The Foerder Institute for Economic Research
at Tel Aviv University

The Eitan Berglas School of Economics

מכון למחקר כלכלי על שם
ד"ר ישעיהו פורדר
על יד אוניברסיטת תל אביב

בית-הספר לכלכלה ע"ש איתן ברגלס

עמותה רשומה

On the Provision of Unemployment Insurance when Workers are Ex-ante Heterogeneous

Ofer Setty and Yaniv Yedid-Levi

Working Paper No. 12-2019

The Foerder Institute for Economic Research
and
The Sackler Institute of Economic Studies

מכון פורדר, אוניברסיטת תל-אביב, תל אביב יפו 6997801 | טל': 03-6409255 | פקס: 03-6405815
Tel Aviv University, Tel Aviv Yafo 6997801 Israel | Tel. 972-3-6409255 | Fax 972-3-6405815 | email: foerder@tauex.tau.ac.il

On the Provision of Unemployment Insurance when Workers are Ex-ante Heterogeneous*

Ofer Setty
Tel Aviv University

Yaniv Yedid-Levi
Interdisciplinary Center (IDC) Herzliya

This Draft: December 2019

Abstract
Labor market outcomes demonstrate considerable variation between and within skill groups. We construct a general equilibrium model with incomplete markets and exogenous differences that matches these facts. We study the role of exogenous heterogeneity in choosing the optimal replacement rate and the maximum benefit for an unemployment insurance (UI) system. The optimal average replacement rate is 27%, compared to 0% in a model without exogenous heterogeneity. The relatively generous choice is due to the redistributive role of UI, which is a manifestation of two elements. First, workers who are unemployed more often receive positive net transfers from the UI system because they draw resources more frequently. Second, the existence of a cap on benefits makes UI progressive. Our main result holds in the presence of a generous progressive taxation system.

JEL Classification: : D52, E21, J63, J64, J65, C68.

Keywords: Heterogeneous agents, Search and Matching, Incomplete markets, Unemployment Insurance, Redistribution.

*Previously titled: “Who Cares about Unemployment Insurance?”. We thank Paul Beaudry, Tobias Broer, Aspen Gorry, Moshe Hazan, Nir Jaimovich, Sebastian Koehne, Per Krusell, Toshihiko Mukoyama, Itay Saporta-Eksten, Henry Siu, David Weiss, Stephen Zeldes and seminar participants for very helpful comments. Special thanks to Avihai Lifschitz for his contribution and insightful comments during the early stages of this paper. Correspondence: Ofer Setty, Tel Aviv University, E-mail: ofer.setty@gmail.com. Yaniv Yedid-Levi, Interdisciplinary Center (IDC) Herzliya, E-mail: yaniv.yl1@gmail.com. Setty’s research is supported by the Israel Science Foundation (Grant No. 418/11). Yedid-Levi thanks the Social Sciences and Humanities Research Council of Canada for financial support.

1 Introduction

It is well documented that labor market outcomes vary substantially between and within skill groups. For instance, Heathcote, Perri, and Violante (2010) document an average college wage premium for men of 80%. It is also known that there exist a substantial variation in wages even when controlling for education and other observable characteristics. In addition, according to CPS data for 1996 - 2014, the average unemployment rate for male college graduates is 2.8%, while that of high-school dropouts is 8.7%, indicating that lower-skilled workers face higher unemployment risk.

In this paper we study the effect of these heterogeneity features on the optimal design of an unemployment insurance (UI) system. The analysis is based on a general equilibrium model with incomplete markets, search frictions, ex-ante skill heterogeneity, and individual productivity shocks. The model generates heterogeneity in unemployment rates and dispersed wage and asset distributions.

Our main quantitative results highlight the role of the exogenous dimensions of heterogeneity. Specifically, while in the model without exogenous heterogeneity it is optimal to shut down the UI system (a 0% replacement rate), our model with exogenous heterogeneity calls for a much higher average replacement rate of 27%. The average replacement rate masks a considerable heterogeneity in replacement rates and the frequency of receiving benefits from the UI system. As a result, the UI system effectively redistributes resources between high-wage and low-wage workers. Such redistribution occurs either when there are differences in unemployment rates among workers, or when the UI policy includes a potentially binding cap on unemployment benefits. The former implies that certain types of workers draw resources from the UI system more frequently then others. The latter generates a degree of progressivity in UI benefits such that the effective replacement rate is higher for lower wage workers.

The justification for redistribution relies on the utilitarian welfare criterion that we use that favors equality. Our model exhibits a realistic variation in income, which in turn generates consumption dispersion across workers. Hence, a policy maker in our model associates the variation in consumption with an incentive for redistribution.

Taken together, the exogenous heterogeneity dimensions generate a model where it is possible to achieve positive welfare gains by redistribution through a UI system. Obviously, the generosity and progressivity of the UI system depend on its potential adverse effects on the economy, which we discuss below.

The analysis builds upon a model by Krusell, Mukoyama, and Şahin (2010) (henceforth KMS) that has two key building blocks. First, unemployment in the model is endogenously determined by a search and matching friction as in Diamond (1982), Mortensen (1982), and Pissarides (1985) (DMP). Second, as in Bewley (undated), Huggett (1993), and Aiyagari (1994) (BHA) workers can self-insure only via risk free assets, and are subject to a borrowing constraint. This implies that workers cannot perfectly insure their idiosyncratic unemployment risk, and that in equilibrium there is endogenous heterogeneity in asset holdings. KMS assume that all workers are ex-ante homogeneous and face no exogenous idiosyncratic shocks hence they abstract from issues of heterogeneity in productivity and unemployment risk.

To analyze the consequences of such heterogeneity we add two dimensions of exogenous heterogeneity. First, we assume that the population is divided into skill types that permanently differ in their unemployment rates and mean productivity level. Second, we allow for idiosyncratic productivity shocks within these types. Those two sources of exogenous heterogeneity play a major role in generating realistic distributions of wages and wealth in the economy.

The model includes two tax and transfer programs. First, the UI system includes a replacement rate typically used in the literature, as well as a cap on UI benefits. Including a cap in a model with a non-degenerate wage distribution allows the government to design a flexible transfer system. In particular, it creates a distribution of replacement rates for different workers in the economy. We refer to the weighted average of those replacement rates as the average effective replacement rate. Second, since we emphasize the role of UI as redistributing resources from high-wage to low-wage workers, we also include a progressive tax system. This allows us to show that UI plays a role even when intensive progressive transfers are present in the model. In what follows we explain how those polices drive our main result given the exogenous heterogeneity in our model.

The point of departure of our quantitative analysis is a model where we shut down exogenous heterogeneity in income and unemployment rates by eliminating both skill types and individual productivity shocks. We find that in this model there is no role for a UI policy, and it is optimal to shut down the UI system. This echoes the finding in KMS, who highlight the tension between BHA and DMP type of models. On the one hand, the fact that workers cannot insure idiosyncratic risks, as in many models in the BHA framework, implies ex-post heterogeneity in consumption even among ex-ante identical workers. Absent any costs of redistribution, these models typically call for a high level of unemployment benefits, in order to equalize consumption among workers. On the other hand, the search and matching friction places an incentive cost of UI on labor demand. Specifically, in the DMP framework wages are determined by Nash bargaining, hence a more generous UI system improves workers' outside options, increases wages, and depresses firms' incentives to maintain vacancies. Therefore, more generous UI benefits imply higher unemployment rate and lower output. In fact, in a typical version of the DMP model where workers are risk-neutral and the efficiency condition (Hosios, 1990) holds, that model calls for no unemployment benefits. Similar to KMS, without exogenous heterogeneity the costs of UI clearly outweigh the benefits.[1]

In contrast, our model with exogenous heterogeneity calls for a much higher average effective replacement rate of 27%. This figure is quite close to the average effective replacement rate implied by the current UI policy (33%). The optimal policy, however, is based on a combination of a higher replacement rate and a lower cap, thus generating more variation in effective replacement rates. Under the current UI policy, the range of effective replacement rates is between 12% and 40%, while under the optimal policy the effective replacement rates are between 5% and 79%.

Given that our model includes exogenous heterogeneity both across and within skill types we consider them separately. In a version of the model where only skill types exist, workers differ in both productivity and separation rates. These differences create an endogenous distribution of unemployment rates and wages across types. As in the data, high skill is associated with higher wages and lower unemployment. The difference in wages generates consumption inequality that incentivises the policy maker to redistribute across workers. The difference in unemployment rates allows the government to do so, as low-skill workers draw benefits at a higher frequency. In addition to this mechanism, the cap on unemployment benefits allows the government to provide low-skill workers with a higher replacement rate. As both higher frequency and higher replacement rate work in favor of redistribution to low-skill types, the government can use UI to redistribute resources across types. In this model the average effective replacement rate at the optimal policy is 17%.

The model with only individual productivity shocks illustrates the role of the cap. In this model there are no differences in unemployment rates and therefore the frequency of drawing benefits is the same for all workers. However, given the empirical distribution of individual productivities, the cap implies a declining profile of effective replacement rates over productivity. Therefore, redistribution from high-wage to low-wage workers is still possible. The resulting average effective replacement rate at the optimal policy for this model is 13%.

Our results highlight the redistributive role of UI even in the presence of a progressive tax

[1] In KMS the optimal replacement rate about 10%. Our model adds progressive taxation and a flexible matching function that is affected by the generosity of the UI system. These elements, respectively, decrease the benefit of UI and increase its cost, leading to a more extreme result.

system. Yet it is possible that the calibrated tax system is not sufficiently progressive in two related dimensions. First, a more progressive general tax system may improve welfare. Second, a more progressive tax system can make the UI system redundant. We therefore extend our analysis to allow for a joint choice of the general tax and the UI systems. The optimal general tax system is substantially more progressive and involves a higher average tax rate relative to the benchmark. The implementation of the optimal tax system makes the UI system less generous but it does not eliminate it. The effective replacement rate implied by the optimal UI system is 17%, and we show that similar patterns of redistribution through UI exist.

The distortions implied by the two system explain why UI is included in the optimal solution even in the presence of highly progressive taxation. Further progressivity of the general tax system substantially distorts capital accumulation, which results in lower wages. In contrast, UI redistributes resources at the cost of lowering employment with little effect on capital. Thus, the policy maker finds UI to be a useful substitution for redistribution resources while shifting the distortion from capital to labor.

Our paper is related to a large body of literature on optimal UI, where a policy maker trades-off insurance against incentives of workers and firms. Earlier papers characterized the incentive cost using workers' moral hazard considerations. Baily (1978) analyzed moral hazard in the context of static models, later generalized by Chetty (2006) in a dynamic set up. Shavell and Weiss (1979) studied an optimal contract between the worker and the planner in a principal-agent environment, which Hopenhayn and Nicolini (1997) used as a basis for a contract during employment as well as unemployment. The addition of savings in various forms is implemented in papers such as Hansen and Imrohoroglu (1992), Abdulkadiroglu, Kuruscu, and Şahin (2002) and Lentz (2009).

While these papers view unemployment as driven by workers' decisions, others have characterized the incentive cost of UI through firms and labor demand. Fredriksson and Holmlund (2001) model this cost through firms' incentives to post vacancies. Reichling (2007) introduces workers' self insurance with an exogenous interest rate. KMS integrate various aspects of these theories with endogenous interest rate, and use this general equilibrium model to consider, among other implications, the optimal level of UI benefits. Mukoyama (2013) demonstrates the importance of the general equilibrium analysis of welfare in that class of models.[2] Our paper advances the literature by emphasizing the implications of various dimensions of worker heterogeneity.

A few previous studies theoretically analyze the redistributive aspects of UI specific contexts.

[2]Mitman and Rabinovich (2015) and Jung and Kuester (2015) study the optimal provision of UI in the context of business cycles.

Wright (1986) characterizes a voting equilibrium in a model with heterogeneity in employment prospects only, no ability to save, and no incentive issues. He shows that under certain conditions, the median voter would use the UI system to insure the ex-ante "high-risk" workers. Marceau and Boadway (1994) consider redistribution between high and low-skill workers in a Mirrleesian economy. They argue that using a minimum wage policy coupled with a UI system can be welfare improving because it resolves the informational constraints hence allows for redistribution towards low-skilled workers. In the law literature, Lester (2001) surveys some of the legal and policy aspects of UI, and describes some of the potential redistributive roles of UI.

Quantitative analysis of models with ex-ante heterogeneity along similar dimensions can be found in Pallage and Zimmermann (2001) and Mukoyama and Şahin (2006). Pallage and Zimmermann (2001) consider the question of optimal UI with ex-ante heterogeneity in skills. Their focus and analysis are different from ours due to the fact that the choice of UI generosity is based on political, or voting considerations, rather than welfare. Their results indicate that it is the voting that matters for the determination of optimal UI, regardless of whether workers are ex-ante homogeneous or heterogeneous. Mukoyama and Şahin (2006) consider the welfare consequences of business cycle fluctuations once skill differences are taken into consideration, and show that unskilled individuals experience a substantial cost associated with business cycle fluctuations. Finally, Conesa and Krueger (2006) analyze the optimal progressive taxation in a model with ex-ante heterogeneous households.

This paper contributes to the optimal UI literature along two related dimensions. First, we show that in the presence of exogenous heterogeneity, an optimal UI system redistributes resources between high and low wage workers. Second, we emphasize the role of a cap on UI benefits in generating an effectively progressive unemployment benefits.

The rest of the paper is organized as follows. The model is presented in Section 2, and a detailed description of the calibration is in Section 3. Section 4 contains the quantitative analysis and the discussion of the results. In Section 5 we extend the analysis to a simultaneous choice of a UI system and a general progressive tax system. Concluding remarks are in Section 6.

2 The Model

The model consists of a few central building blocks. First, workers' productivity is a combination of a fixed type-specific level, and draws of individual productivity from a stochastic process. Second, unemployment is a result of a search and matching friction in the labor market. Third, heterogeneity in wealth arises endogenously from individual workers' asset accumulation decisions. Fourth, a standard neoclassical production function determines the level of output produced by each match. Finally, the government has two tax and benefit systems: (i) an unemployment insurance system that consists of a replacement rate, a cap on the level of maximum benefits, and a flat tax rate that balances that budget; (ii) a progressive tax system with lump sum redistribution.

We follow Krueger, Mitman, and Perri (2017) and assume that a constant fraction ν of workers dies every period and replaced by new workers of the same type. We assume that new workers are born unemployed with zero assets. Our analysis focuses on the stationary steady state of the model, thus we assume no aggregate risk. For comparability, where possible, we keep the notation close to KMS.

2.1 Sources of Heterogeneity

There is a measure one continuum of workers in the economy. We assume N types of workers, where the fraction of type $i \in \{1, ..., N\}$ is ϕ_i, and $\sum_i \phi_i = 1$. The fraction of workers of each type is constant. Workers of type i have type-specific separation rate s_i and a recruiting cost ξ_i. Productivity of workers, $z_i p$, is a product of a type-specific fixed effect z_i and an individual level (within type) p, which follows an AR(1) process:

$$\log(p_t) = \rho_i \log(p_{t-1}) + \epsilon_t \tag{1}$$

where ρ_i and σ_i^ϵ denote type specific persistence and standard deviation of the innovations. We assume that a new ϵ is drawn every employment period and when transitioning from unemployment to employment. A worker who transitions from employment to unemployment maintains his most recent p throughout the unemployment spell. Newborns draw initial individual productivity from the invariant distribution of p.

Another dimension of endogenous heterogeneity arises through asset accumulation. Workers can save and partially insure against unemployment risk by holding risk-free assets. In equilibrium, there exists a non-degenerate distribution of asset holding, as in BHA models.

Taken together, these sources of heterogeneity endogenously generate income and wealth differences across workers and unemployment rates differences across types.

2.2 Matching and Market Tightness

We assume that a worker's type is observable and that the labor market is segmented by types. Accordingly, firms maintain type-specific vacancies (v_i), and unemployed workers apply only to vacancies that correspond to their type. Let u_i denote the unemployment rate for type i, and assume that all unemployed workers search for jobs, such that the number of searchers in market i is $\phi_i u_i$. A constant returns to scale matching function, $M(v_i, \phi_i u_i) = \chi(\phi_i u_i)^\eta v_i^{1-\eta}$ determines the number of new type i matches in a period.

We define market tightness in market i, $\theta_i \equiv v_i/(\phi_i u_i)$, as the ratio of the number of vacancies to the number of unemployed workers in market i. Thus, we denote the probability that a worker meets a vacant job by $\lambda_i^w = \lambda^w(\theta_i)$ where λ^w is strictly increasing in θ. Similarly, let $\lambda_i^f = \lambda^f(\theta_i)$ denote the probability that a firm with a vacancy meets an unemployed worker of the same type, where λ^f is strictly decreasing in θ.

A type i match separates with constant and exogenous probability s_i in each period. Matches that are formed in the current period become productive in the next period.[3] Workers die with probability ν regardless of employment status and are replaced by unemployed workers of the same type. Firms treat the death of a worker as an exogenous separation. Denoting next period variables by a prime ($'$), the evolution of unemployment rate of type i, u_i, is

$$u_i' = \nu + (1-\nu)\left((1-\lambda_i^w)u_i + s_i(1-u_i)\right)$$

In equilibrium, when unemployment benefits increase, firms have a weaker incentive to post vacancies and therefore the job-finding rate falls. In order to quantitatively discipline the total effect of UI benefits on the implied job-finding rate we allow χ – the matching efficiency parameter – to depend on the generosity of the UI system.[4] Specifically, let B_i denote the average ratio of a given level of benefits relative to the level of benefits associated with some benchmark economy. Then we can characterize matching efficiency by $\chi = \tilde{\chi} + \Gamma \times (\exp(1) - \exp(B_i))$, resulting in the matching function:

[3] Our model includes idiosyncratic productivity shocks thus allows endogenous separations. However, in our calibration such separations are never optimal. We therefore describe the model only with exogenous separations, to save on notation.

[4] Our model, as in Fredriksson and Holmlund (2001), Reichling (2007), KMS, and Mukoyama (2013), characterizes the cost of UI through labor demand. Other studies, e.g. Hopenhayn and Nicolini (1997), Baily (1978), Lentz (2009), and Hansen and Imrohoroglu (1992) focus on labor supply. However, the empirical literature typically reports the elasticity of the job-finding rate to unemployment benefits, without distinction between supply and demand channels. The flexible χ makes it possible to match this total elasticity.

$$M(v_i, \phi_i u_i) = \left(\tilde{\chi} + \Gamma \times (\exp(1) - \exp(B_i))\right)(\phi_i u_i)^{\eta} v_i^{1-\eta}, \tag{2}$$

If $\Gamma = 0$ or UI benefits equal their benchmark level ($B_i = 1$) then matching efficiency is the constant $\tilde{\chi} > 0$, as in the standard DMP model. However, setting $\Gamma > 0$ enables us to capture the negative effects of the generosity of UI on matching efficiency in a reduced form manner.

2.3 Unemployment Insurance and Taxes

There are two tax and transfer systems: UI and a general progressive tax.

The UI system consists of a replacement rate h and a ceiling on the benefits κ. As long as the cap does not bind, the UI benefit is a fraction h of the average wage $\overline{w}_i(p)$ earned by employed workers of type i and productivity p.[5] We assume that UI is financed by a proportional tax τ^{UI} on labor earnings - wages for the employed, and unemployment benefits for the unemployed.[6] The government sets τ^{UI} to keep the UI budget balanced.

In addition, the government collects income taxes according to the tax function suggested by Benabou (2002) and more recently used by Heathcote, Storesletten, and Violante (2017):

$$T(y) = y - \lambda y^{1-\tau} \tag{3}$$

where y is the total flow income, which consists of wage or unemployment benefits, interest and dividend income, and $T(y)$ is tax paid. In this formulation $1 - \lambda$ is the tax rate levied on a person who earns the average income and τ governs the degree of progressivity. For instance, if $\tau = 0$ then the tax rate is flat at $1 - \lambda$, and the system is progressive if $\tau > 0$. Proceeds from this tax system are redistributed lump sum, denoted by Ξ.

2.4 Asset Structure

Workers have access to two types of assets: capital (k) and claims on aggregate profits (equity, x). The pre-tax return on capital is the rental rate r net of depreciation δ. The pre-tax return on equity

[5] We use the average wage in order to avoid the need to keep track of workers' individual histories. Our model results in wage functions that have little variation in wages *within* (i, p) pairs.

[6] In the US, UI is financed by firms' payroll taxes according to "experience rating" - firms that layoff workers more frequently pay higher tax rates. However, as shown by Card and Levine (1994) and argued by Ratner (2013), the experience rating system in the US is imperfect. To simplify, we abstract from experience rating.

is $\frac{d+\pi}{\pi}$, where d denotes dividends and π denotes the price of equity. Workers cannot hold claims on individual jobs, hence they cannot insure the idiosyncratic employment risk that they face.

A standard no-arbitrage condition implies that the returns on holding capital and equity are equal.[7] As a result, workers are indifferent with respect to the composition of the two assets in their portfolios. This allows us to track the pre-tax "total financial resources", $a \equiv (1 + r - \delta)\, k + (\pi + d)x$, as a single state variable for each worker. In addition, there exists an ad-hoc borrowing constraint $\underline{a}$.

2.5 Workers

Let $W_i(a, p)$ denote the value function of an employed worker of type i and individual productivity p, who owns a assets. Similarly, $U_i(a, p)$ denotes the value function of an unemployed worker of type i, individual productivity p ,who owns a assets. Workers' productivity level evolves according to Equation (1). They move between employment and unemployment according to the endogenous job-finding rate (λ_i^w), and the exogenous job separation rate (s_i). Workers take both probabilities parametrically.

Workers' period utility is represented by an increasing and strictly concave function $u(c)$, and they discount future streams of utility by a discount factor $\beta \in (0, 1)$. Utility depends on consumption (c) only, and there is no disutility from labor, home production, or search cost.[8] Therefore, all unemployed workers actively seek employment.

Workers allocate their available resources between consumption and accumulation of assets in order to maximize the discounted value of lifetime utility.

An employed worker begins a period with some level of assets (a), earns the period wage (w), pays UI and general taxes, and receives the lump sum transfer. The worker's wage - determined by Nash bargaining as explained below - is a function of the worker's type and asset holdings. Therefore, the beginning of period asset holdings a is the endogenous state variable, and p is the exogenous state variable of the problem. We follow Krueger, Mitman, and Perri (2017) in assuming that the assets of the deceased pay extra returns to survivors. Denoting the inverse of the gross real interest by $q \equiv \frac{1-\nu}{1+r-\delta}$, imposing the borrowing constraint, and taking the transition probabilities

[7] As there is no aggregate risk, the equity price remains constant in equilibrium. In addition, we assume that the same tax rate applies to both dividend and capital income. Therefore: $\pi = \frac{d+\pi}{1+r-\delta}$.

[8] While these features are not explicitly modeled, the flexible matching function described in equation 2 captures such elements in a reduced-form manner.

into account, we specify the employed worker's problem:

$$\begin{aligned} W_i\left(a,p\right) &= \max_{c,a'}\{u\left(c\right)+\beta_i(1-\nu)\left[s_iU_i\left(a',p\right)+\left(1-s_i\right)\mathbb{E}\left[W_i\left(a',p'\right)\right]\right]\} \\ \text{s.t.} &: \\ & c+qa'=a+w_i(a,p)-w_i(a,p)\tau^{UI}-T\left(a\times\frac{r-\delta}{1+r-\delta}+w_i(a,p)\right)+\Xi \\ & a'\geq \underline{a} \end{aligned} \tag{4}$$

where the argument in $T()$ is the flow taxable income for the general tax system.[9]

An unemployed worker begins a period with some level of assets (a), receives unemployment benefits $b_i(p)=\min\{h\overline{w}_i(p),\kappa\}$, pays UI and general taxes, and receives the lump sum transfer. Taking the transition probabilities into account, the unemployed worker's problem is

$$\begin{aligned} U_i(a,p) &= \max_{c,a'}\{u(c)+\beta_i(1-\nu)\left[(1-\lambda_i^w)U_i(a',p)+\lambda_i^w\mathbb{E}\left[W_i(a',p')\right]\right]\} \\ \text{s.t.} &: \\ & c+qa'=a+b_i(p)-b_i(p)\tau^{UI}-T\left(a\times\frac{r-\delta}{1+r-\delta}+b_i(p)\right)+\Xi \\ & a'\geq \underline{a} \end{aligned} \tag{5}$$

2.6 Firms and Production

There is a large number of firms that can potentially maintain vacancies of any type, as long as they pay the type-specific cost ξ_i. The value of maintaining a vacancy of type i, V_i , is

$$V_i=-\xi_i+q\left[(1-\lambda_i^f)V+\lambda_i^f(1-\nu)\mathbb{E}\left[J_i(a',p')\right]+\lambda_i^f\nu V\right], \tag{6}$$

where $V=\max\left\{V_1,V_2,...V_N,0\right\}$ because firms are free to choose between any of the N types of vacancies and being inactive. In equilibrium, firms post new vacancies until $V_i=0$ for all i.

We assume that firms discount future profits by q – the marginal rate of substitution of equity owners. The expected value of a match to the firm depends on the expected wage it will pay, that in turn depends on the worker's asset holdings (a) and individual level productivity (p). Therefore, the firm must form expectations regarding the (a,p) pair it will be matched with.

In order to produce, a firm with a filled vacancy has to rent capital. Let $k_i(p)$ be the capital-

[9] The flow asset income is $\frac{\nu+r-\delta}{1+r-\delta}$. However, we assume that the tax is levied only on the income generated by the worker's assets at the beginning of the period ($\frac{r-\delta}{1+r-\delta}$), and not on the return realized due to death ($\frac{\nu}{1+r-\delta}$).

labor ratio for matches of type i and individual productivity p. We assume a standard neoclassical production function $f(k)$ with $f' > 0, f'' < 0$, such that a match of type i and productivity p produces $z_i p f(k_i(p))$ units of output. With a frictionless capital market, all firms pay the same rental rate r, implying equal marginal products across firms.

The value of a filled job for a firm is the sum of the current period flow profits and the discounted continuation value

$$J_i(a,p) = \max_{k_i(p)} \{z_i p f(k_i(p)) - r k_i(p) - w_i(a,p) + q(1-\nu)\left[s_i V_i + (1-s_i)\mathbb{E}\left[J_i(a',p')\right]\right] + q\nu V_i\} \tag{7}$$

2.7 Wage Determination

As in many other papers in the DMP literature, including KMS, we assume that the wage is determined, period-by-period, by Nash bargaining. The resulting wage functions are solutions to the problems

$$\max_{w_i(a,p)} \left(W_i(a,p) - U_i(a,p)\right)^{\gamma} \left(J_i(a,p) - V_i\right)^{1-\gamma} \tag{8}$$

where $\gamma \in (0,1)$ represents the bargaining power of workers.

Due to the type-heterogeneity the solution involves a separate wage function $w_i(a,p)$ for each type. Wages are also a function of asset holdings (a) because the workers' value function depends on a.

We define the stationary equilibrium and describe the computational algorithm in Appendix A.

3 Calibration

In this section we describe the calibration of the model that is used to characterize a benchmark economy for the numerical analysis of policy experiments.

We identify skill with education and divide the labor force into four types: Less than high-school, High-school graduates, Some college, and Bachelor's degree and over, denoted $\{1,2,3,4\}$, respectively. The calibration of parameters relevant for unemployment differences is based on data from the CPS. The calibration of parameters that govern the differences in productivity across types relies on data from the PSID.[10] We use data from 1996 to 2014 for male labor force participants

[10] We use the data from Blundell, Pistaferri, and Saporta-Eksten (2018). We thank Itay Saporta-Eksten for supplying the data set.

who are 25 years and older, reflecting the assumption that most people have made their education level choice by that age. Finally, the calibration of type-specific discount factors relies on wealth moments from the Survey of Consumer Finances (SCF), for the years 1998-2013. As in many equilibrium models, there is no one-to-one correspondence between a single parameter or a single set of parameters and a calibration target. However, we organize this section such that targets are associated with the parameters that mostly affect them.

As in KMS, we set one period to 6 weeks, the production function to $f(k) = k^{\alpha}$, the utility function to $u(c) = \log(c)$, and the borrowing constraint $\underline{a}$ to 0. We choose $\alpha = 0.3$ and $\delta = 0.01$ to generate a capital share of 0.3 and investment–output ratio of 0.22.[11] We calibrate $\nu = 0.00036$ to match the social security data on death probability for men in 2004 at age 43 (the mid point of our sample and roughly the mid point of the population we consider in the next section).[12].

3.1 Policy Parameters

In our benchmark calibration of the UI system we set the replacement rate $h = 0.4$, i.e. a 40% replacement rate, as is typically used to describe the replacement rate in the US economy. We also set the ceiling on unemployment benefits $\kappa = 1.15$, which amounts to a fraction of about 48% of the median wage in the model. This calibration is based on data on maximum benefits by state, which is available for the years 2000-2009.[13] For each year, we calculate the level of maximum benefits for the median state. We use data from the Current Population Survey (CPS) to calculate the median weekly earnings for men who are either full or part time workers.[14] The calibration target for κ is the ratio of maximum benefits at the median state to median weekly earnings.

The parameters of the general income tax function are set to $\lambda = 0.9$ and $\tau = 0.15$ in accordance with Holter, Krueger, and Stepanchuk (2019), who use U.S. labor income tax data.

3.2 Labor Force, Matching and Unemployment

The top row of Table 1 describes the share of each education type ϕ_i, equal to the average share of each type in the labor force in CPS data over the sample period.

[11] In steady state aggregate capital is constant hence investment in our model is equal to the replenishment of depreciated capital.

[12] Available at `https://www.ssa.gov/OACT/STATS/table4c6_2004.html`

[13] see `https://workforcesecurity.doleta.gov/unemploy/uilawcompar/`

[14] We use data on men for consistency with our PSID sample, which is described below. The median weekly earnings are calculated as the weighted average of median weekly earnings of full time workers and part time workers.

The matching function we use (Equation 2) requires the calibration of η, $\tilde{\chi}$, and Γ. In addition, vacancies and unemployment are affected by the costs ξ_i and the separation rates s_i. We now discuss the calibration of these parameters in detail.

Calibration of η. Summarizing the literature that estimates the elasticity parameter η, Petrongolo and Pissarides (2001) establish a range of 0.5 - 0.7. Using more recent data, Brügemann (2008) finds a range of 0.54 - 0.63. In our benchmark calibration, we specify $\eta = 0.6$ to be near the mid point of these ranges. We set the worker's bargaining power parameter $\gamma = \eta$. In a textbook DMP model, setting $\gamma = \eta$ guarantees that the allocation is constrained efficient, as this calibration satisfies the Hosios (1990) condition for efficiency. This would imply zero unemployment benefits if utility is linear but possibly positive UI if utility is concave due to the value of insurance. It is important to stress that satisfying this condition in our model does not guarantee efficiency. As Davila, Hong, Krusell, and Rios-Rull (2012) show, BHA models are not generally efficient because of externalities involved in the accumulation of capital. We also note that given the incompleteness of the assets market in our model there are benefits for having insurance (see discussion in Mukoyama, 2013).

The joint calibration of $\tilde{\chi}$, s_i and ξ_i. In the benchmark economy $B_i = 1$, hence matching efficiency affects the job-finding rate only through $\tilde{\chi}$, which we calibrate next and requires some discussion. As in other DMP models, differences in unemployment rates across types can stem from different separation rates, different job-finding rates, or both, as visible in the equation that describes the steady state unemployment rates

$$u_i = \frac{s_i + \nu - s_i\nu}{s_i + \nu - s_i\nu + \lambda_i^w(1-\nu)}$$

The average unemployment rates decline with skill and equal 8.7%, 6.1%, 4.8%, and 2.8% for types 1-4 equal, respectively.

In order to determine which one is mostly responsible for the observed differences in unemployment rates we follow the approach described by Shimer (2012), which is based on analysis of stocks and correction for short-term unemployment. Interestingly, the data suggest a clear pattern of declining separation (employment exit) and job-finding probabilities with skills.[15]

[15] The monthly separation probabilities from low to high-skill types are: 3.3%, 2.1%, 1.6%, and 0.8%. The monthly job-finding probabilities from low to high-skill types are: 50%, 45%, 45%, and 39%. Elsby, Hobijn, and Şahin (2010) report similar findings using CPS data for all working age population. Contemporaneous with our work and using a

Note that the differences in job-finding rates alone would imply a counterfactual increasing pattern of unemployment with skill. Therefore, and to keep the model parsimonious, we calibrate the model such that in the benchmark calibration, the entire difference in unemployment rates between types is due to the variation in the job separation rate. Specifically, we target a single equilibrium job finding rate of 0.6 per six-weeks period, consistent with the average monthly job-finding rate in the data. Then we compute the implied separation rates such that the unemployment rate per type is consistent with CPS data. The resulting values of s_i are described in the second row of Table 1.

We use the set of zero profit conditions - one for each type of vacancies - to calibrate the recruiting cost parameters ξ_i as follows. In order to set the job-finding rate at 0.6 for all types, we normalize the values of θ_i to equal 1 for all types, and set the matching efficiency parameter χ to equal 0.6. Given the productivity levels z_i, the expected individual productivity, and the separation rates, we use the zero profit conditions to solve for ξ_i such that $\theta_i = 1\ \forall i$. The resulting values of ξ_i are described in the third row of Table 1.

There is some empirical evidence supporting the result of vacancy costs that increase with education. Dolfin (2006) finds that the number of hours required for recruiting, searching, and interviewing workers depends on their education. Assuming that the skill of the workers engaged in recruiting is independent of the worker recruited, Dolfin (2006) finds that the cost of recruiting a high-school graduate is 50% higher than the cost of recruiting a lower skill worker, and that the cost of recruiting a worker with more than high-school education is 170% higher than the cost of recruiting a worker with less than high-school education. Barron, Berger, and Black (1997) report findings based on a variety of data sources, all clearly suggest that the cost of recruiting a worker increases in the worker's level of education.[16]

Calibration of Γ. Our target moment is the elasticity of the job-finding rate with respect to unemployment benefits. Early empirical literature suggests a wide range of estimates between 0.2 and 0.9 (Krueger and Meyer (2002)). More recent studies point to a narrower and somewhat lower range. Chetty (2008) estimates an elasticity of 0.53 using SIPP data and average UI benefits. Michelacci and Ruffo (2015) estimate an elasticity of 0.36 using the same SIPP data but impute

very similar methodology, Cairo and Cajner (2013) document similar patterns across education groups.

[16] Cairo and Cajner (2013) calibrate their model such that the recruiting cost is proportional to workers' productivity, which is not the case in our calibration. One reason for consistency between the two calibration strategies is that in their model, Cairo and Cajner separate between recruiting cost and training cost, and argue that the latter is higher for high-skilled workers. If we think about recruiting costs as inclusive of such training costs, then the pattern of our calibration is consistent with theirs.

Table 1: Type-specific parameters

	Less than high school	High school	Some college	Bachelor's and over
Population share (ϕ_i)	0.1128	0.3059	0.2566	0.3247
Separation rate (s_i)	0.0568	0.0384	0.0302	0.0170
Vacancy cost (ξ_i)	0.8092	1.1467	1.4208	2.3122
Productivity fixed effect (z_i)	0.7200	0.8615	0.9683	1.2527
Productivity persistence (ρ_i^ϵ)	0.9821	0.9821	0.9821	0.9821
Productivity shock (σ_i^ϵ)	0.0976	0.0976	0.0976	0.0976
Discount factor (β_i)	0.9940	0.9949	0.9949	0.9961

individual UI benefits rather than using averages. Meyer and Mok (2014) estimate a range from 0.1 to 0.2 using a policy change in the state of New York. We choose a benchmark elasticity of 0.36, as in Michelacci and Ruffo because our calibration exercise uses individual changes in UI benefits, which is consistent with their estimation. For completeness, we also show the effects of lower and higher elasticities on our main results in Appendix B.4.

In the basic DMP model more generous UI benefits strengthen the outside option for workers. As a result, firms post fewer vacancies and the job-finding rate falls. This mechanism operates in our model and results in an elasticity of 0.20 even when $\Gamma = 0$. In order to match an elasticity of 0.36, we change UI benefits by 10% for each worker in the benchmark economy, and check the elasticity for various levels of Γ. A value of $\Gamma = 0.03$ matches an elasticity of 0.36.

3.3 Productivity Parameters

To capture the differences in productivity parameters we use data on hourly wage from the PSID.[17] We restrict attention to male household heads who are 25 years or older, continuously employed, and have no missing data on wages or hours of work.

To calibrate the group fixed effects (z_i) we compute the hourly wage for each person in every year, assign people to the appropriate education group, and compute the median hourly wage within an education group for a given year. The median wages are used to compute the "education premiums" in each year. The parameter values reported in the fourth row of Table 1 take into

[17] In DMP models with Nash bargaining the separation rate has an effect on the wage as well. However, our model results indicate that differences in productivity account for more than 98% of the wage variation across type. Therefore we use data on wages to calibrate the productivity process.

account the average wage premiums over all years in our sample, while keeping the weighted average of ex-ante productivity equal to one.

To facilitate comparability across the various calibrations we discuss below, we choose identical persistence and standard deviation parameters for individual productivity.[18] These parameters are estimated as follows. First, we run a standard Mincer regression of log wages with standard controls, including education.[19] Second, we use the regressions to predict the residuals and use the panel dimension of the sample to estimate a regression identical to Equation 1. The point estimates for the AR(1) coefficient are based on a two year period hence in the fifth row of Table 1 we report the values that correspond to the model period of six weeks. Finally, we use the predicted residuals from the second regression to compute the standard deviation of the residuals. The reported values in the sixth row of Table 1 are converted to the model frequency and used as our calibration parameters for the standard deviation of idiosyncratic shocks.

3.4 Discount Factors

Heterogeneous discount factors have been used in conjunction with BHA models in order to generate more realistic wealth distributions.[20] We introduce heterogeneity in discount factors across education groups in order to match differences in wealth between the groups in the data. The SCF reports (every three years) the median family net worth and provides a breakdown by education of household heads that accords with our four education groups. We normalize the median wealth of high school dropouts to 1, and compute the median wealth ratios by education for each year. Our calibration targets are the averages of these premiums for the years 1998 to 2013: 2.9, 3.3, 12.0 for high school graduates, some college, and Bachelor's degree and over, respectively.

The four discount factors, reported in the last row of Table 1, are chosen to reasonably match the three premiums. Together with the depreciation rate δ and the death rate ν the annual interest rate is 4.1%. We discuss the model's results with regards to the wealth distribution in Section 4.1.

[18] For our baseline model, we verify in Appendix B.2 that heterogeneity along these dimensions does not affect the main results.

[19] Experience, experience squared, and dummies for year, state, marital status, and race.

[20] See, for example, Krusell, Mukoyama, Şahin, and Smith (2009) and Krueger, Mitman, and Perri (2017).

Table 2: Wage moments

	Data	Benchmark calibration	Only individual shocks	No individual shocks
Wage premiums				
Type 2	31%	30%	NA	31%
Type 3	56%	55%	NA	55%
Type 4	127%	126%	NA	126%
Gini	0.39	0.44	0.39	0.19

Notes: Wage premium for type i is the percent difference between the median wage of type i and the median wage of type 1 (high school dropouts). The Gini coefficient in the data column is the average of the yearly Gini coefficients in the PSID sample we use.

4 Results: the UI System

In this section we use the calibrated model to study the dual role of the UI system in the economy as insurance against unemployment and as an instrument for redistribution of resources from high-wage to low-wage workers. First, we show that the inclusion of individual productivity shocks and ex-ante heterogeneity results in substantially more dispersed wage and wealth distributions. Second, we demonstrate the costs of UI by looking at its effect on unemployment, capital, aggregate consumption, and GDP. Then we discuss the welfare criterion that we use to determine the optimal policy (or policies) throughout our analysis, and turn to analyzing the welfare effects of changing the UI policy parameters.

We implement the policy analysis by computing the stationary equilibrium for the benchmark calibration with a replacement rate $h = 40\%$ and a cap on unemployment benefits $\kappa = 1.15$, as well as alternative economies with different combinations of h and κ. For these alternative economies, the only parameter we adjust other than the cap and replacement rate is the tax rate τ^{UI} that balances the government budget. To clarify the roles of UI in the model, we compare the results to those of a model with ex-ante homogeneous workers, as well as models where only some heterogeneity dimensions are present.

4.1 Wages and Wealth

One motivation for considering additional heterogeneity dimensions in this context is to generate an economy with more realistically dispersed wages and wealth relative to a typical BHA economy with ex-post asset heterogeneity only.

Table 2 describes the effect of sources of exogenous heterogeneity on the wage distribution. Column (1) shows the wage premiums and Gini coefficient in the PSID, Column (2) shows the same moments for our benchmark calibration, Column (3) describes the moments for a model with individual shocks only, while the last column describes the results of a model with all dimensions of heterogeneity other than individual shocks. As point of reference we note that a model with no exogenous heterogeneity (i.e. similar to KMS) has a low Gini coefficient (0.05) and, by construction, no wage premiums. Individual productivity shocks contribute substantially to increasing the Gini coefficient of wages (0.39) due to the fact that the individual productivity process is highly persistent and contributes to high ex-post variation in wages. The results in the last column indicate that the existence of ex-ante heterogeneity is instrumental in generating the skill wage premiums. Finally, it is worth noting that wages within type-productivity pairs are fairly inelastic with respect to assets.[21]

Table 3 describes various moments of the wealth distribution in the data (Column 1), in our benchmark calibration (Column 2), and in a calibration without exogenous heterogeneity that resembles KMS (Column 3). The top panel shows that our benchmark calibration provides a fair match to the wealth ratios in the data. The middle panel describes the share of wealth owned by quintiles. The data figures are taken from Krueger, Mitman, and Perri (2017), who show that the overall wealth at the hands of the bottom 40% of the economy is around 1%. While our calibration does not match the data precisely, it is a substantial improvement over the model with no ex-ante heterogeneity. The bottom 40% hold 3.7% of wealth in our benchmark calibration and 19.4% in a model with ex-ante homogeneous workers.[22]

4.2 Analysis of Steady States

In our main set of experiments the benchmark economy corresponds to the calibration described in Section 3, with a replacement rate $h = 40\%$ and a cap on unemployment benefits $\kappa = 1.15$. The alternative economies that we consider involve fixing all the parameters but the replacement rate, the cap, and the implied UI tax. We consider replacement rates in the range $[0, 1]$ and caps in the

[21] Krusell, Mukoyama, and Şahin (2010) and Bils, Chang, and Kim (2011) present similar wage functions in similar frameworks. The low variability of wages within type-productivity pairs supports the simplification in characterizing unemployment benefits as a replacement rate times the average wage for a type-productivity pair.

[22] Krueger, Mitman, and Perri (2017) achieve an even better fit for the quintiles. We adopt their approach of using individual productivities and death shocks. For computational reasons, our implementation of heterogeneous discount factors is at the type level and not an additional individual shock.

Table 3: Wealth moments

	Data	Benchmark Calibration	No exogenous Heterogeneity
Wealth ratios			
Type 2	2.9	2.8	1.0
Type 3	3.3	3.2	1.0
Type 4	12.0	12.3	1.0
% share by			
Q1	-0.2	0.5	5.8
Q2	1.2	3.2	13.6
Q3	4.6	11.1	20.9
Q4	11.9	24.8	27.5
Q5	82.5	60.4	32.2
Gini	0.78	0.60	0.28

Notes: Top panel: wealth ratio for type i is the ratio of median wealth of type i relative to type 1 (high school dropouts). Middle panel: share of aggregate wealth owned by quintiles of the wealth distribution. Data source: wealth ratios - SCF; qunitiles and Gini coefficient - Table 1 of Krueger, Mitman, and Perri (2017).

range $[0, 2]$, as well as no cap.[23]

In order to create a more generous UI system, a policy maker can increase the replacement rate up to the point where the cap binds for the entire population, or increase the cap in cases that it does not bind for (at least) a fraction of the population. The costs of a more generous UI system follow the logic of the DMP model: it improves workers' outside option, increases wages, depresses firms' incentive to maintain vacancies, and increases unemployment. Lower employment leads to a decline in the demand of capital. Hence aggregate production is expected to decline as well.

Considering alternatives around our benchmark calibration illustrates this point. First, when we fix the replacement rate at 40% and raise the cap from zero (i.e. no UI benefits) to a non-binding cap (the minimum and maximum values we consider), we naturally increase the effective replacement rate from 0% to 40%. In this case we observe a drop of 1.87% in capital, a GDP loss of 1.73%, aggregate consumption decline of 1.11%, and increase in unemployment rates in the range of 42% to 50% for the different types of workers.[24] Second, when fixing the cap at 1.15 and increasing the replacement rate from 0 to 1, the effective replacement rate increases from 0% to 56%. This lowers capital by 2.86%, consumption by 1.32%, and GDP by 1.96%. The response of unemployment rates varies considerably across types as the point at which the cap becomes binding varies due to the level differences in wages. In this case, the unemployment rates increase by 69%, 49%, 40%, and 27% for types 1-4, respectively.

4.3 A Welfare Criterion

To study the choice of an "optimal" replacement rate, we adopt the welfare criterion used in KMS and Mukoyama and Şahin (2006), which also resembles that in Pallage and Zimmermann (2001). First, we define a benchmark economy, such as our benchmark calibration, and calculate its stationary equilibrium. We then consider alternative economies, where we fix all the parameters except those relevant for the policy question, and calculate their steady state equilibrium. For each alternative we calculate the individual (characterized by type, individual productivity, employment status, and asset holding) welfare gain or loss relative to the benchmark. This measure of individual

[23]Other than the benchmark, we consider 987 alternatives, with 21 points for h and 47 options for κ.

[24]The increase in unemployment rate is from 6.55% to 9.32% for type 1, 4.67% to 6.71% for type 2, 3.76% to 5.46% for type 3, and 2.27% to 3.42% for type 4.

welfare difference is characterized by Ω, defined by:

$$E_0\left[\sum_{t=0}^{\infty}\beta^t\log\left(\left(1+\Omega\right)c_t\right)\right]=E_0\left[\sum_{t=0}^{\infty}\beta^t\log\left(\widetilde{c}_t\right)\right] \tag{9}$$

where c_t is consumption under the benchmark and $\widetilde{c}_t$ is consumption under an alternative. Hence, Ω for each worker is based on his status in the benchmark economy and his value in the alternative economy, which is affected by prices, probabilities and policy changes.

Finally, for each alternative economy we sum over the individual Ωs according to the distribution in the benchmark economy. This results in a measure of the aggregate welfare gain, where a positive aggregate gain is considered preferable over the benchmark. We refer to the policy with the highest aggregate gain as the "optimal" replacement rate and cap pair. This welfare criterion is preferable over summing steady state welfare levels for the different economies because a plain steady state comparison would miss the potentially important consequences of the short run savings adjustments along the transition to a new steady state. While admittedly we do not consider the entire transition path for all our results, in Section 4.7 we show that the main result is insensitive to whether or not the full transition path is taken into account: the welfare gain associated with shifting to the optimal policy is similar, and the optimal policy dominates alternative policies in its neighborhood.

A few issues regarding the welfare criterion warrant discussion. First, as pointed by Mukoyama (2010), this welfare criterion favors policies that redistribute resources from rich to poor individuals. This property of the welfare criterion is central to our analysis as we associate more inequality with stronger motivation to redistribute towards equality.

Second, and related to the first point, the welfare function operates over equivalent consumption rather than wealth. This is important because it is not wealth per se that matters for the policy maker but rather the present discounted value of each individual, which is composed of both wealth and human capital. Mukoyama (2010) describes this point in more detail.

Third, note that the optimal choice is determined by the total gain. In this respect, our choice is consistent with the analysis in KMS, but departs from the analysis in Pallage and Zimmermann (2001) that considers voting patterns, and therefore emphasizes the fraction of population that gains from a change in UI policy.

4.4 The Optimal UI System

In this subsection we present the results of a series of experiments where the sources of policy variation are the replacement rate, the cap, and the implied UI tax. First, we describe the optimal policy based on the benchmark calibration of our model with ex-ante heterogeneity as described in Sections 2 and 3. Then we describe the optimal policy for a model that is similar to KMS, where there is no exogenous heterogeneity.[25] The two models imply very different policy prescriptions. In order to understand what drives the large differences between the policy prescriptions, we gradually introduce the components that differentiate the two models. For each model we set the benchmark to have a replacement rate of 40% and a cap $\kappa = 1.15$, and consider alternative pairs of replacement rate and cap such that $h \in [0, 1]$ and $\kappa \in [0, 2]$ as well as no cap. Table 4 summarizes the results across models.

Our benchmark model suggests that welfare peaks at $h = 0.8$ and $\kappa = 0.44$. At the optimum, the average effective replacement rate is 27%, as opposed to 34% in the benchmark. The welfare effects are non-negligible. For instance, switching from the benchmark to the optimal UI system results in an aggregate welfare gain of 0.45%. By comparison, using the same welfare measure in a different context, Mukoyama and Şahin (2006) find an average welfare gain of 0.024% when eliminating business cycles.

In sharp contrast to the benchmark model, the optimal policy in a model without exogenous heterogeneity workers calls for $h = 0.0$ and $\kappa = 0.0$, effectively shutting down UI. The substantial difference in the optimal policy between the two models can stem from any of the differences between the two models: idiosyncratic productivity shocks (p), ex-ante heterogeneity in discount rates (β), separation rates (s), and productivity (z). We gradually introduce these features to the exogenously homogeneous model in order to better understand their effect on the optimal policy. For each of these "counterfactual" exercises, we recalibrate the model such that at $\{h = 0.4, \kappa = 1.15\}$ the economy reaches the same unemployment rate, median wage, and real return as in the calibration described in Section 3.[26] We then search for the optimal policy by altering the replacement rate and the cap, where for each counterfactual, by construction, the welfare gain is zero at $\{h = 0.4, \kappa = 1.15\}$.

Departing from ex-ante homogeneity, we observe that heterogeneous discount factors have no

[25] This model is essentially KMS with progressive taxes and the modified matching function described in Equation (2). When we consider ex-ante homogeneous workers, we calibrate the model such that the productivity level, the separation rate and the discount rate are all equal across types.

[26] Clearly, certain data moments cannot be matched (e.g. wage dispersion without productivity differences, wealth dispersion without heterogeneity in discount factors, etc.)

Table 4: Optimal policy: various models

Model	Optimal RR	Optimal Cap	Effective RR
Benchmark	0.8	0.44	0.27
No exogenous heterogeneity	0.00	0.00	0.00
Add β	0.00	0.00	0.00
Add β, s, z	0.25	0.35	0.17
Add β, p	0.35	0.26	0.13

effect on the optimal UI policy. Therefore, while heterogeneous discount factors are instrumental for matching data moments, they cannot explain the difference in optimal policy choice between ex-ante homogeneity and ex-ante heterogeneity. In contrast, the inclusion of either ex-ante differences in separation rates and productivity, or productivity shocks, appears to have a substantial effect on the optimal design of UI policy. The findings reported in the last two rows of Table 4 indicate that for both models the optimal UI policy is significantly more generous relative to the ex-ante homogeneous case. In what follows we argue that UI redistributes income from high-wage workers to low-wage workers, and that this is a key reason for the increasing generosity when moving from the model with no exogenous heterogeneity towards the benchmark model.

4.5 The Redistributive Role of UI

The goal of redistributive policies is lowering consumption dispersion. Simply put, had redistribution been costless, and given the fact that the welfare criterion favors equality, a policy maker would prescribe the same level of consumption to all workers. In our model we note three important features. First, using UI is costly, as illustrated by higher unemployment, lower capital, lower GDP, and lower aggregate consumption. Second, there is heterogeneity in consumption *across* types that may justify some degree of reallocation. Finally, there is also heterogeneity *within* type, due to individual productivity shocks. These facts may increase the gains from redistributing resources between workers in the economy, according to the welfare criterion. With this, our interpretation of the results is that given that UI is costly, the optimal policy is affected by the value of insurance, gains from redistribution, and the ability to use the UI system to redistribute resources.

As an illustration of the effect of UI on consumption dispersion, we note that the Gini coefficient for steady state consumption equals 0.26 when there is no UI and 0.24 when using either the calibration described in Section 3 $\{h = 0.4, \kappa = 1.15\}$, or the optimal policy $\{h = 0.8, \kappa = 0.44\}$.

Table 5: Implications of UI policies

	Effective RR (%)		Net transfers (%)		Welfare
	Benchmark	Optimal	Benchmark	Optimal	Gain (%)
Total	34	27	0.0	0.0	0.45
Type 1, average	37	37	2.1	1.5	0.75
Type 1, low p	40	79	2.3	5.6	1.75
Type 1, med p	40	29	2.3	1.7	0.61
Type 1, high p	27	10	1.1	0.2	0.01
Type 2, average	35	28	0.7	0.4	0.46
Type 2, low p	40	61	1.2	2.7	0.96
Type 2, med p	40	22	1.2	0.6	0.35
Type 2, high p	20	8	0.0	-0.2	0.18
Type 3, average	34	24	0.2	0.0	0.39
Type 3, low p	40	52	0.7	1.6	0.72
Type 3, med p	40	19	0.7	0.2	0.29
Type 3, high p	17	7	-0.4	-0.3	0.27
Type 4, average	29	16	-0.8	-0.5	0.40
Type 4, low p	40	36	-0.1	0.3	0.44
Type 4, med p	33	13	-0.3	-0.3	0.38
Type 4, high p	12	5	-0.9	-0.5	0.42

To capture the heterogeneous effect of the UI system across workers, we start by describing in Table 5 the implications of implementing the optimal policy relative to the benchmark. The existence of a cap on benefits implies variation of the effective replacement rates across type-productivity pairs. At the benchmark economy (Column 1) replacement rates vary between 12% for the highest income individuals, and up to 40% for workers who earn lower incomes. The optimal policy (Column 2) involves a higher replacement rate and a lower cap, thus generating more dispersion in effective replacement rates: from 5% to 79%. Importantly, the larger dispersion is along two dimensions. First, we observe that the effective replacement rate is higher for lower skill types, both on average and conditional on individual productivity. Second, within types, the effective replacement rates decline substantially for workers who earn more due to higher productivity.

Columns 3 and 4 of Table 5 describe the implied net transfers – the difference between UI benefits and UI taxes paid by an average worker of each type-productivity pair. For comparability, we report these transfers as percents of the median wage of that type-productivity workers. The ability of the UI system to redistribute resources across workers is clearly visible by the fact that some workers are net payers to the system (i.e. negative values) while others are net recipients. Moreover, net transfers in the benchmark model clearly indicate that the highest skill workers are the net payers to the system, while low-skill workers receive the most according to this metric. This is due to the fact that unemployment rates are different, and therefore low-skill types draw resources from the UI system more frequently relative to high-skill workers. The cap on UI benefits has an important role with regards to net transfers as well. Focusing on the differences *within types* we observe that as long as workers have the same effective replacement rate, they have similar net transfer as a percent of their wage. Once we move from the benchmark to the optimal policy, the optimal cap is binding for more workers, thus creating a more dispersed effective replacement rate. This, coupled with an identical UI tax rate, leads to an increase of net transfers relative to the wage for workers who experience an increase in the effective replacement rate.

As a result of the differences between the optimal UI system and the benchmark economy, we observe a substantial variation in welfare consequences (Column 5) both across and within types. Interestingly, the optimal policy involves a welfare gain for all type-productivity pairs. The reason is that the optimal system is less generous than the benchmark (on average) and involves a lower UI tax rate, which leads to lower unemployment rates and higher GDP.[27] Hence, the more progressive optimal UI system improves welfare by distributing fewer resources more efficiently. Clearly, changes in the elasticity of the job-finding rate to UI benefits will affect the cost of UI. In Appendix B.4 we demonstrate this point by considering both lower and higher elasticities relative to our benchmark calibration. As expected, the higher the elasticity the less generous the optimal UI system is. However, the patterns of redistribution implied by UI remain.

The cross-type effects operate in a similar way in the version of the model that has no individual productivity shocks, but has all other dimensions of ex-ante heterogeneity. In that model the optimal UI system $\{h = 0.25, \kappa = 0.35\}$ generates an effective replacement rate of 17% (see Table 4). The effective replacement rate exhibits a declining profile across types and vary between 23% for type 1 to 10% for type 4. Therefore UI achieves similar redistribution goals by increasing transfers to the lowest productivity type on account of the highest productivity type. In this model, the differences in unemployment rates are sufficient to support a similar effective replacement rate even when the cap never binds because lower types are unemployed more frequently and draw more resources from the UI system.

[27] The UI tax rate drops from 1.3% at the benchmark to 0.6% at the optimal policy. The unemployment rates are lower for all types by about 10%, and GDP is higher by 0.6%.

The effect of the persistent individual productivity shocks on the optimal UI system can also be described using the results of the model that includes such shocks but does not have ex-ante differences in s and z. We first note that this model calls for a UI system of $\{h = 0.35, \kappa = 0.26\}$, resulting in an effective replacement rate of 13%, as described in Table 4. The existence of a cap implies that the effective replacement rate is higher for low-productivity workers, for whom the cap is less likely to bind. As a result, the UI system generates redistribution even absent differences in unemployment rates due to the negative correlation between the effective replacement rate and the wage. Under the optimal policy for that model the effective replacement rate varies from 29% for the lowest productivity type to just under 4% for the highest productivity worker. Interestingly, in this model (with just productivity shocks), if we set the cap to be at a level such that it never binds, then the optimal policy calls for shutting down UI. This is due to the fact that since there are no differences in unemployment rates, and as the cap never binds, the UI system can no longer be used to redistribute resources.

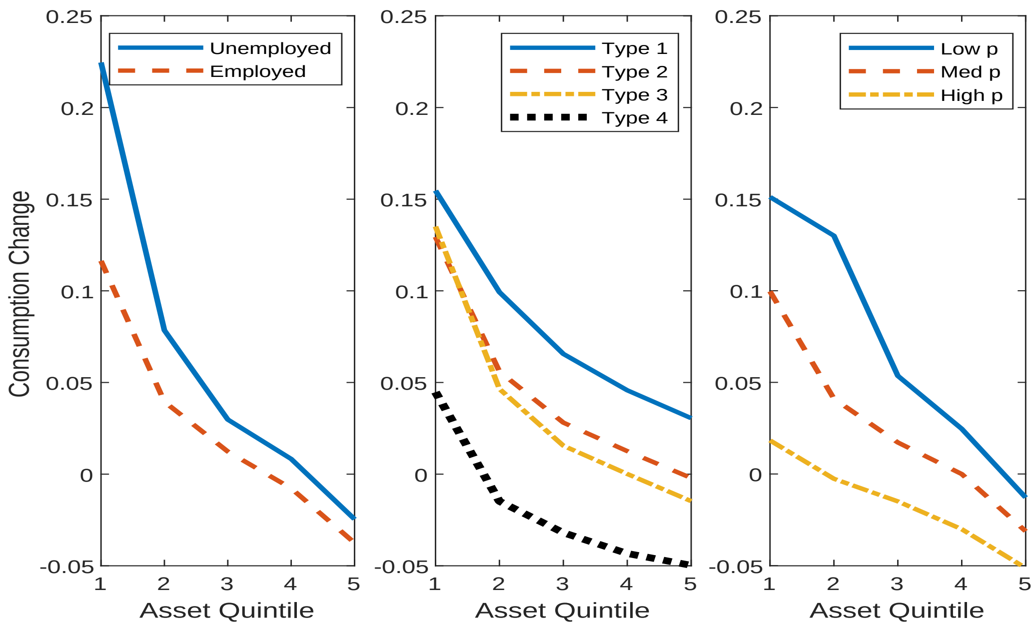
Taking stock, we conclude that both individual productivity shocks and ex-ante productivity differences across types generate income and consumption inequality hence potential welfare gains from redistribution. UI achieves two dimensions of redistribution. Redistribution within types is possible due to differences in effective replacement rates that are induced by the cap. Redistribution across types is possible due to variation in effective replacement rates as well as variation in unemployment rates that implies that low-skilled workers draw resources from the UI system more frequently.

4.6 The Insurance Role of UI

Our analysis thus far suggests that in our model UI has a redistributive role beyond the standard insurance role. Furthermore, judging by the results of the model with ex-ante homogeneous workers, it appears that the insurance role is relatively small, while heterogeneity allows for redistribution using UI. To shed more light on the quantitative importance of insurance and redistribution we conduct a thought experiment in which we measure the consumption changes associated with moving from a no UI policy $\{h = 0, \kappa = 0\}$ to the optimal one $\{h = 0.8, \kappa = 0.44\}$. To be consistent with the welfare analysis we calculate the consumption difference for each worker (with his employment status, asset position, and individual productivity) when moving from an economy without UI to an economy with the optimal policy.

Figure 1 depicts the consumption differences by asset quintiles for three states of interest: employment status, types and individual productivity. The left panel presents the results for employed

Figure 1: The Effect of UI on Consumption



Notes: Change in consumption levels when changing the UI policy from a no UI policy $\{h = 0, \kappa = 0\}$ to optimal $\{h = 0.8, \kappa = 0.44\}$, by asset quintile. Results based on the consumption policy functions. Left: by employment status; Middle: by education type; Right: by individual productivity.

and unemployed workers. In this panel the unemployed experience a greater increase in their consumption relative to the unemployed across all quintiles. This pattern illustrates the typical insurance role of UI. A second pattern is that workers at lower quintiles experience a greater level increase in their consumption. This result is an indication for a typical redistribution from the asset-rich to the asset-poor. In our model, lower asset bins have a larger proportion of low education types and low individual productivity workers.[28] Therefore, the redistribution from asset-rich to asset-poor is effectively a redistribution along those two dimensions.

The middle and the right panels of Figure 1 illustrate this point again. In the middle panel we repeat the same exercise for the four eduction types. This panel shows that lower types experience a greater consumption increase for all asset quintiles, where the gains and losses are of the same order of magnitudes as those in the left panel. In the right panel we repeat this exercise again but this time using low, medium and high individual productivity levels. This panel shows another clear pattern of redistribution, this time across productivity, reflecting redistribution from high-wage to

[28]Table 3 shows the wealth of types 2-4 is 2.6, 3.2, and 12.8 times the wealth of type 1. In addition, a worker with high (medium) productivity holds 3.55 (1.78) times the assets held by a worker with low productivity.

low-wage workers.

Taken together, the three panels show an elaborated transfers scheme, which consists of both insurance against unemployment and important channels of redistribution. Moreover, while unemployment is a rather transitory state in the model, productivity is far more persistent and eduction types are permanent, explaining why these dimensions of exogenous heterogeneity have a sizable effect on the optimal UI in Table 4.

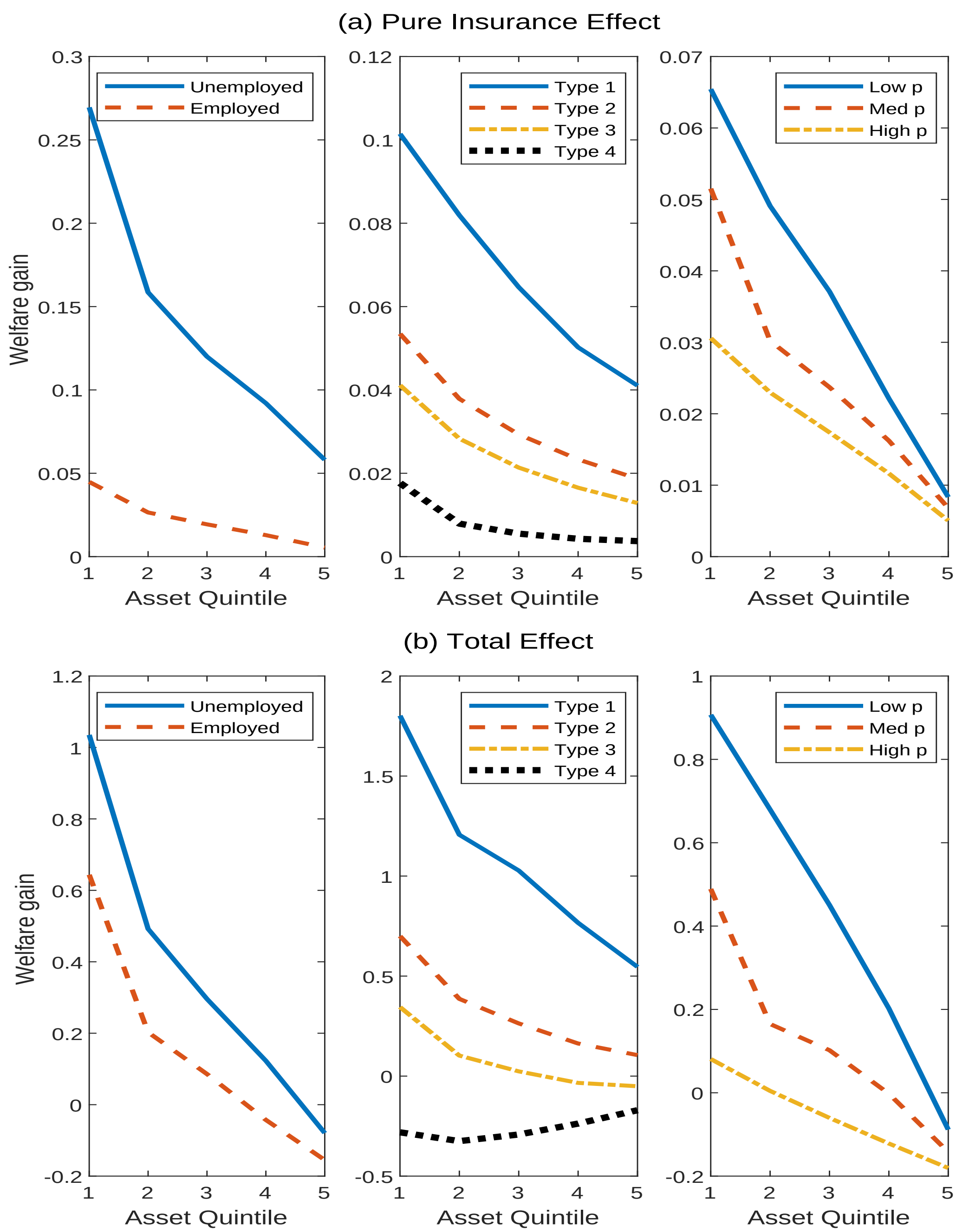
Next, we analyze the value of insurance in the model, as suggested and implemented in Mukoyama (2013) and Mokoyama (2012). In this exercise, each worker pays an "actuarially fair" insurance premium every period so that the present value of this premium is equal to the expected present value of the UI benefits received, given the worker's type and his current employment and productivity state.[29] In our analysis we consider an example of a policy change from zero UI benefits to the optimal UI system described in Section 4.4 $\{h = 0.8, \kappa = 0.44\}$. By construction, introducing the UI system involves no net transfers, hence it captures the pure insurance value of this policy change.

The top panels of Figure 2 describe the welfare gains from the actuarially fair insurance for this policy change. The horizontal axis represents quintiles of the asset distribution. The vertical axis represents the welfare gain according to the same metric as in Section 4.3. The left panel breaks down the results by employment status, the middle panel by education type, and the right panel by individual productivity. There are several takeaways from this figure. First, since the insurance provided involves no distortion, all agents gain from the actuarially fair insurance, as demonstrated by the positive values throughout the top panels. Second, some workers have larger gains than others: workers who are already unemployed appreciate the insurance more than employed workers (top left panel); workers with a higher unemployment risk and higher effective replacement rate have a higher value of insurance (top middle panel); workers who receive higher replacement rates, which is associated with low productivity, have a higher gain from pure insurance (top right panel); and workers who own more assets value insurance less (all top panels).

The bottom panels of Figure 2 present the total welfare gain from the same policy change, breaking down the results along identical dimensions. A comparison of the total welfare effects to the welfare gains due to insurance leads to two important conclusions. First, the value of insurance is about an order of magnitude smaller than the overall gains. Second, while the insurance value is always positive, the overall welfare effect from the introduction of the optimal UI system is negative for some workers and generally lower for workers who have higher wages and/or more

[29]The general tax and transfer system, as well as prices, remain unchanged.

Figure 2: The Effect of UI on Welfare – Insurance vs Total



Notes: The welfare effects of changing the UI policy from no UI $\{h = 0, \kappa = 0\}$ to optimal $\{h = 0.8, \kappa = 0.44\}$, by asset quintile. Top panels describe the pure insurance effect. Bottom panels describe the total welfare effect. Left: by employment status; Middle: by education type; Right: by individual productivity.

wealth. These differences reflect the importance of redistribution rather than insurance of UI.

4.7 Transition Dynamics

Our analysis so far, including the welfare gain, has focused on a steady state analysis between the benchmark policy and any alternative policy. We emphasized that our welfare criterion takes into account the complete distribution of assets, employment status and individual productivity at the benchmark. Therefore, and unlike a naive steady state comparison, no resource instantly appears or evaporates (including employment matches) in the transition. What is neglected, however, is the complete transition of prices along the path. In particular, the implied assumption in our analysis is that prices immediately adjust. Mukoyama (2013) discusses this in detail for a simpler, yet closely related, incomplete markets general equilibrium model and provides a comprehensive analysis for the various moving parts along the transition path.

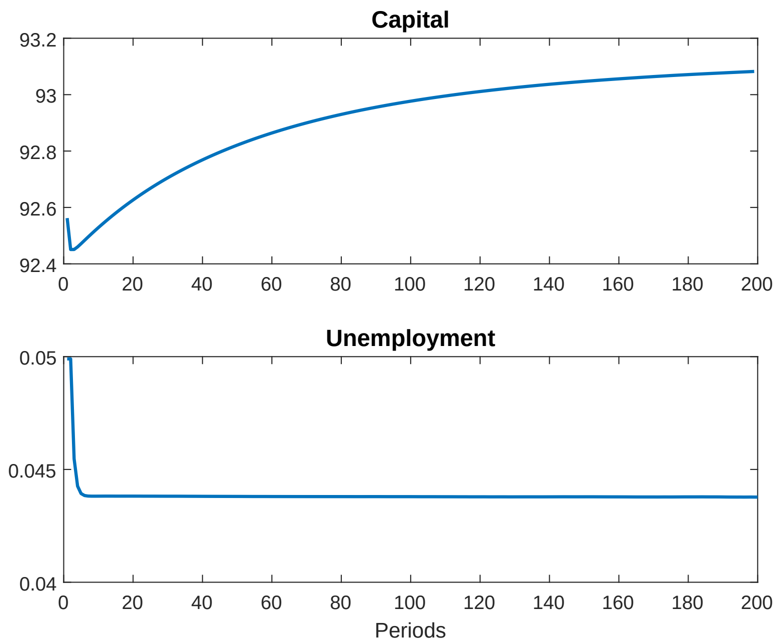
In this section we test the importance of this approximation for the main result. Our analysis of the transition closely follows that of Mukoyama (2013), and we refer the interested reader to that paper. Here we briefly explain how we compute the transition. An unexpected and permanent change in the policy is announced while the economy is in its original steady state. Following that change, both prices and quantities change endogenously according to the optimal decisions of both workers and firms. The transition is allowed to continue until the economy reaches a state that is sufficiently close to the steady state after the reform. Then, the welfare gain (or loss) is computed according to the difference in the value of workers in the period immediately following the reform to one period before.

We perform the transition path for the change from the benchmark economy $\{h = 0.4, \kappa = 1.15\}$ to the optimal one $\{h = 0.8, \kappa = 0.44\}$. Figure 3 shows the transition path for capital and unemployment over the transition path of 200 model periods (about 23 years). The top panel shows that capital changes slowly over the transition path. This is related to the desire of workers to smooth consumption over time. The bottom panel shows the dynamics of unemployment. Given that the value of unemployment increases upon the change in UI, wages immediately increase, the value of firms decreases and therefore vacancy creation declines. The fast adjustment of vacancies and job-finding rates implies then that the change in employment rate is relatively quick.[30]

Table 6 presents the total and type-specific welfare gains for three cases: the welfare metric

[30]Overall, the transition is very similar to that in Mukoyama (2013), who also shows wages, capital labor ratio and other statistics. We do not show those here for brevity of description and since many of our variables (e.g. wages) are multidimensional due to the various sources of heterogeneity in our model.

Figure 3: Transition path: capital and unemployment



we use throughout the analysis, the one implied by the complete transition, and the one associated with the naive comparison of steady states. The difference between the first two columns confirms that our welfare metric is a good comparison for the complete transition. The results of the naive comparison, both total and type-specific, show that this measure does not provide a good approximation for the welfare gains.

To further confirm the validity of the welfare metric we repeat the transition path exercise for UI policies in the neighborhood of the optimal policy. Specifically, we study the transition path for UI policies keeping the replacement rate at $h = 0.8$ as in the optimal policy and letting the cap

Table 6: Comparison of welfare gains (%)

	Benchmark	Transition	Naive
Type 1	0.75	0.72	0.49
Type 2	0.46	0.44	0.43
Type 3	0.39	0.37	0.53
Type 4	0.40	0.40	0.60
Total	0.45	0.44	0.52

vary in the set $\{0.26, 0.35, 0.53, 0.62\}$, as well as keeping the cap at $\kappa = 0.44$ as in the optimal UI and letting the replacement rate vary in the set $\{0.4, 0.5, 0.6, 0.7\}$. In all those experiments we find that there is no meaningful difference in the welfare gain comparing to the metric we use for the main analysis hence the ranking of candidate policies is identical. We conclude that the welfare metric that we use (and that has been used in the literature) is a reasonable approximation for the gain associated with the complete transition path in our model.

4.8 Voting Patterns

Given that the welfare criterion favors redistribution, we study whether the optimal policy is implementable in the sense of receiving sufficient support relative to the status quo. We address this by computing the fraction of workers in the economy who experience a positive welfare gain, regardless of its magnitude, when moving from the benchmark policy to the optimal one.

Consistent with the welfare gains reported in Table 5, we find an almost unanimous support for moving from the benchmark policy to the optimal one $\{h = 0.8, \kappa = 0.44\}$. There is also a majority (84%) in support of eliminating UI, though workers of type 1 are almost unanimously against it and unemployed workers of type 2 are roughly divided.

5 Progressive Taxes

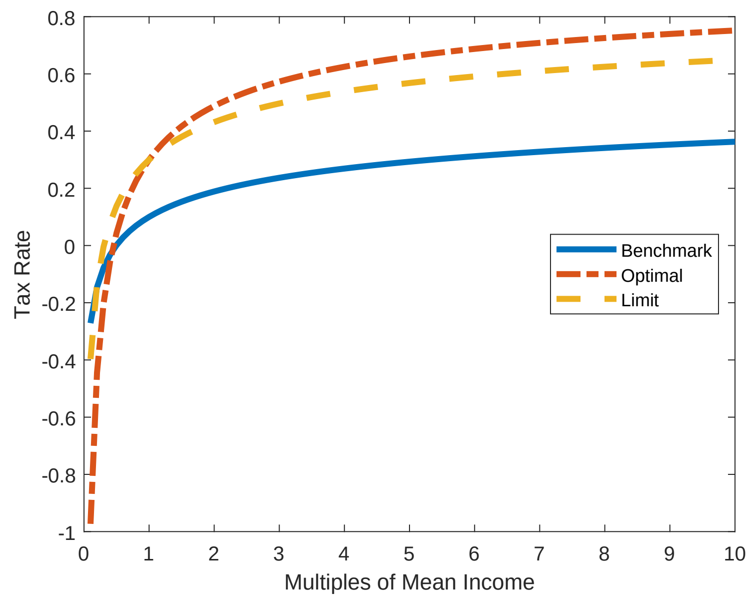
In this section we extend our analysis by allowing for a flexible choice of the general progressive tax system. The results thus far indicate that UI serves as a mean for redistribution even in the presence of a progressive tax system, as calibrated in Section 3. However, it is possible that the calibrated tax system is not sufficiently progressive in two related dimensions. First, given that the welfare criterion that we use favors redistribution from rich to poor, it is possible that a different choice of parameters for general taxation may improve welfare.[31] Second, a more progressive tax system can make the UI system redundant.

The level and progressivity of the general tax system in the model are governed by the two parameters of the tax function described in equation 3. Specifically, $1 - \lambda$ determines the tax rate levied on a worker who earns the average income in the economy, and a higher τ increases the progressivity of the tax system around this point. We consider alternative tax systems that span over a relatively wide range: $\lambda \in [0.7, 1]$ and $\tau \in [0, 0.45]$.[32] The benchmark calibration of the

[31] See, for example, Conesa and Krueger (2006) and Heathcote, Storesletten, and Violante (2017).

[32] When $\lambda = 1$ and $\tau = 0$ there are no taxes. When $\lambda = 0.7$ the tax rate levied on the average income is 30%.

Figure 4: Tax Functions



Notes: Parameters of the tax function: benchmark $\{\lambda = 0.9, \tau = 0.15\}$; optimal $\{\lambda = 0.7, \tau = 0.3\}$; limit $\{\lambda = 0.7, \tau = 0.45\}$.

tax function, as well as the one with the highest level ($\lambda = 0.7$) and progressivity ($\tau = 0.45$) (labeled as "Limit") are plotted in Figure 4. For each choice of a (λ, τ) pair, we consider the same possible combinations of cap and replacement rate as in Section 4, and compare the welfare gains and losses relative to the benchmark economy calibrated in Section 3. This amounts to a choice of optimal policy over four parameters. The optimal combination over the policy grid is $\{\lambda = 0.7, \tau = 0.3, h = 0.55, \kappa = 0.26\}$.

The optimal general tax system (see Figure 4) is substantially more progressive than the benchmark calibration, as τ increases from 0.15 to 0.3. Moreover, there is a level shift towards higher tax rates in the sense that the average income is taxed at 30% vs. 10% in the current benchmark. Not surprisingly, the implied lump sum transfer more than doubles, from 0.47 (or 10.3% of GDP) in the benchmark model to just over 1.16 (or 27.7% of GDP) under the optimal policy. The aggregate welfare gain implied by switching from the benchmark model to the optimal policy equals to 4.9%. This high welfare gain is another indication for the fact that the welfare criterion favors redistribution, as the optimal policy also involves a lower Gini coefficient for consumption (0.18 instead of 0.24) but at a cost of a substantial drop in GDP (9%) and aggregate consumption (3.6%).[33]

[33] Conesa and Krueger (2006) make a similar point with regards to a proportional tax system and a welfare criterion

While the substantial change in tax policy has an effect on the optimal UI policy, it does not eliminate it. The optimal UI system involves a replacement rate of $h = 0.55$ and a cap that equals $\kappa = 0.26$, implying an average effective replacement rate of 17%. The progressivity of the replacement rate is also maintained, as replacement rates range from 3% to 52%.[34]

To better understand the role of UI when the tax system is more progressive, we first demonstrate the insurance and redistributive roles of UI by repeating the exercise described in Section 4.6 for the optimal tax policy ($\{\lambda = 0.7, \tau = 0.3\}$). The results are presented in Figure 5 and consider a shift from no UI to the optimal UI ($\{h = 0.55, \kappa = 0.26\}$) under this tax system. Recall that the top panels of the figure describe the welfare gains from the actuarially fair insurance, whereas the bottom panels present the total welfare gains from the same policy change. As before, we break down the results along identical dimensions (employment status, type, and individual productivity over asset quintiles). The comparison of the two figures shows that quantitatively the welfare gains decline when the tax system is (much) more progressive. Qualitatively, however, the welfare gains patterns along the various dimensions are quite similar, implying that there is further role of UI that operates in a similar fashion as in the benchmark calibration of the general tax system.

UI is included in the optimal solution even in the presence of highly progressive taxation due to the distortions of the two system. Recall that increasing the progressivity of the general tax system increases the tax rate on capital, thus reducing capital and consequently reducing the marginal product of labor as well as wages. On the other hand, when the general taxation is already highly progressive, as implied by the optimal policy, introducing the optimal UI system lowers employment but have a small quantitative effect on capital. Thus, when taxes are highly progressive and capital accumulation is substantially distorted, a policy maker finds UI to be a useful substitution for redistribution resources while shifting the distortion from capital to labor.

In summary, our results indicate that the benchmark calibration of the tax system is indeed not progressive enough in the sense that the optimal involves a level shift as well as more progressivity. This shift generates substantial welfare gains. The more progressive tax system attanuates both the insurance and the redistributive role of UI, but not completely, hence there are still meaningful welfare gains from implementing the optimal UI system.[35]

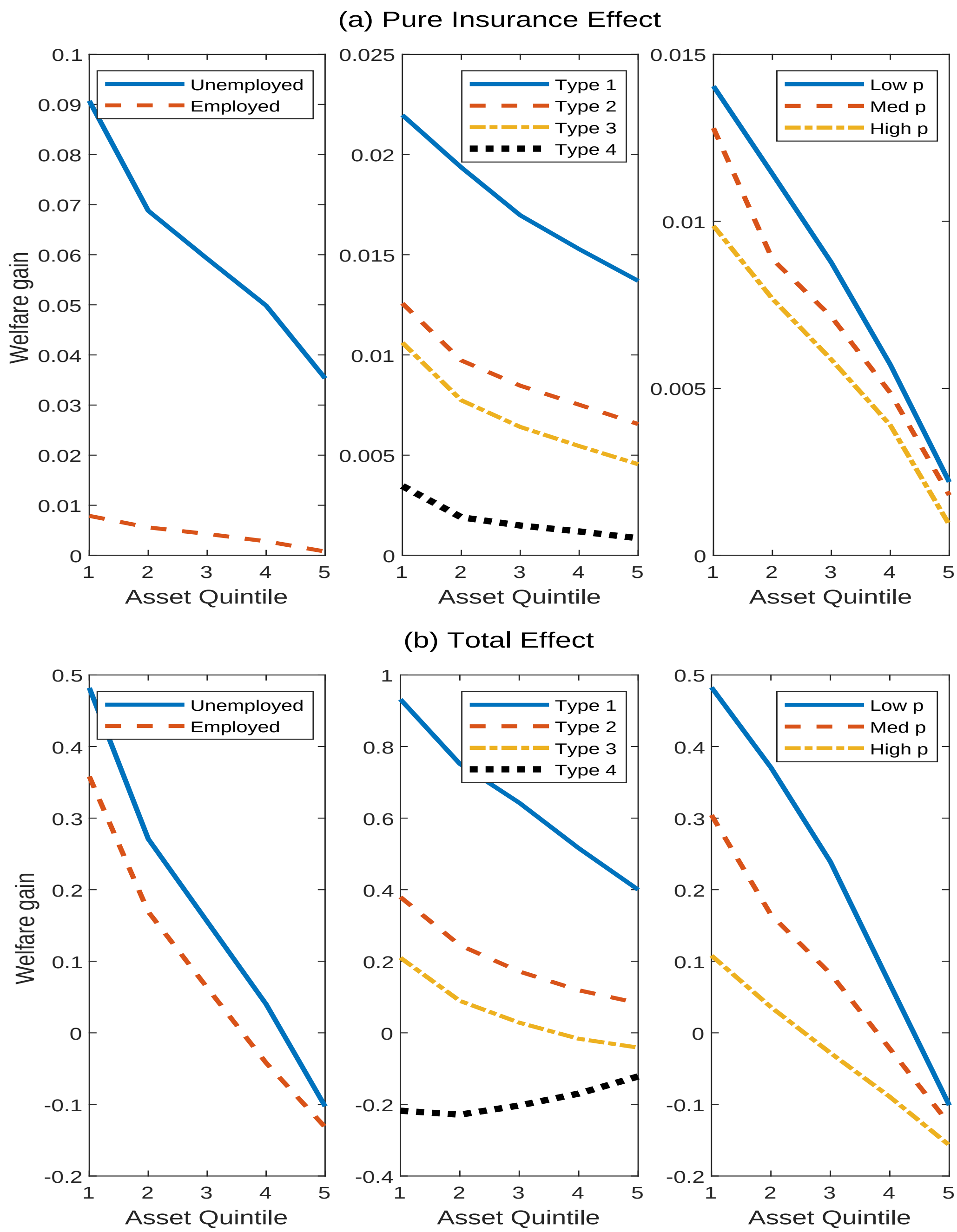
---

that sums steady state values.

[34] In addition, even for the most generous and progressive tax system that we consider, which is sub optimal, the average effective replacement rate is 16%, ranging from 3% to 48%.

[35] Our findings echo the empirical results in Attanasio and Davis (1996). They find that the progressivity of the US tax system, as well as various welfare program, is still insufficient in providing cross-type consumption insurance.

Figure 5: The Effect of UI on Welfare – Insurance vs Total for Optimal Progressive Tax



Notes: The welfare effects of changing the UI policy from no UI $\{h = 0, \kappa = 0\}$ to optimal $\{h = 0.55, \kappa = 0.26\}$, when $(\{\lambda = 0.7, \tau = 0.3\})$, by asset quintile. Top panels describe the pure insurance effect. Bottom panels describe the total welfare effect. Left: by employment status; Middle: by education type; Right: by individual productivity.

6 Concluding Remarks

In this paper we claim that the redistributive role of UI is qualitatively and quantitatively important. We demonstrate this using a incomplete markets general equilibrium model with exogenous heterogeneity in productivity and separation rates, which results in heterogeneity in labor income and unemployment risk. We calibrate the model to match the considerable income dispersion and other key characteristics observed in US data, which also results in a considerable variation in consumption across workers. The quantitative implications are substantial: the welfare maximizing policy involves an average effective replacement rate of 27%, ranging from 5% to 79%, with lower income workers facing higher replacement rates. This is in contrast to a model without exogenous heterogeneity, where it is optimal to have zero UI benefits.

This finding is an outcome of a number of features in our analysis. First, since lower wage workers also face greater unemployment risk these workers draw resources more frequently from the the UI system. Second, the existence of a cap on UI benefits implies an essentially progressive benefits schedule as the cap is more likely to bind for higher wage workers. Finally, the welfare criterion favors equality hence provides an incentive for a policy maker to use UI for redistribution.

Our main finding that UI has a redistributive role holds in the presence of the current progressive general tax and redistribution system. We therefore extend the analysis and allow for a simultaneous choice of both UI and general taxation. We find that the optimal general tax system should be far more progressive than its current state, and that the optimal choice attenuates the gains from redistribution through UI. However, the optimal choice does not eliminate the UI system and its redistributive aspects. We believe that these findings present a promising and challenging avenue for future research regarding the optimal mix of redistributive policies. To conduct this type of analysis one has to enrich the current model along a few dimensions. First, to fully capture the distortions presented by progressive taxation, a labor supply decision should be added to the model. Second, more welfare programs that are potentially redistributive should be incorporated into the analysis.

References

ABDULKADIROGLU, A., B. KURUSCU, AND A. ŞAHIN (2002): “Unemployment Insurance and the Role of Self-Insurance,” *Review of Economic Dynamics*, 5(3), 681–703.

AIYAGARI, S. R. (1994): “Uninsured Idiosyncratic Risk and Aggregate Saving,” *The Quarterly Journal of Economics*, 109(3), 659–84.

ATTANASIO, O., AND S. J. DAVIS (1996): “Relative Wage Movements and the Distribution of Consumption,” *Journal of Political Economy*, 104(6), 1227–62.

BAILY, M. N. (1978): “Some aspects of optimal unemployment insurance,” *Journal of Public Economics*, 10(3), 379–402.

BARRON, J. M., M. C. BERGER, AND D. A. BLACK (1997): “On-The-Job Training,” *W.E. Upjohn Institute for Employment Research Michigan, USA*.

BENABOU, R. (2002): “Tax and Education Policy in a Heterogeneous-Agent Economy: What Levels of Redistribution Maximize Growth and Efficiency?,” *Econometrica*, 70(2), 481–517.

BEWLEY, T. F. (undated): “Interest Bearing Money and the Equilibrium Stock of Capital,” *Mimeo*, 47(3), 895–936.

BILS, M., Y. CHANG, AND S.-B. KIM (2011): “Worker Heterogeneity and Endogenous Separations in a Matching Model of Unemployment Fluctuations,” *American Economic Journal: Macroeconomics*, 3(1), 128–54.

BLUNDELL, R., L. PISTAFERRI, AND I. SAPORTA-EKSTEN (2018): “Children, Time Allocation, and Consumption Insurance,” *Journal of Political Economy*, 126(S1), 73–115.

BRÜGEMANN, B. (2008): “What elasticity of the matching function is consistent with U.S. aggregate labor market data?,” .

CAIRO, I., AND T. CAJNER (2013): “Human Capital and Unemployment Dynamics: Why More Educated Workers Enjoy Greater Employment Stability,” Finance and Economics Discussion Series 2014-9, Board of Governors of the Federal Reserve System (U.S.).

CARD, D., AND P. B. LEVINE (1994): “Unemployment insurance taxes and the cyclical and seasonal properties of unemployment,” *Journal of Public Economics*, 53(1), 1–29.

CHETTY, R. (2006): “A general formula for the optimal level of social insurance,” *Journal of Public Economics*, 90(10-11), 1879–1901.

——— (2008): “Moral Hazard vs. Liquidity and Optimal Unemployment Insurance,” *Journal of Political Economy*, 116, 173–234.

CONESA, J. C., AND D. KRUEGER (2006): “On the optimal progressivity of the income tax code,” *Journal of Monetary Economics*, 53(7), 1425–1450.

DAVILA, J., J. H. HONG, P. KRUSELL, AND J.-V. RIOS-RULL (2012): “Constrained Efficiency in the Neoclassical Growth Model With Uninsurable Idiosyncratic Shocks,” *Econometrica*, 80(6), 2431–2467.

DIAMOND, P. A. (1982): “Aggregate Demand Management in Search Equilibrium,” *Journal of Political Economy*, 90(5), 881–94.

DOLFIN, S. (2006): “An examination of firms’ employment costs,” *Applied Economics*, 38(8), 861–878.

ELSBY, M. W. L., B. HOBIJN, AND A. ŞAHIN (2010): “The Labor Market in the Great Recession,” *Brookings Papers on Economic Activity*, 41(1 (Spring), 1–69.

FREDRIKSSON, P., AND B. HOLMLUND (2001): “Optimal Unemployment Insurance in Search Equilibrium,” *Journal of Labor Economics*, 19(2), 370–399.

HANSEN, G. D., AND A. IMROHOROGLU (1992): “The Role of Unemployment Insurance in an Economy with Liquidity Constraints and Moral Hazard,” *Journal of Political Economy*, 100, 118–142.

HEATHCOTE, J., F. PERRI, AND G. L. VIOLANTE (2010): “Unequal We Stand: An Empirical Analysis of Economic Inequality in the United States, 1967-2006,” *Review of Economic Dynamics*, 13(1), 15–51.

HEATHCOTE, J., K. STORESLETTEN, AND G. L. VIOLANTE (2017): “Optimal Tax Progressivity: An Analytical Framework,” *The Quarterly Journal of Economics*, 132(4), 1693–1754.

HOLTER, H. A., D. KRUEGER, AND S. STEPANCHUK (2019): “How Does Tax Progressivity and Household Heterogeneity Affect Laffer Curves?,” *Quantitative Economics*, 10(4), 1317–1356.

HOPENHAYN, H. A., AND J. P. NICOLINI (1997): "Optimal Unemployment Insurance," *Journal of Political Economy*, 105(2), 412–438.

HOSIOS, A. J. (1990): "On the Efficiency of Matching and Related Models of Search and Unemployment," *Review of Economic Studies*, 57(2), 279–98.

HUGGETT, M. (1993): "The risk-free rate in heterogeneous-agent incomplete-insurance economies," *Journal of Economic Dynamics and Control*, 17(5-6), 953–969.

JUNG, P., AND K. KUESTER (2015): "Optimal Labor-Market Policy in Recessions," *American Economic Journal: Macroeconomics*, 7(2), 124–156.

KRUEGER, A. B., AND B. D. MEYER (2002): "Labor supply effects of social insurance," in *Handbook of Public Economics*, ed. by A. J. Auerbach, and M. Feldstein, vol. 4 of *Handbook of Public Economics*, chap. 33, pp. 2327–2392. Elsevier.

KRUEGER, D., K. MITMAN, AND F. PERRI (2017): "Macroeconomics and Heterogeneity, Including Inequality," in *Handbook of Macro Economics*, vol. 2B, chap. 11.

KRUSELL, P., T. MUKOYAMA, AND A. ŞAHIN (2010): "Labour-Market Matching with Precautionary Savings and Aggregate Fluctuations," *Review of Economic Studies*, 77(4), 1477–1507.

KRUSELL, P., T. MUKOYAMA, A. ŞAHIN, AND A. A. SMITH (2009): "Revisiting the Welfare Effects of Eliminating Business Cycles," *Review of Economic Dynamics*, 12(3), 393–402.

LENTZ, R. (2009): "Optimal Unemployment Insurance in an Estimated Job Search Model with Savings," *Review of Economic Dynamics*, 12(1), 37–57.

LESTER, G. (2001): "Unemployment Insurance and Wealth Redistribution," *UCLA LAW REVIEW*, 49(1), 335–393.

MARCEAU, N., AND R. BOADWAY (1994): "Minimum Wage Legislation and Unemployment Insurance as Instruments for Redistribution," *Scandinavian Journal of Economics*, 96(1), 67–81.

MEYER, B. D., AND W. K. C. MOK (2014): "A Short Review of Recent Evidence on the Disincentive Effects of Unemployment Insurance and New Evidence From New York State," *National Tax Journal*, 67(1), 219–252.

MICHELACCI, C., AND H. RUFFO (2015): "Optimal Life Cycle Unemployment Insurance," *American Economic Review*, 105(2), 816–59.

MITMAN, K., AND S. RABINOVICH (2015): "Optimal unemployment insurance in an equilibrium business-cycle model," *Journal of Monetary Economics*, 71(C), 99–118.

MOKOYAMA, T. (2012): "Understanding the welfare effects of unemployment insurance policy in general equilibrium," Working paper, University of Virginia.

MORTENSEN, D. T. (1982): "Property Rights and Efficiency in Mating, Racing, and Related Games," *American Economic Review*, 72(5), 968–79.

MUKOYAMA, T. (2010): "Welfare effects of unanticipated policy changes with complete asset markets," *Economics Letters*, 109(2), 134–138.

——— (2013): "Understanding the welfare effects of unemployment insurance policy in general equilibrium," *Journal of Macroeconomics*, 38(PB), 347–368.

MUKOYAMA, T., AND A. ŞAHIN (2006): "Costs of business cycles for unskilled workers," *Journal of Monetary Economics*, 53, 2179–2193.

PALLAGE, S., AND C. ZIMMERMANN (2001): "Voting on Unemployment Insurance," *International Economic Review*, 42(4), 903–23.

PETRONGOLO, B., AND C. A. PISSARIDES (2001): "Looking into the Black Box: A Survey of the Matching Function," *Journal of Economic Literature*, 39(2), 390–431.

PISSARIDES, C. A. (1985): "Short-run Equilibrium Dynamics of Unemployment Vacancies, and Real Wages," *American Economic Review*, 75(4), 676–90.

RATNER, D. D. (2013): "Unemployment Insurance Experience Rating and Labor Market Dynamics," *FEDS Working Paper*, (2013-86).

REICHLING, F. (2007): "Optimal Unemployment Insurance in Labor Market Equilibrium when Workers can Self-Insure," MPRA Paper 5362, University Library of Munich, Germany.

ROUWENHORST, K. (1995): "Asset pricing implications of equilibrium business cycle models.," in *Frontiers of Business Cycle Research*, ed. by T. Cooley. Princeton University Press, Princeton, NJ, pp. 294330.

SHAVELL, S., AND L. WEISS (1979): "The Optimal Payment of Unemployment Insurance Benefits over Time," *Journal of Political Economy*, 87(6), 1347–62.

SHIMER, R. (2012): "Reassessing the Ins and Outs of Unemployment," *Review of Economic Dynamics*, 15(2), 127–148.

WRIGHT, R. (1986): "The redistributive roles of unemployment insurance and the dynamics of voting," *Journal of Public Economics*, 31(3), 377–399.

A Stationary Equilibrium

In this appendix we describe the stationary equilibrium of the economy. For ease of notation and consistency with the computational method we describe a discrete state space. We use the notations $Pr(p'|p)$ as the transition probability of individual productivity, and $Pr(p)$ as the unconditional probability for individual productivity draws. A stationary equilibrium consists of:

1. A set of value functions $\{W_i(a,p)$, $J_i(a,p)$, $U_i(a,p)$, $V\}$
2. Consumption $c_i^e(a,p)$ and $c_i^u(a,p)$ for employed and unemployed workers, respectively, as well as asset accumulation policy functions $g_i^e(a,p)$ and $g_i^u(a,p)$
3. Prices $\{r$,$w_i(a,p)$,$\pi\}$
4. Vacancies v_i and demand for capital (per worker) $k_i(p)$
5. Tightness ratios θ_i and implied probabilities λ_i^w and λ_i^f
6. A UI policy of replacement rate h, a ceiling on benefits κ and a UI tax rate τ^{UI}
7. A general tax policy $T(y)$ and lump sum transfers Ξ
8. Dividends d
9. Distributions over type i, employment status (either e or u), assets a and individual productivity p, denoted by $\mu_i^e(a,p)$ and $\mu_i^u(a,p)$

such that:

1. Given the job finding probability λ_i^w, the wage function, and prices $\{r,\pi\}$, the worker's choices of c and a' solve the optimization problem for each individual. This results in the value functions $W_i(a,p)$, and $U_i(a,p)$.
2. Given the wage functions, prices, the distribution $\mu_i^e(a,p)$, and the workers asset accumulation decisions, each firm solves the optimal choice of $k_i(p)$. This results in $J_i(a,p)$.
3. Given the wage functions, prices, the distribution $\mu_i^u(a,p)$, the unemployed workers asset accumulation decisions, and the job filling probability λ_i^f, firms compute the value V_i. With free entry, $V_i = 0$.

4. The asset market clears, and the aggregate demand for capital equals supply.
5. The wage functions $w_i(a,p)$ are determined by Nash bargaining.
6. The government's UI system has a balanced budget.
7. The government's general taxation system has a balanced budget.
8. The dividend paid to equity owners every period is the sum of flow profits from all matches, net of the expenditure on vacancies.[36]

$$d = \sum_i \left[\sum_a \sum_p \left[\left(z_i p f(k_i(p)) - r k_i(p) - w_i(a,p) \right) \mu_i^e(a,p) \right] - \xi_i v_i \right] \tag{A.1}$$

9. The distributions $\mu_i^e(a,p)$ and $\mu_i^u(a,p)$ are invariant and generated by $\{\lambda_i^w, s_i, \nu, \phi_i\}$, the law of motion for individual productivity and the asset accumulation policy functions as follows:

$$\begin{aligned}
\mu_i^e(a',p') &= (1-\nu)\{(1-s_i)\sum_a \sum_p \mu_i^e(a,p) \times Pr(p'|p) \times \mathbb{1}\{g_i^e(a,p)=a'\} \\
&\quad + \lambda_i^w \sum_a \sum_p \mu_i^u(a,p) \times Pr(p'|p) \times \mathbb{1}\{g_i^u(a,p)=a'\}\} \\
\mu_i^u(a',p') &= (1-\nu)\{s_i \sum_a \mu_i^e(a,p') \times \mathbb{1}\{g_i^e(a,p')=a'\} \\
&\quad + (1-\lambda_i^w)\sum_a \mu_i^u(a,p') \times \mathbb{1}\{g_i^u(a,p')=a'\}\} \\
&\quad + \phi_i \times \nu \times Pr(p) \times \mathbb{1}\{a'=0\} \\
\\
\phi_i &= \sum_a \sum_p \left(\mu_i^e(a,p) + \mu_i^u(a,p) \right)
\end{aligned}$$

B Computation

B.1 Solution Algorithm

In order to maximize her utility, the worker needs to know the entire wage function, $w_i(a,p)$. Therefore the algorithm we use aims at finding a *functional* fixed-point.

[36]As flow profits depend on asset holdings of individual workers, this distribution is taken into account.

1. Start with an initial guess for $w_i(a, p)$, r, θ_i and τ^{UI}.

2. Given the current guess for θ_i, compute the probability of finding a job λ_i^w for each type and the associated unemployment level u_i.

3. Solve the workers' dynamic programming problem for each type of worker and for each level of assets. This gives both the value function and the capital accumulation path.

4. Given the employee's capital accumulation path and the wage associated with her next period's assets, calculate the firm's value function for each type of employee and for each asset level. This does not require the asset distribution, which is calculated in the next step.

5. Based on the optimal saving decisions of workers and the transitions probabilities between employment and unemployment, as well as the transition probabilities across types, calculate the stationary distribution of assets for employed and unemployed workers of each type. Calculate the aggregate stationary distribution of workers across asset holdings given the weights ϕ_i of each group, the distribution of individual productivity p and the measures of employed and unemployed workers within each group. This gives the total capital stock.

6. Update of the guess for $\left\{w_i(a, p), r, \theta_i, \tau^{UI}\right\}$ as follows.

   - Given the value functions of workers in step 3 and firms in step 4 perform Nash bargaining, which delivers an update for $w_i(a, p)$.
   - Use the total capital stock from step 5, u_i from step 2 and the first-order condition of each type of firm to compute k_i and r.
   - Use the firm's value and the distribution of assets over unemployed to calculate the expected value for the firm from a match. Given the vacancy cost and the value of a match we update θ_i such that the value of a vacancy is zero. Note that we do not force θ_i to be the same across types.
   - Given $u_i, w_i(a, p)$ and the stationary distribution of workers across asset holdings of each type in step 5, update the tax rate so that the budget is balanced.

7. Repeat steps 2-6 until convergence is reached.

Table B.1: Calibrated type-specific parameters

	Less than high school	High school	Some college	Bachelor's and over
Productivity persistence (ρ_i^ϵ)	0.9722	0.9789	0.9780	0.9848
Productivity shock (σ_i^ϵ)	0.0983	0.0907	0.1001	0.1032

B.2 Type-specific Productivity Processes

As we explain in Section 3 we use an identical productivity process for all types for our main analysis. This is in order to facilitate comparability across the various models summarized in Table 4. As expected, estimation of the AR(1) productivity process separately for each type results in different productivity processes. Table B.1 reports the persistence and standard deviation for each type.

Accounting for the type-specific productivity processes has minor effects on the results. Specifically, the wage premiums are essentially identical to the reported figures in Table 2. In addition, in Table B.2 we report minor differences between the wealth moments resulting from the benchmark calibration and the ones resulting from the type-specific processes. The optimal policy is $\{h = 0.65, \kappa = 0.41\}$, implying an effective replacement rate of 0.24, as opposed to 0.27 in the benchmark. The redistribution patterns remain as the effective replacement rate varies between 4% and 60%, as opposed to 5% to 79% in the benchmark.

B.3 Approximation of the Productivity Process

We appproximate the AR(1) process for individual productivities using the method described by Rouwenhorst (1995). We discretize the process estimated in Section 3 using three grid points, which we refer to in the text as low, medium and high. Any discretization method (including Rouwenhorst) truncates the distribution. To assess the importance of the truncation associated with our three point grid we repeat in this section the main exercise for a discretization using a five point grid.[37]

We start by reporting the truncation for each case. Given the parameters of the productivity

[37] The stationary weights of each node are $\{0.25, 0.50, 0.25\}$ for the three-point grid and $\{0.0625, 0.25, 0.375, 0.25, 0.0625\}$ for the five-point grid.

Table B.2: Wealth moments

	Data	Benchmark Calibration	Heterogeneous P Processes
Wealth ratios			
Type 2	2.9	2.8	2.64
Type 3	3.3	3.2	3.55
Type 4	12.0	12.3	11.4
% share by			
Q1	-0.2	0.5	0.6
Q2	1.2	3.2	3.6
Q3	4.6	11.1	10.6
Q4	11.9	24.8	23.5
Q5	82.5	60.4	61.7
Gini	0.78	0.60	0.60

Notes: Top panel: wealth ratio for type i is the ratio of median wealth of type i relative to type 1 (high school dropouts). Middle panel: share of aggregate wealth owned by quintiles of the wealth distribution. Data source: wealth ratios - SCF; qunitiles and Gini coefficient - Table 1 of Krueger, Mitman, and Perri (2017).

Table B.3: Wage moments

	Data	3 point grid	5 point grid
Wage premiums			
Type 2	31%	30%	31%
Type 3	56%	55%	56%
Type 4	127%	126%	127%
Gini	0.39	0.44	0.42

Notes: Wage premium for type i is the ratio of median wage of type i to the median wage of type 1 (high school dropouts), minus 1. The Gini coefficient in the data column is the average of the yearly Gini coefficients in the PSID sample we use.

process in Table 1 the three point grid covers 84% of the income distribution (i.e., truncates 8% of each side), whereas the five point grid covers 95% of the income distribution (i.e., truncates 2.5% of each side).

We then assess the effect of the number of grid points on the endogenous moments of the model. Tables B.3 and B.4 present the wage and wealth moments as in the main text. For comparability, the second column in each table shows the same figures as in the main text for the benchmark calibration. The wage moments are barely affected by the number of grid points, as those are mostly affected by the type-specific productivity (z_i). For the wealth moments we observe that there are some differences in the wealth ratios, though the overall pattern remains, and the shares of aggregate wealth and the Gini coefficient are quite similar.

Finally, we repeat the main exercise of finding the optimal UI policy given the benchmark tax policy for the five point grid. For the purpose of this exercise we allow the replacement rate to exceed 100% when coupled with cap levels that are binding for high productivity workers.[38] This may result in more generous transfers to low-productivity unemployed workers, while not necessarily generating a negative surplus from employment. For low productivity workers, the surplus is positive even though the flow surplus is negative. This is due to the option of drawing a higher productivity level, which is conditional on being employed. For high productivity workers, UI benefits are capped and do not exceed the wage, making the flow surplus and total surplus positive. In the numerical analysis of the model we verify that the surpluses ($W - U$ and J) are

[38]Those high replacement rates were not optimal in the benchmark calibration with three grid points for the productivity process.

Table B.4: Wealth moments

	Data	3 point grid	5 point grid
Wealth ratios			
Type 2	2.9	2.8	2.5
Type 3	3.3	3.2	2.9
Type 4	12.0	12.3	10.5
% share by			
Q1	-0.2	0.5	0.5
Q2	1.2	3.2	3.4
Q3	4.6	11.1	10.6
Q4	11.9	24.8	24.5
Q5	82.5	60.4	61.0
Gini	0.78	0.60	0.60

Notes: Top panel: wealth ratio for type i is the ratio of median wealth of type i relative to type 1 (high school dropouts). Middle panel: share of aggregate wealth owned by quintiles of the wealth distribution. Data source: wealth ratios - SCF; qunitiles and Gini coefficient - Table 1 of Krueger, Mitman, and Perri (2017).

positive for all the policy experiments in this range.

The resulting optimal policy for this exercise is $\{h = 1.14, \kappa = 0.47\}$, implying an effective replacement rate of 28% and a welfare gain of 0.45%. Both figures are very close to those implied by the three point calibration (27% and 0.45%, respectively). Table B.5 describes in detail the effective replacement rates, net transfers and the welfare gains as done in the main text (Table 5) for the benchmark exercise. The results implied by the two grids lead to very similar patterns. In particular, there is a substantial progressivity in replacement rates, net transfers indicate the ability of the UI system to redistribute across workers, and there exists a variation in welfare gains. In addition, the averages by skill types are affected very little by the change in the grid. As expected, the finer grid increases the variation within type, as the productivity distribution is less truncated.

B.4 Sensitivity Analysis: Elasticity of Job Finding Rate

Our baseline calibration uses $\Gamma = 0.03$, which implies an elasticity of job finding rate w.r.t. benefits of 0.36. As we discuss in the main text, changes in the elasticity of the job finding rate to UI benefits will affect the cost of UI. Here we demonstrate this point by considering both lower (0.25) and higher (0.50) elasticities relative to our benchmark calibration. As expected, the higher the elasticity the less generous is the optimal UI system. For the low elasticity the optimal policy is $\{h = 1.13, \kappa = 0.80\}$, implying an average effective replacement rate of 47%. For the high elasticity the optimal policy is $\{h = 0.45, \kappa = 0.23\}$, implying an average effective replacement rate of 14%. This is in comparison to $\{h = 0.8, \kappa = 0.44\}$ and an average effective replacement rate of 0.27 for the benchmark.

Tables B.6 and B.7 present detailed results of these two alternative calibrations. Both tables show that while there are level differences in the generosity of the UI system, the main result of a UI system that redistributes resources across workers is still valid. For example, the effective replacement rate varies between 2% and 42% for the high elasticity, and between 8% and 113% for the low elasticity[39]

[39] As we discuss in Appendix B.3, a replacement rate higher than 100% may become optimal under some calibrations and does not generate a negative surplus.

Table B.5: Implications of UI policies - five grid points

	Effective RR (%)		Net transfers (%)		Welfare
	Benchmark	Optimal	Benchmark	Optimal	Gain (%)
Total	34	28	0.0	0.0	0.45
Type 1, average	37	38	2.2	1.6	0.72
Type 1, lowest p	40	114	2.2	8.0	2.11
Type 1, low p	40	63	2.3	4.3	1.43
Type 1, med p	40	31	2.3	1.8	0.61
Type 1, high p	36	15	1.9	0.5	0.02
Type 1, highest p	17	7	0.2	-0.1	-0.06
Type 2, average	35	30	0.7	0.4	0.46
Type 2, lowest p	40	101	1.2	4.6	1.21
Type 2, low p	40	48	1.2	2.0	0.79
Type 2, med p	40	24	1.2	0.6	0.36
Type 2, high p	28	11	0.5	0.0	0.17
Type 2, highest p	13	5	-0.4	-0.4	0.18
Type 3, average	34	26	0.1	0.0	0.40
Type 3, lowest p	40	85	0.6	2.8	0.92
Type 3, low p	40	41	0.7	1.1	0.62
Type 3, med p	40	20	0.7	0.2	0.30
Type 3, high p	23	10	-0.1	-0.2	0.24
Type 3, highest p	11	5	-0.7	-0.5	0.28
Type 4, average	29	18	-0.8	-0.5	0.40
Type 4, lowest p	40	59	-0.3	0.6	0.49
Type 4, low p	40	28	-0.1	0.1	0.42
Type 4, med p	33	14	-0.3	-0.3	0.37
Type 4, high p	16	7	-0.8	-0.5	0.39
Type 4, highest p	8	3	-1.0	-0.6	0.42

Table B.6: Implications of UI policies - low elasticity

	Effective RR (%)		Net transfers (%)		Welfare
	Benchmark	Optimal	Benchmark	Optimal	Gain (%)
Total	34	47	0.0	0.0	0.34
Type 1, average	37	59	2.1	2.9	1.18
Type 1, low p	40	113	2.3	9.0	2.27
Type 1, med p	40	52	2.3	3.5	1.12
Type 1, high p	27	19	1.1	0.5	0.20
Type 2, average	35	51	0.7	0.9	0.52
Type 2, low p	40	111	1.2	5.4	1.19
Type 2, med p	40	40	1.2	1.2	0.41
Type 2, high p	20	14	0.0	-0.3	0.06
Type 3, average	34	44	0.2	0.0	0.22
Type 3, low p	40	94	0.7	3.2	0.69
Type 3, med p	40	34	0.7	0.4	0.11
Type 3, high p	17	12	-0.4	-0.6	-0.03
Type 4, average	29	30	-0.8	-0.9	-0.02
Type 4, low p	40	65	-0.1	0.5	0.04
Type 4, med p	33	23	-0.3	-0.6	-0.06
Type 4, high p	12	8	-0.9	-1.0	-0.02

Table B.7: Implications of UI policies - high elasticity

	Effective RR (%)		Net transfers (%)		Welfare
	Benchmark	Optimal	Benchmark	Optimal	Gain (%)
Total	34	14	0.0	0.0	0.71
Type 1, average	37	19	2.1	1.1	0.67
Type 1, low p	40	42	2.3	2.7	1.43
Type 1, med p	40	15	2.3	0.7	0.56
Type 1, high p	27	5	1.1	0.1	0.15
Type 2, average	35	15	0.7	0.4	0.68
Type 2, low p	40	32	1.2	1.3	1.09
Type 2, med p	40	11	1.2	0.3	0.59
Type 2, high p	20	4	0.0	-0.1	0.49
Type 3, average	34	13	0.2	0.2	0.70
Type 3, low p	40	27	0.7	0.8	0.97
Type 3, med p	40	10	0.7	0.1	0.62
Type 3, high p	17	3	-0.4	-0.1	0.63
Type 4, average	29	9	-0.8	-0.1	0.76
Type 4, low p	40	19	-0.1	0.1	0.81
Type 4, med p	33	7	-0.3	-0.1	0.75
Type 4, high p	12	2	-0.9	-0.2	0.78