.75$ . The mis-specified model ignoring the wage effect of UI, as described above, would result in  $\tilde{\epsilon}_{\tau,b} = 1.5$  and a corresponding welfare gain of  $\tilde{\mathcal{W}}_b = 0.7$ . In other words, a 1% increase in  $b$  raises the average steady-state wage by approximately 0.05%, or about 1/10 the amount by which it lowers the job-finding probability. A researcher mistakenly assuming

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<sup>5</sup>Setting  $\rho = 0.4$  amounts to assuming, as we did in this paper, that the only source of consumption during unemployment is unemployment insurance. We note that higher values of  $\rho$  would only imply lower values of  $\mu$  and therefore lower values of the wage elasticity, all else equal. See the discussion of figures [5c](#) and [5d](#) below.

a zero wage effect of UI would overestimate the marginal fiscal cost of UI by about 3.5% and underestimate its marginal welfare benefit by about 6.8%.

It is notable that the model implies substantial wage dispersion, which, as emphasized by [Krolikowski \(2017\)](#), is a key moment for model validation. Using several data sources, [Hornstein \*et al.\* \(2007\)](#) argue that plausible values of the mean-min ratio of wages (controlling for observables) range from 1.5 to 2, a range that includes our model-implied value of 1.53. As shown by [Hornstein \*et al.\* \(2011\)](#), a sequential search model with risk-neutral workers and no on-the-job search implies a much smaller mean-min ratio, usually around 1.05. A model with risk-neutral workers and on-the-job search, parameterized identically to ours but with  $\gamma = 0$ , would imply a mean-min ratio of about 1.15. On the other hand, a model with risk-averse workers but no on-the-job search (i.e.,  $\lambda_e = h_{ee} = 0$ , all else equal) would imply a mean-min ratio of about 1.33. Our result illustrates that a plausibly calibrated model with both risk aversion and on-the-job search can deliver an even larger mean-min ratio, and in fact one within the range of empirical estimates, though still at the lower end.

**Role of on-the-job search efficacy.** We next examine how sensitive the results on the wage elasticity are to the chosen values of the worker flows  $\delta$  and  $h_{ee}$ . This sensitivity analysis is appropriate both because the estimates of the worker flows themselves vary in the literature, and because, as described above, our baseline implied value of  $\mu$  is at the lower end of what is computed in [Hornstein \*et al.\* \(2007\)](#) and [Tjaden and Wellschmied \(2014\)](#). In the following figures, we vary  $\kappa_e$  by varying both  $\delta$  and  $h_{ee}$  in accordance with the range of values suggested by the literature. The broad lesson is, as emphasized above, that a higher  $\kappa_e$  leads to a higher implied mean-min ratio but not a higher wage elasticity, because of the two opposing effects of higher on-the-job search efficacy.

Figure 1 illustrates the model-implied wage dispersion and effects of UI for a range of job-to-job transition rates, which, all else equal, correspond to different values of  $\kappa_e$ . All other parameters, including  $\delta$ , are fixed at their baseline calibration levels as described above. In each panel, the shaded region corresponds to the range of job-to-job transitions commonly assumed in the literature, namely between 2.2% and 3.2%. The top graph, figure 1a, displays the model-implied mean-min ratio. Under our baseline calibration, this mean-min ratio is 1.53, but larger – though still plausible – values of job-to-job transition rates permit mean-min ratios as high as 1.68. The next panel, 1b, illustrates how the efficacy of on-the-job search impacts the tax elasticity  $\epsilon_{\tau,b}$ . The curve labeled “True” displays the tax elasticity  $\epsilon_{\tau,b}$  given by (18). The curve labeled “Misspecified” displays the tax elasticity  $\tilde{\epsilon}_{\tau,b}$  given by (21), i.e. the tax elasticity implied by the model if ignoring the effect of UI on wages. Figure 1c displays the implications for welfare. The curves labeled “True” and “Misspecified” display the values of  $\mathcal{W}_b$  (given by (19)) and  $\widetilde{\mathcal{W}}_b$  (given by (20)), respectively. Figures 1b and 1c illustrate, in particular, that the wage effect of UI and the welfare gain from UI are largest when the efficacy of on-the-job search is low. Intuitively, when  $\kappa_e$  is small, a better initial re-employment wage is more consequential since it persists for a longer period of time. Note that this occurs despite the fact that a higher  $\kappa_e$  would make the model consistent

with higher wage dispersion (as shown in 1a), which, as explained above, would (all else equal) amplify the effect of UI on wages. This numerical result indicates that the former effect outweighs the latter, showcasing a tension between the model’s ability to generate large wage dispersion and its ability to generate a large wage elasticity.

Figures 2, 3 and 4 repeat the exercise for both larger and smaller values of  $\delta$ , to reflect the range of values considered in the literature (Krolikowski (2017), Fujita and Ramey (2012) and Hall (2017)). Smaller values of  $\delta$  imply larger  $\mu$  but also larger tax elasticities and, as a result, a smaller degree of difference between the misspecified and true models in terms of welfare gains, across the range of plausible  $\kappa_e$  values. This again illustrates that larger wage dispersion need not translate into a larger wage elasticity. A broader lesson is that the wedge resulting from the wage effect of UI is not very large: across plausible parameter values, a researcher ignoring the wage effect of UI would overstate its marginal fiscal cost by at most 5%.

It is useful to discuss these results in light of the recent and closely related empirical findings of Faberman *et al.* (2022). That paper finds, using novel survey data, that on-the-job search is *more* effective for the employed than for the unemployed. The fact that the job-finding rate exceeds the job-to-job transition rate in the data still obtains, not because the employed face a lower arrival rate of job offers but because they are more selective in accepting them (a similar point is made by Krolikowski (2017)). This feature makes employment more attractive, in turn allowing the model to be consistent with a higher mean-min ratio. In the context of our work, this finding would correspond to a higher  $h_{ee}$  and hence a higher  $\kappa_e$ . Our results imply that this *need not* lead to a higher wage effect of UI, precisely because the same feature makes the employed effective at escaping a bad initial job placement quickly. This interpretation is consistent with the result that, as we show numerically, a higher job-to-job transition rate *dampens* the wage elasticity even as it raises the model-implied mean-min ratio.<sup>6</sup>

**Role of other parameters.** Figure 5 illustrates the model-implied effects of UI for alternative values of risk aversion,  $\gamma$ , and replacement rate,  $\rho$ . The top-left graph, figure 5a, displays the model-implied elasticity of taxes with respect to  $b$  under various values of risk aversion, keeping all other parameters fixed. The wedge resulting from the wage effect is small, even for very large values of risk aversion; a researcher ignoring the effect of UI on wages would overestimate its marginal fiscal cost by at most 6%. The size of the wedge is even smaller for more conservative values of risk aversion. Figure 5b displays the implications for welfare. The bias resulting from neglecting the wage effect of UI is likewise small in this case. Figures 5c and 5d illustrate that this result is also robust to the chosen value

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<sup>6</sup>Another distinguishing feature of Faberman *et al.* (2022) is the crucial role assigned to endogenous search intensity. As we discuss in section 3, endogenous search intensity would lead to an additional effect of UI on the re-employment probability without a corresponding effect on wages, hence further dampening the implied wage elasticity for a given job-finding elasticity.

of the replacement rate  $\rho$ .<sup>7</sup>

## 6 Discussion

The potential of UI to improve re-employment job quality has long been recognized in principle, and is an important part of the discussion of its optimal design. A growing literature, described above, has addressed the wage effects of UI empirically. This paper complements this literature by more deeply examining the selectivity effect theoretically. Our focus is on the relationship between two elasticities: the wage elasticity and the job-finding elasticity. The main message is that the standard search framework puts sharp restrictions on what *combinations* of the two elasticities are consistent with the theory. Among other things, our result implies that - from a theoretical point of view - one should not be surprised to find small wage elasticities in the data. Importantly, however, the search framework does not rule out a large wage elasticity per se; instead, it puts bounds on the wage elasticity for any given job-finding elasticity. This is important, since, as we have shown, the *relative* magnitude of the two elasticities is important for the welfare gain from UI. On the normative side, our results suggest that the selectivity effect is not very consequential for this welfare gain.

Our result has a very natural economic interpretation, tightly linked to the “unpleasant search arithmetic” of [Hornstein \*et al.\* \(2011\)](#). Because the standard search framework places bounds on model-implied wage dispersion (given observed worker flows), it also places bounds on the selectivity effect of UI. If workers do not have much to be selective about, little gain can be achieved by making them more selective. Finally, our formula draws attention to the central role of on-the-job search in driving the effects of UI on average wages. A high rate of on-the-job search relative to separations into unemployment mutes the importance of initial wages for steady-state wages, because workers manage to “escape” bad initial job placement quickly. This underscores the importance on accounting for job-to-job transitions in studying optimal UI.

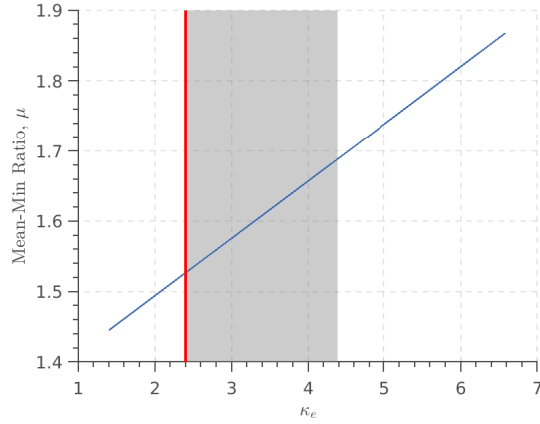
All of these results beg the question of how the model would need to be modified in order to generate larger wage elasticities. First, we note that the most obvious modifications of the standard model would in fact imply that our formula provides an upper bound on the wage elasticity for a given job-finding elasticity. For example, if UI also reduces search intensity, this reduces the job-finding rate without an accompanying increase in wages. In addition, if human capital also depreciates over the unemployment spell (as in [Ortego-Marti \(2016\)](#)), the longer unemployment duration generates a negative effect on wages that would offset the positive match quality effect of higher selectivity (as argued by [Schmieder \*et al.\* \(2016\)](#) and [Nekoei and Weber \(2017\)](#)). In both cases, the model-implied wage elasticity, for a given job-finding elasticity, would be smaller than implied by our formula. Generating a higher

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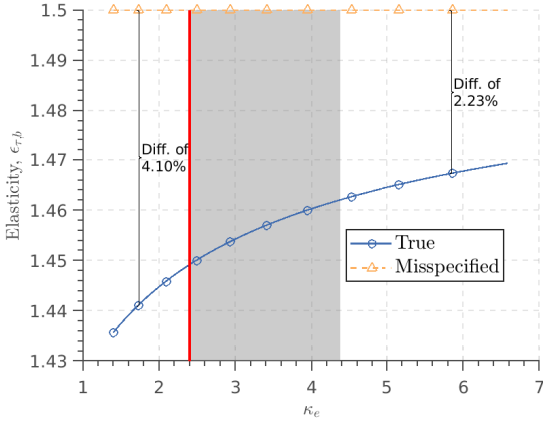
<sup>7</sup>Note that the wedge is lower for higher values of  $\rho$ . Our chosen value of  $\rho = 0.4$  is likely to be a conservative (i.e. lower-bound) value for unemployment consumption, both in light of the business cycle literature ([Hagedorn and Manovskii \(2008\)](#), [Hall and Milgrom \(2008\)](#), [Hornstein \*et al.\* \(2011\)](#)) and because it abstracts from sources of unemployment consumption other than UI (see e.g. [Aguiar and Hurst \(2005\)](#)).

wage elasticity would require UI to increase wages without an accompanying decrease in the job-finding rate. This may be the case, e.g. if wages are Nash-bargained, so that UI has a direct effect on wages through the worker's outside option, as argued in the empirical work of [Hagedorn \*et al.\* \(2013\)](#). We should note that such modifications of the standard model do not invalidate the argument *per se*. They would imply that UI has effects on wages through channels other than the selectivity effect. Our insight - that the selectivity effect itself is bounded above - should continue to hold in some form in extensions of the baseline model, as long as there is a tradeoff between accepted wages and job-finding probability. Finally, an intriguing question is how alternative models of job mobility would affect the conclusions here. As we have argued, the very classic search framework implies that on-the-job search dampens the long-run effects of initial job placement. Our findings suggest that a larger wage effect of UI could obtain when there is large dispersion of wage offers *and* the initial job placement has persistent effects. As a consequence, alternative models of how workers climb the job ladder (e.g. [Jung and Kuhn \(2019\)](#), [Krolikowski \(2017\)](#), [Jarosch \(2021\)](#)) could potentially have interesting implications for optimal UI.

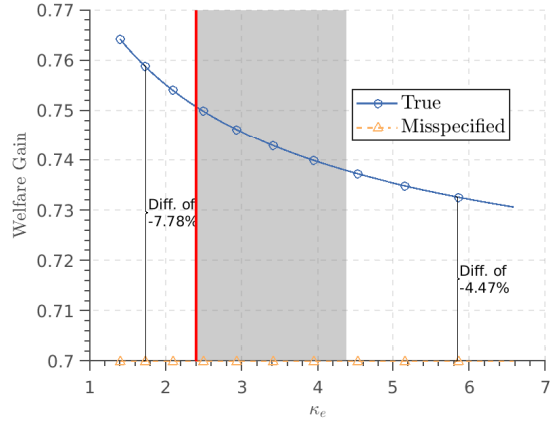




(a) The mean-min ratio,  $\mu$ .

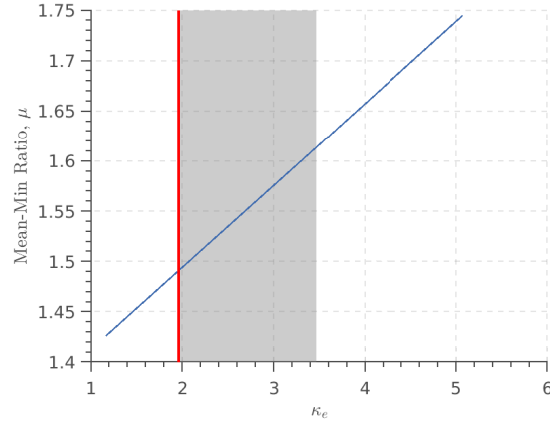


(b) The fiscal cost of UI,  $\epsilon_{\tau,b}$ .

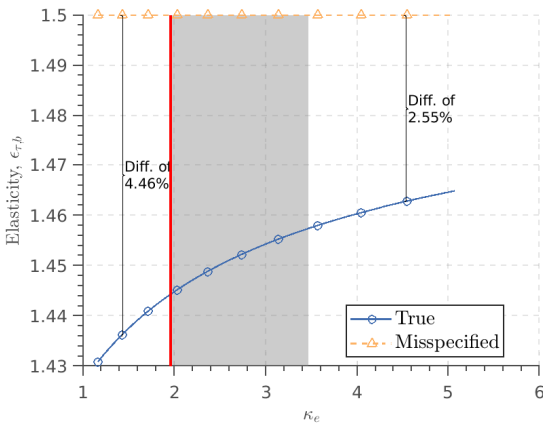


(c) Welfare gains from UI,  $\mathcal{W}_b$ .

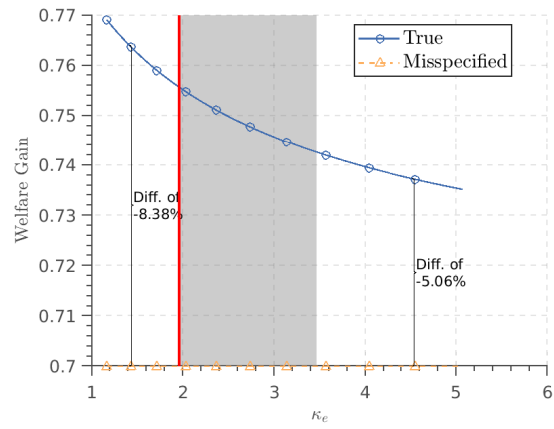
Figure 1: Model-implied wage dispersion and effects of UI at different values of  $\kappa_e$ , baseline  $\delta$  calibration. The variation in  $\kappa_e$  is generated by varying  $h_{ee}$  while keeping  $\delta$  fixed at 0.03, with the shaded region corresponding to  $h_{ee} \in [0.022, 0.032]$ , and the red line corresponding to  $h_{ee} = 0.022$ .



(a) The mean-min ratio,  $\mu$ .

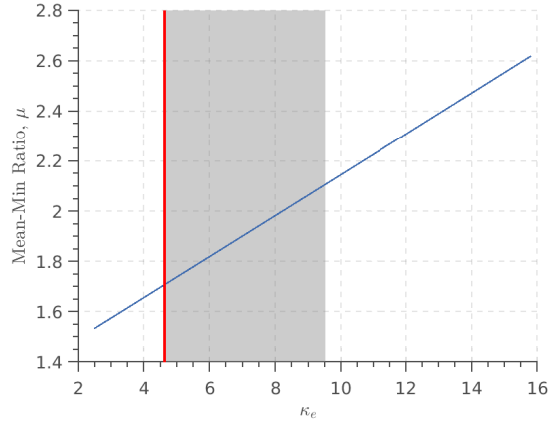


(b) The fiscal cost of UI,  $\epsilon_{\tau,b}$ .

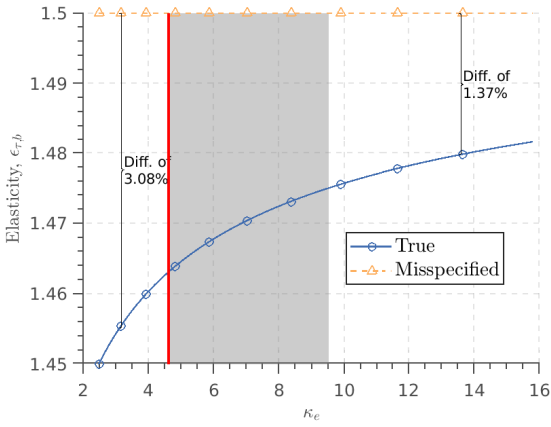


(c) Welfare gains from UI,  $\mathcal{W}_b$ .

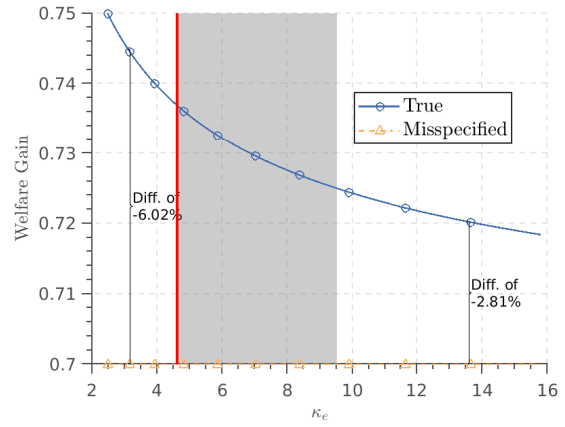
Figure 2: Model-implied wage dispersion and effects of UI at different values of  $\kappa_e$ , with  $\delta = 0.035$ . The variation in  $\kappa_e$  is generated by varying  $h_{ee}$  while keeping  $\delta$  fixed at 0.035, with the shaded region corresponding to  $h_{ee} \in [0.022, 0.032]$ , and the red line corresponding to  $h_{ee} = 0.022$ .



(a) The mean-min ratio,  $\mu$ .

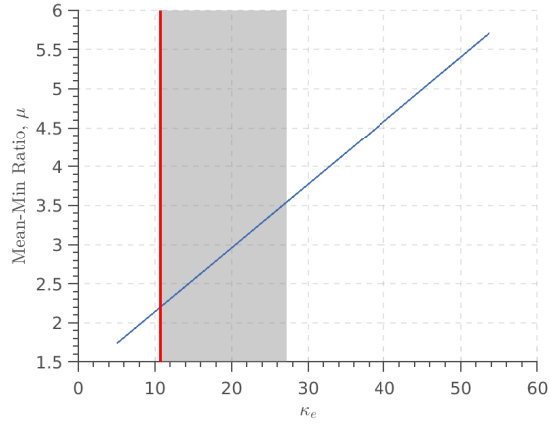


(b) The fiscal cost of UI,  $\epsilon_{\tau,b}$ .

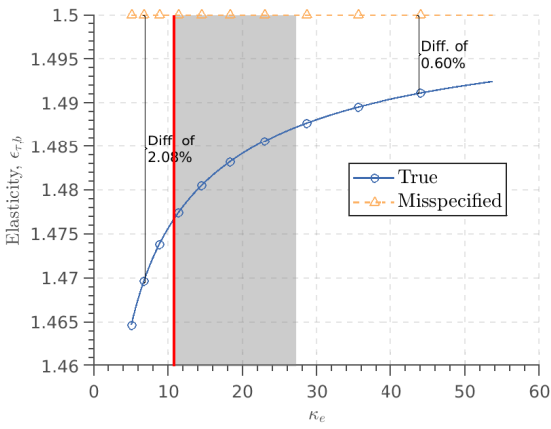


(c) Welfare gains from UI,  $\mathcal{W}_b$ .

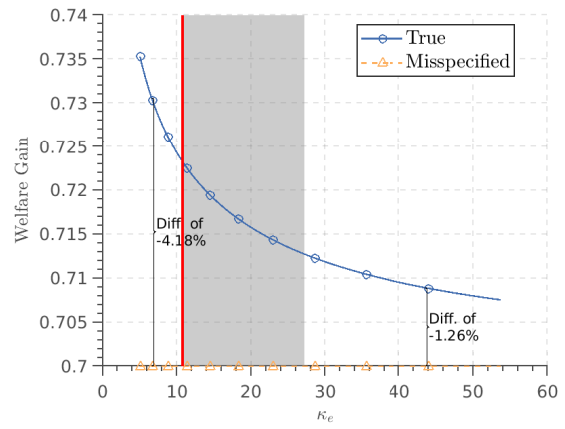
Figure 3: Model-implied wage dispersion and effects of UI at different values of  $\kappa_e$ , with  $\delta = 0.02$ . The variation in  $\kappa_e$  is generated by varying  $h_{ee}$  while keeping  $\delta$  fixed at 0.02, with the shaded region corresponding to  $h_{ee} \in [0.022, 0.032]$ , and the red line corresponding to  $h_{ee} = 0.022$ .



(a) The mean-min ratio,  $\mu$ .

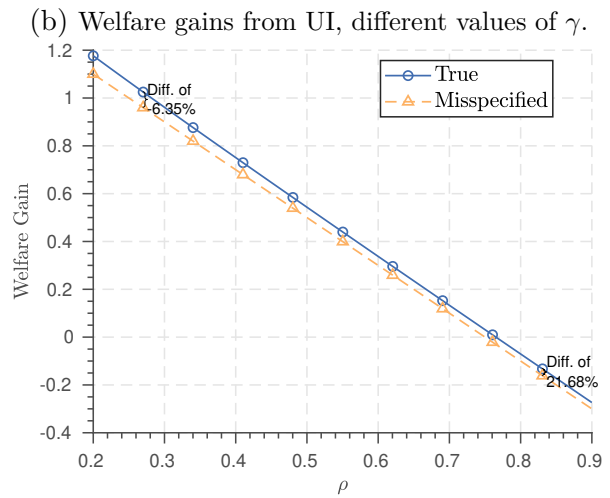
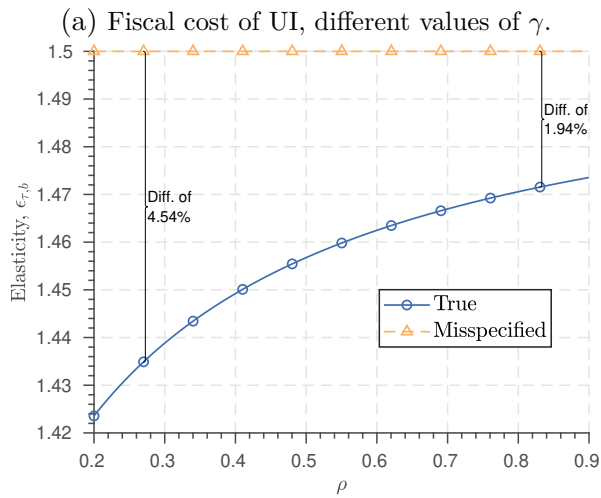
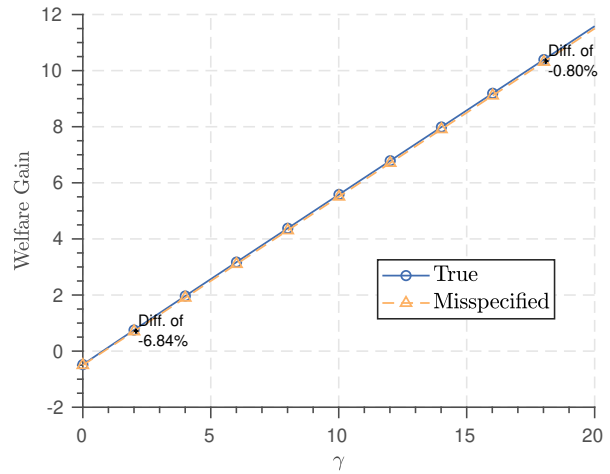
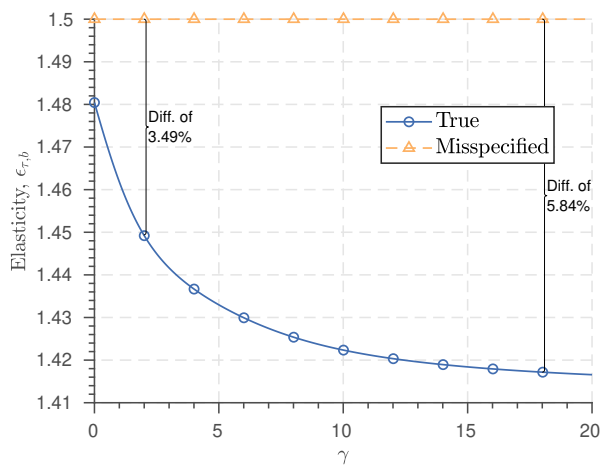


(b) The fiscal cost of UI,  $\epsilon_{\tau,b}$ .



(c) Welfare gains from UI,  $\mathcal{W}_b$ .

Figure 4: Model-implied wage dispersion and effects of UI at different values of  $\kappa_e$ , with  $\delta = 0.013$ . The variation in  $\kappa_e$  is generated by varying  $h_{ee}$  while keeping  $\delta$  fixed at 0.013, with the shaded region corresponding to  $h_{ee} \in [0.022, 0.032]$ , and the red line corresponding to  $h_{ee} = 0.022$ .



(c) Fiscal cost of UI, different values of  $\rho$ .

(d) Welfare gains from UI, different values of  $\rho$ .

Figure 5: Model-implied effects of UI under various values of risk aversion and replacement rate.

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# A Proofs and derivations

## A.1 The reservation wage equation

**Derivation of (4).** Since  $W(w)$  is strictly increasing in  $w$ , we can rewrite (2) and (3) as

$$rU = v(b) + \lambda_u \int_{w_R}^{\infty} W(w) - U dF(w) \quad (22)$$

and

$$(r + \delta)W(w) = v((1 - \tau)w) + \delta U + \lambda_e \int_w^{\infty} W(w') - W(w) dF(w') \quad (23)$$

Differentiating (23) with respect to  $w$  and rearranging, we obtain

$$W'(w) = \frac{(1 - \tau)v'((1 - \tau)w)}{r + \delta + \lambda_e(1 - F(w))} \quad (24)$$

and therefore

$$W(w') - W(w) = \int_w^{w'} \frac{(1 - \tau)v'((1 - \tau)x)}{r + \delta + \lambda_e(1 - F(x))} dx \quad (25)$$

It then follows that

$$\begin{aligned} \int_{w_R}^{\infty} W(w') - W(w_R) dF(w') &= \int_{w_R}^{\infty} \int_{w_R}^{w'} \frac{(1 - \tau)v'((1 - \tau)x)}{r + \delta + \lambda_e(1 - F(x))} dx dF(w') \\ &= \int_{w_R}^{\infty} \int_x^{\infty} \frac{(1 - \tau)v'((1 - \tau)x)}{r + \delta + \lambda_e(1 - F(x))} dF(w') dx \\ &= \int_{w_R}^{\infty} \frac{(1 - \tau)v'((1 - \tau)x)(1 - F(x))}{r + \delta + \lambda_e(1 - F(x))} dx \end{aligned} \quad (26)$$

Using  $U = W(w_R)$  and using (26) in (22), we obtain

$$rW(w_R) = v(b) + \lambda_u \int_{w_R}^{\infty} \frac{(1 - \tau)v'((1 - \tau)x)(1 - F(x))}{r + \delta + \lambda_e(1 - F(x))} dx \quad (27)$$

Similarly, using (26) in (23) evaluated at  $w = w_R$ , we obtain

$$rW(w_R) = v((1 - \tau)w_R) + \lambda_e \int_{w_R}^{\infty} \frac{(1 - \tau)v'((1 - \tau)x)(1 - F(x))}{r + \delta + \lambda_e(1 - F(x))} dx \quad (28)$$

Combining (27) with (28) gives (4). ■

## A.2 Steady-state wage distribution

**Derivation of (7).** In steady state, inflows into employment at wages less than or equal to  $w$  equal outflows. Inflows are equal to

$$\lambda_u (F(w) - F(w_R)) u.$$

Outflows, into both unemployment and higher-wage jobs, are equal to

$$(\delta + \lambda_e (1 - F(w))) G(w) (1 - u).$$

Setting the two expressions equal to each other, and substituting for  $u$  from (6), gives (7). ■

## A.3 Wage/job-finding tradeoff

**Proof of Proposition 1.** Differentiating (5) with respect to  $b$  gives

$$\epsilon_{h,b} = \frac{d \ln h_u}{d \ln w_R} \frac{\partial \ln w_R}{\partial \ln b} = - \frac{w_R f(w_R)}{1 - F(w_R)} \frac{\partial \ln w_R}{\partial \ln b} \quad (29)$$

Next, we note that

$$\bar{w} = w_R + \int_{w_R}^{\infty} (w - w_R) dG(w) \quad (30)$$

$$= w_R + \int_{w_R}^{\infty} (1 - G(w)) dw \quad (31)$$

$$= w_R + \int_{w_R}^{\infty} \frac{[\delta + \lambda_e (1 - F(w_R))] (1 - F(w))}{[\delta + \lambda_e (1 - F(w))] (1 - F(w_R))} dw \quad (32)$$

where the second line is obtained from integrating by parts and the third line is obtained by substituting for  $G$  from (7). Differentiating (32) with respect to  $w_R$  gives us

$$\frac{d\bar{w}}{dw_R} = \frac{f(w_R)}{1 - F(w_R)} \int_{w_R}^{\infty} \frac{1}{1 - F(w_R)} \cdot \frac{\delta (1 - F(w))}{\delta + \lambda_e (1 - F(w))} dw \quad (33)$$

$$= \frac{f(w_R)}{1 - F(w_R)} \left( \frac{\delta}{\delta + \lambda_e (1 - F(w_R))} \right) (\bar{w} - w_R), \quad (34)$$

where the last line follows by substituting again from (32). Now, multiplying both sides by  $\frac{w_R}{\bar{w}} \frac{\partial \ln w_R}{\partial \ln b}$  and using (29) gives (9). ■

## A.4 Mean-min ratio of wages

**Proof of Lemma 1.** First, we observe that

$$\int_{w_R}^{\infty} \frac{(1-\tau)v'((1-\tau)x)(1-F(x))}{r+\delta+\lambda_e(1-F(x))} dx \approx \int_{w_R}^{\infty} \frac{(1-\tau)v'((1-\tau)x)(1-F(x))}{\delta+\lambda_e(1-F(x))} dx \quad (35)$$

$$= \frac{1-F(w_R)}{\delta+\lambda_e(1-F(w_R))} \int_{w_R}^{\infty} (1-G(x))(1-\tau)v'((1-\tau)x) dx \quad (36)$$

$$= \frac{1-F(w_R)}{\delta+\lambda_e(1-F(w_R))} \int_{w_R}^{\infty} [v((1-\tau)w) - v((1-\tau)w_R)] dG(x), \quad (37)$$

where the first line follows from the approximation  $r \approx 0$ , the second line substitutes  $G$  from (7), and the third line uses integration by parts. We can then re-write the reservation wage equation (4) as

$$v((1-\tau)w_R) \approx v(b) + \frac{\kappa_u - \kappa_e}{1 + \kappa_e} [\mathbb{E}\{v((1-\tau)w)\} - v((1-\tau)w_R)] \quad (38)$$

where the expectation is taken over the distribution  $G$ . Next, we use a second-order Taylor approximation of  $v(z)$  around  $v(\bar{z})$ ,

$$v(z) \approx v(\bar{z}) + v'(\bar{z})(z - \bar{z}) + \frac{1}{2}v''(\bar{z})(z - \bar{z})^2 \quad (39)$$

Setting  $z = (1-\tau)w$  and  $\bar{z} = (1-\tau)\bar{w}$ , taking expectations of (39) gives us

$$\mathbb{E}\{v((1-\tau)w)\} \approx v((1-\tau)\bar{w}) + \frac{1}{2}(1-\tau)^2 v''((1-\tau)\bar{w}) \text{var}(w) \quad (40)$$

Substituting this expression for  $\mathbb{E}\{v((1-\tau)w)\}$  into (38), assuming CRRA utility (10), and denoting  $b = \rho(1-\tau)\bar{w}$  gives (11). ■

## A.5 The government objective and budget constraint

This section formally confirms the approximate equivalence of the government's problem to maximizing (12) subject to (13). First, when  $r \approx 0$ , we have

$$\begin{aligned} rU &\approx v(b) + \lambda_u \int_{w_R}^{\infty} \frac{(1-\tau)v'((1-\tau)x)(1-F(x))}{\delta+\lambda_e(1-F(x))} dx \\ &= v(b) + \frac{\lambda_u(1-F(w_R))}{\delta+\lambda_u(1-F(w_R))} \left[ (\lambda_u - \lambda_e) + \frac{\delta+\lambda_e(1-F(w_R))}{1-F(w_R)} \right] \int_{w_R}^{\infty} \frac{(1-\tau)v'((1-\tau)x)(1-F(x))}{\delta+\lambda_e(1-F(x))} dx \\ &= uv(b) + (1-u) \left[ v(w_R) + \int_{w_R}^{\infty} (1-\tau)v'((1-\tau)x)(1-G(x)) dx \right] \\ &= uv(b) + (1-u) \int_{w_R}^{\infty} v((1-\tau)w) dG(w), \end{aligned} \quad (41)$$

showing that the government objective is approximately equivalent to (12). Next, consider the budget constraint. Let  $\Omega_u$  be the present discounted revenue to the government from an unemployed worker, and let  $\Omega_e$  be the present discounted revenue from a worker employed at wage  $w$ , both for a given  $\tau$  and  $b$ , and taking into account that the worker responds optimally to this  $\tau$  and  $b$  via (4). These values then satisfy

$$r\Omega_u = -b + \lambda_u \int_{w_R}^{\infty} (\Omega_e(w) - \Omega_u) dF(w) \quad (42)$$

and

$$r\Omega_e(w) = \tau w + \delta(\Omega_u - \Omega_e(w)) + \lambda_e \int_w^{\infty} (\Omega_e(w') - \Omega_e(w)) dF(w') \quad (43)$$

Differentiation of (43) gives

$$\Omega'_e(w) = \frac{\tau}{r + \delta + \lambda_e(1 - F(w))} \quad (44)$$

and therefore

$$(r + \delta)\Omega_e(w) = \tau w + \delta\Omega_u + \lambda_e \int_w^{\infty} \int_w^{w'} \frac{\tau}{r + \delta + \lambda_e(1 - F(x))} dx dF(w') \quad (45)$$

$$= \tau w + \delta\Omega_u + \lambda_e \int_w^{\infty} \int_x^{\infty} \frac{\tau}{r + \delta + \lambda_e(1 - F(x))} dF(w') dx \quad (46)$$

$$= \tau w + \delta\Omega_u + \lambda_e \int_w^{\infty} \frac{\tau(1 - F(x))}{r + \delta + \lambda_e(1 - F(x))} dx \quad (47)$$

Budget balance requires  $\Omega_u = 0$ . Setting this in (42) and (47), and substituting (47) into (42), we obtain

$$b = \frac{\lambda_u \tau}{r + \delta} \int_{w_R}^{\infty} \left[ w + \lambda_e \int_w^{\infty} \frac{(1 - F(x))}{r + \delta + \lambda_e(1 - F(x))} dx \right] dF(w) \quad (48)$$

We will now show that (48) approaches (14) when  $r \rightarrow 0$ . Define

$$J(w) = w + \lambda_e \int_w^{\infty} \frac{(1 - F(x))}{r + \delta + \lambda_e(1 - F(x))} dx \quad (49)$$

It transpires, from differentiating  $J$ , that

$$J(w) = J(w_R) + \int_{w_R}^w \frac{\delta}{r + \delta + \lambda_e(1 - F(x))} dx \quad (50)$$

and therefore (48) can be written as

$$b = \frac{\lambda_u \tau}{r + \delta} \int_{w_R}^{\infty} \left[ J(w_R) + \int_{w_R}^w \frac{\delta}{r + \delta + \lambda_e (1 - F(x))} dx \right] dF(w) \quad (51)$$

$$= \frac{\lambda_u (1 - F(w_R)) \tau}{r + \delta} \left[ w_R + \lambda_e \int_{w_R}^{\infty} \frac{(1 - F(x))}{r + \delta + \lambda_e (1 - F(x))} dx \right] \quad (52)$$

$$+ \frac{\lambda_u \tau}{r + \delta} \int_{w_R}^{\infty} \int_{w_R}^w \frac{\delta}{r + \delta + \lambda_e (1 - F(x))} dx dF(w) \quad (53)$$

$$= \frac{\lambda_u (1 - F(w_R)) \tau}{r + \delta} \left[ w_R + \lambda_e \int_{w_R}^{\infty} \frac{(1 - F(x))}{r + \delta + \lambda_e (1 - F(x))} dx \right] \quad (54)$$

$$+ \frac{\lambda_u \tau}{r + \delta} \int_{w_R}^{\infty} \frac{\delta (1 - F(x))}{r + \delta + \lambda_e (1 - F(x))} dx \quad (55)$$

$$= \frac{\lambda_u (1 - F(w_R)) \tau}{r + \delta} \left[ w_R + \frac{\lambda_e (1 - F(w_R)) + \delta}{1 - F(w_R)} \int_{w_R}^{\infty} \frac{(1 - F(x))}{r + \delta + \lambda_e (1 - F(x))} dx \right] \quad (56)$$

When  $r \approx 0$ , this becomes

$$b \approx \frac{\lambda_u (1 - F(w_R)) \tau}{\delta} \left[ w_R + \frac{\lambda_e (1 - F(w_R)) + \delta}{1 - F(w_R)} \int_{w_R}^{\infty} \frac{(1 - F(x))}{\delta + \lambda_e (1 - F(x))} dx \right] \quad (57)$$

$$= \frac{\lambda_u (1 - F(w_R)) \tau}{\delta} \left[ w_R + \int_{w_R}^{\infty} (1 - G(x)) dx \right] \quad (58)$$

$$= \frac{h_u \tau}{\delta} \bar{w} \quad (59)$$

from (5), (7), and (31).

## A.6 Welfare gains from unemployment insurance

From (27), the value of an unemployed worker  $U$  satisfies

$$rU = v(b) + \lambda_u \int_{w_R}^{\infty} (1 - \tau) v'((1 - \tau)x) A(x) dx \quad (60)$$

where, for convenience, we defined the function  $A(x) = \frac{1 - F(x)}{r + \delta + \lambda_e (1 - F(x))}$ . Totally differentiating with respect to  $b$  gives

$$\begin{aligned} \frac{dU}{db} = & v'(b) - \lambda_u (1 - \tau) v'((1 - \tau)w_R) A(w_R) \left[ \frac{\partial w_R}{\partial b} + \frac{\partial w_R}{\partial \tau} \frac{d\tau}{db} \right] \\ & - \lambda_u \frac{d\tau}{db} \int_{w_R}^{\infty} [(1 - \tau) x v''((1 - \tau)x) + v'((1 - \tau)x)] A(x) dx \end{aligned} \quad (61)$$

Next, we derive expressions for  $\frac{\partial w_R}{\partial b}$  and  $\frac{\partial w_R}{\partial \tau}$ , which come from differentiating (4) with respect to  $b$  and  $\tau$ , respectively. This gives

$$\frac{\partial w_R}{\partial b} = \frac{v'(b)}{(1-\tau)u'((1-\tau)w_R)[1+(\lambda_u-\lambda_e)A(w_R)]} \quad (62)$$

and

$$\frac{\partial w_R}{\partial \tau} = \frac{w_R v'((1-\tau)w_R) - (\lambda_u - \lambda_e) \int_{w_R}^{\infty} [(1-\tau)xv''((1-\tau)x) + v'((1-\tau)x)] A(x) dx}{(1-\tau)v'((1-\tau)w_R)[1+(\lambda_u-\lambda_e)A(w_R)]} \quad (63)$$

Substituting (62) and (63) into (61) and simplifying gives

$$\begin{aligned} \frac{dU}{db} = & \frac{r+\delta}{r+\delta+\lambda_u(1-F(w_R))} v'(b) - \frac{\lambda_u(1-F(w_R))}{r+\delta+\lambda_u(1-F(w_R))} \frac{d\tau}{db} w_R v'((1-\tau)w_R) \\ & - \lambda_u \frac{d\tau}{db} \frac{r+\delta+\lambda_e(1-F(w_R))}{r+\delta+\lambda_u(1-F(w_R))} \int_{w_R}^{\infty} [(1-\tau)xv''((1-\tau)x) + v'((1-\tau)x)] A(x) dx \end{aligned} \quad (64)$$

Next, we use integration by parts, together with  $r \approx 0$ , to get

$$\begin{aligned} & \int_{w_R}^{\infty} [(1-\tau)xv''((1-\tau)x) + v'((1-\tau)x)] A(x) dx \\ & \approx \frac{1-F(w_R)}{\delta+\lambda_u(1-F(w_R))} \left[ -w_R v'((1-\tau)w_R) + \int_{w_R}^{\infty} w v'((1-\tau)w) dG(w) \right] \end{aligned} \quad (65)$$

Substituting back into (64) and imposing  $r \approx 0$  everywhere, we get

$$\frac{dU}{db} \approx uv'(b) - (1-u) \frac{d\tau}{db} \int_{w_R}^{\infty} wv'((1-\tau)w) dG(w) \quad (66)$$

To get (16), we substitute in  $\frac{b}{\tau}$  using the budget constraint (14).

**Derivation of (19).** To derive the approximation in (19), we proceed in two steps. First, for any  $w$ , we write the Taylor expansion

$$wv'((1-\tau)w) \approx \bar{w}v'((1-\tau)\bar{w}) + (w-\bar{w})[(1-\tau)\bar{w}v''((1-\tau)\bar{w}) + v'((1-\tau)\bar{w})] \quad (67)$$

Since  $\bar{w} = \int_{w_R}^{\infty} w dG(w)$  by definition, we have

$$\int_{w_R}^{\infty} wv'((1-\tau)w) dG(w) \approx \bar{w}v'((1-\tau)\bar{w}) \quad (68)$$

A similar Taylor expansion establishes that

$$\int_{w_R}^{\infty} v'((1-\tau)w) dG(w) \approx v'((1-\tau)\bar{w}) \quad (69)$$

Next, we write the Taylor expansion

$$v'(b) \approx v'((1-\tau)\bar{w}) - ((1-\tau)\bar{w} - b)v''((1-\tau)\bar{w}) \quad (70)$$

Dividing both sides by  $v'((1-\tau)\bar{w})$  and using  $\int_{w_R}^{\infty} v'((1-\tau)w)dG(w) \approx v'((1-\tau)\bar{w})$ , we obtain

$$\begin{aligned} \frac{v'(b)}{\int_{w_R}^{\infty} v'((1-\tau)w)dG(w)} &\approx \frac{v'(b)}{v'((1-\tau)\bar{w})} \\ &\approx 1 - \frac{(1-\tau)\bar{w} - b}{(1-\tau)\bar{w}} \cdot \frac{(1-\tau)\bar{w}v''((1-\tau)\bar{w})}{v'((1-\tau)\bar{w})} \\ &= 1 + \gamma(1-\rho) \end{aligned} \quad (71)$$

Substituting (68), (69) and (71) into (16) gives (19).

## B Additional details on the calibration

In this section we detail how we calculate  $\kappa_u$  and  $\kappa_e$  for a given unemployment-to-employment flow rate  $h_u$ , employment-to-unemployment flow rate  $\delta$ , and job-to-job transition rate  $h_{ee}$ . We obtain  $\kappa_u = h_u/\delta$  directly from the job-finding rate and the job separation rate. We calculate  $\kappa_e = \lambda_e^*/\delta$ , where we define  $\lambda_e^* = \lambda_e(1 - F(w_R))$ . Following Nagypal (2008) and Hornstein *et al.* (2011),  $\lambda_e^*$  can be obtained from the job-to-job transition rate, denoted by  $h_{ee}$ , as follows. The job-to-job transition rate is given by

$$\begin{aligned} h_{ee} &= \lambda_e \int_{w_R}^{\infty} (1 - F(w)) dG(w) \\ &= \lambda_e \int_{w_R}^{\infty} G(w) dF(w) \\ &= \lambda_e \int_{w_R}^{\infty} \frac{\delta}{\delta + \lambda_e(1 - F(w))} \frac{F(w) - F(w_R)}{1 - F(w_R)} dF(w) \\ &= \delta \lambda_e^* \int_0^1 \frac{z}{\delta + \lambda_e^*(1 - z)} dz \end{aligned} \quad (72)$$

where the second line uses integration by parts, the third line uses the expression for  $G$ , and the fourth line uses the change of variables

$$z = \frac{F(w) - F(w_R)}{1 - F(w_R)}.$$

It then transpires that

$$h_{ee} = \delta \left[ \frac{\delta + \lambda_e^*}{\lambda_e^*} \ln \left( \frac{\delta + \lambda_e^*}{\delta} \right) - 1 \right], \quad (73)$$

which can be inverted to obtain  $\lambda_e^*$ .