1 Unemployment Insurance Extension - Appendix

The baseline version of our model does not consider unemployment benefits. In the penultimate section of the paper we have shown a summary of results for a model version that features unemployment insurance. In this appendix, we describe this version of the model and present all the results in detail.

1.1 Program of the Single Household

To make the household's problem more transparent we begin with the program of the single household. Let $\mathcal{S}$ denote the set of labor market states (excluding the retirement state) in which the agent may be in a given period. In the model with unemployment benefits we introduce two additional states. First, let U_b denote the state 'unemployment with benefits', which is separate from state U: 'unemployment without benefits'. Second, E_b is the employment state when the worker is entitled to (eligible for) unemployment benefits (E is the employment state when the worker is not (yet) entitled to receive benefits upon separation). Therefore $\mathcal{S} = \{O, U, U_b, E, E_b\}$.

We assume that when the agent is unemployed and is eligible for benefits he receives income equal to $\xi \epsilon_t \overline{h} w$ in period t where ϵ_t is the idiosyncratic productivity in t and ξ is the replacement rate. Benefits are financed with payroll taxes (τ); if the agent becomes employed, his net income is $(1-\tau)\epsilon_t \overline{h} w$.

Not all unemployed agents receive benefits. The structure of the UI scheme is as follows. First, individuals may receive unemployment compensation if they move from state E_b to state U_b following an exogenous separation shock (which occurs at constant rate χ). Job quitters do not receive any unemployment income. Second, not all employed individuals are in state E_b. We assume that newly employed agents are initially in state E and move to E_b at exogenous rate $1-\theta_E$ in every period. When they reach E_b they remain in this state until they become unemployed or flow to out of the labor force. Third, we assume that benefits expire at rate $1-\theta_U$ in every period. An individual in U_b may therefore leave (non-voluntarily) this state either when he receives a job offer or when he becomes 'non-eligible' for unemployment compensation.[1] We motivate these choices and compare them to the rest of the literature in Section 1.1.2.

1.1.1 Value Functions

Let $V^S(a, \epsilon)$ denote the lifetime utility of the agent in state $S \in \mathcal{S}$ when wealth is a and productivity is ϵ.

As in the main text, the non-employed agent will receive job offers at a rate which depends on the search effort he exerts. Let $p(s)$ denote the arrival rate of offers for $s \in \{\underline{s}, \overline{s}\}$ and $p(\underline{s}) < p(\overline{s}) < 1$. Based on the search effort, an agent is classified as out of the labor force if $s = \underline{s}$, and is unemployed otherwise. Notice further that since our analysis focuses on the steady state, the distribution of agents across the state space and total factor productivity (normalized to 1 here) no longer need to be stored as separate objects in the value functions.

[1] Notice also that workers retire at rate ϕ_R and reenter the labor market at rate ϕ_A. The new entrants do not receive unemployment income from the government either.

The Bellman equations are as follows:

$$V^S(a,\epsilon) = \max_{c,a'\geq 0} u(c, 1-\kappa(s)) + \beta(1-\phi_R)\int \Big(p(s)Q^e(a',\epsilon') + (1-p(s))Q^n(a',\epsilon')\Big)dF(\epsilon',\epsilon)$$

(1) $$+\beta\phi_R \int V_R(a',\epsilon')dF(\epsilon',\epsilon)$$

$$s.t: a' = (1+r)a - c$$

$$s = \underline{s} \quad \text{if} \quad S = O \qquad \text{and} \qquad s = \overline{s} \quad \text{if} \quad S = U$$

(2) $$V^{U_b}(a,\epsilon) = \max_{c,a'\geq 0} u(c, 1-\kappa(\overline{s})) + \beta\phi_R \int V_R(a',\epsilon')dF(\epsilon',\epsilon)$$

$$+\beta(1-\phi_R)\int \Big(p(\overline{s})Q^e(a',\epsilon') + (1-p(\overline{s}))\left[(1-\theta_U)Q^n(a',\epsilon') + \theta_U Q^{n_b}(a',\epsilon')\right]\Big)dF(\epsilon',\epsilon)$$

$$s.t: a' = (1+r)a - c + \xi w\epsilon\overline{h}$$

(3) $$V^E(a,\epsilon) = \max_{c,a'\geq 0} u(c, 1-\overline{h}) + \beta\phi_R \int V_R(a',\epsilon')dF(\epsilon',\epsilon)$$

$$+\beta(1-\phi_R)\int \Big((1-\chi)\left[\theta_E Q^e(a',\epsilon') + (1-\theta_E)Q^{e_b}(a',\epsilon')\right] + \chi\left[\theta_E Q^n(a',\epsilon') + (1-\theta_E)Q^{n_b}(a',\epsilon')\right]\Big)dF(\epsilon',\epsilon)$$

$$s.t: a' = (1+r)a - c + w\epsilon\overline{h}(1-\tau)$$

(4) $$V^{E_b}(a,\epsilon) = \max_{c,a'\geq 0} u(c, 1-\overline{h}) + \beta(1-\phi_R)\int \Big((1-\chi)Q^{e_b}(a',\epsilon') + \chi Q^{n_b}(a',\epsilon')\Big)dF(\epsilon',\epsilon)$$

$$+\beta\phi_R \int V_R(a',\epsilon')dF(\epsilon',\epsilon)$$

$$s.t: a' = (1+r)a - c + w\epsilon\overline{h}(1-\tau)$$

along with the retirement state, which has a similar Bellman equation as in the main text and is omitted for brevity. We further define

(5) $$Q^k(a,\epsilon) = \begin{cases} \max_{S\in\{O,U\}} \{V^S(a,\epsilon)\} & \text{if } (k=n) \\ \max_{S\in\{O,U,U_b\}} \{V^S(a,\epsilon)\} & \text{if } (k=n_b) \\ \max_{S\in\{O,U,E\}} \{V^S(a,\epsilon)\} & \text{if } (k=e) \\ \max_{S\in\{O,U,E,E_b\}} \{V^S(a,\epsilon)\} & \text{if } (k=e_b) \end{cases}$$

where n, n_b, e and e_b are random (state) variables which determine the availability of job offers and the eligibility for unemployment insurance at the beginning of the period.

There are several comments to be made. Consider first equation (1), which gives the lifetime utility of the non-employed individual (not eligible for UI). As in the main text, the worker chooses $s \in \{\underline{s}, \overline{s}\}$ and based on his optimal choice he can be either O (if $s = \underline{s}$) or U (if $s = \overline{s}$). Second, consider the program in state U_b (equation (2) 'unemployed with benefits'). The agent receives a fraction ξ of his income $w\epsilon\overline{h}$ in unemployment. With probability θ_U he remains eligible to receive benefits in the next period. Moreover, from (5), if this agent does not receive an offer the next day and remains eligible for UI (at rate $(1-p(\overline{s}))\theta_U$) he can choose whether he wants to remain in U_b or flow to U or O. However, if his benefits expire (at rate $(1-p(\overline{s}))(1-\theta_U)$ he may only choose between U and O; state U_b is no longer available. Notice also that when the agent is in state U_b we assume that he does not choose search intensity $s \in \{\underline{s}, \overline{s}\}$. Instead he has to set $s = \overline{s}$, i.e. exert high search effort. Thus Q^{n_b} gives the option to the unemployed to opt out of the insurance scheme. For example, some individuals may experience a productivity shift and decide that it is not worthwhile to keep effort at high levels to remain in the UI scheme.[2]

Equation (3) represents the program of the employed agent who is not eligible for benefits. With probability $1-\theta_E$ this agent becomes eligible in the next period and the option value then is $Q^{e_b} = \max\{V^O, V^U, V^E, V^{E_b}\}$. Last, (4) is the Bellman equation for the employed agent who is eligible to receive benefits. If he remains employed in the next period, the option value Q^{e_b} applies. If he experiences a separation shock then he can choose whether he wants to be unemployed with benefits or give up on unemployment compensation and hence flow out of the labor force.

1.1.2 Summary of the UI Scheme — Relation to the Literature

The unemployment scheme assumed in the model is a simplistic version of the UI scheme in the US. We have assumed that eligibility for unemployment insurance is summarized by two lotteries: benefits expire with probability $1-\theta_U$ and workers may qualify for benefits (when their matches end) at $1-\theta_E$. It is well known that benefits in the US expire after six months.[3] Through setting $\theta_U = \frac{5}{6}$ we can capture the average duration of unemployment benefits, this simplification is made in many papers and the aim is to avoid having to introduce unemployment duration in the state vector.[4]

In contrast, assuming $\theta_E > 0$ is much less common in the literature. In reality, to be eligible for unemployment benefits, job losers in the US must meet several requirements, the most important of which is to have sufficiently worked during a defined base period. Wang and Williamson (2002), for example, report that agents need to have worked at least 20 weeks within the previous year to qualify

[2] Notice that workers will never quit U_b to flow to U because the effort level remains high, but in U the worker is not paid any benefits. Workers can move from U_b to U either when their benefits expire or with an intervening O spell (i.e. experience a sequence of productivity shocks). The same principle applies to the option value Q^{e_b}. Workers will never give up on their eligibility for unemployment benefits unless they also quit their job. In other words, $V^{E_b}(X) \geq V^E(X)$ for all values of X.

[3] This holds, in particular, during periods of 'normal unemployment'. In 'high unemployment'periods, benefits may be extended. The length of these extensions has varied historically and across states. See, for example, Hagedorn et al. (2016) among others for an analysis of the most recent extensions.

[4] See, for example, Mitman and Rabinovich (2015), Fredriksson and Holmlund (2001) among many others. Wang and Williamson (2002), Young (2004) and Oikonomou (2016) are heterogeneous agents models where durations are explicitly considered. These are papers with single agent households and with quarterly horizons. Since we will consider couples households and the horizon of the model is monthly, keeping track of benefit histories increases the computational costs considerably.

for benefits. Using the lottery θ_E, we are able to capture parsimoniously this salient feature of the US unemployment insurance scheme.[5] Since most previous papers assume instantaneous eligibility, we also do this and use $\theta_E = 0$ as our benchmark model.

Another important requirement that benefit recipients in the US have to meet is to 'continue being unemployed' that is to search intensively for jobs and to be available for work. Recall that in equation (1) we set the effort level equal to $\overline{s}$ in state U_b. This makes the search effort and the job finding probabilities of U_b agents equal to the analogous objects for U agents. We later discuss these choices further.

Finally, notice that the fact that unemployment compensation is a constant fraction ξ of the income that the individual would obtain in the labor market is a simplification. A more realistic arrangement would set income in unemployment proportional to past realizations of labor income, when the agent was employed. Again this would require us to keep track of the worker's employment history, which would increase the state space considerably. Since productivity is persistent in the model, assuming that benefits vary with the current value of ϵ is a reasonable approximation.

We now make several remarks to identify which of the ingredients of the model are new to the literature. Many papers have considered the impact of unemployment benefits using models in which individuals exert costly search effort. This is the case in Hopenhayn and Nicolini (1997, 2009), Wang and Williamson (2002), and Young (2004) among many others. The reader should note that though our model possesses a costly effort margin, it does not allow unemployed individuals to choose between different effort levels as in the papers mentioned above. We have therefore abstracted completely from the standard 'moral hazard argument' that benefits reduce search intensity, leading to longer durations in unemployment. This modeling choice is not made simply for convenience; the sentiment in the recent empirical literature is that the moral hazard impact of unemployment benefits is rather small (see, for example, Hagedorn et al., 2016; Rothstein, 2011; Card et al., 2007; Kroft and Notowidigdo, 2016). In contrast, a stream of recent papers has found a (statistically) significant impact of unemployment insurance on the transitions between states U and O. Card et al. (2007), for example, argue that the spike in the outflow from unemployment observed when benefits expire does not represent an inflow into employment; it is rather an outflow from the labor force.[6] In the same spirit, Farber et al. (2015) find that the 2012 benefit extensions have led to reduced exits from the civilian labor force but detect no significant effects on the job finding probabilities. Despite the empirical evidence which advocates that unemployment benefits influence the effort choice at the unemployment - out of the labor force margin, at the theoretical level the interplay between benefits and participation remains by and large unexplored in the literature.

To give the reader a brief preview on why this margin becomes important in our model, consider the allocation under complete markets we solve in the paper and describe explicitly in the online appendix. Under a complete financial market, obviously, unemployment insurance does not need to be modeled explicitly as in the previous subsections devoted to the incomplete market model (i.e. since households pool resources and finance consumption through transfers). However, we can still interpret the transfers to the unemployed as unemployment insurance. Notice that these transfers are lump sum and (moreover) they do not influence the labor force participation choice of

[5] As in the case of θ_U, the lottery θ_E helps us to keep the computational model tractable.

[6] The early literature has interpreted this spike as evidence in favor of the moral hazard narrative (see, for example, Baily, 1978).

individuals. Participation is *perfectly contractible* by the planner. In other words, the planner can control the search intensity and labor supply of individuals. The optimal allocation is one where the least productive individuals are outside the labor force and marginal utility becomes independent of the labor market status.

In the case of incomplete markets, however (both under bachelors and couples), the government cannot separately control the search intensity of individuals and insure consumption through transfers.[7] We will later show that in this case unemployment benefits give us a very steep tradeoff between insurance and incentives. When benefits increase, some individuals who would be out of the labor force in the absence of unemployment insurance will prefer to receive benefits after a job separation, then wait until benefits expire to flow to out of the labor force. This tradeoff will be important in both incomplete market models we consider (bachelors and couples).

A final comment ends this subsection. We have chosen to leave the following frictions outside the model. As in Hansen and İmrohoroğlu (1992), we could have allowed unemployed agents to 'hide' job search outcomes from the government and therefore continue receiving benefits after having turned down an offer. As in Hopenhayn and Nicolini (1997) and Wang and Williamson (2002), we could also have allowed quitters to receive, with some positive probability, unemployment compensation. We abstract from these margins for two reasons. First, because we wish to focus our attention on the impact of UI on participation along the lines described above. Second, because given the steady state calibration of our model, these margins are not important. Since $p(\underline{s}) < p(\overline{s})$, our model will give us high search costs to match the target U-rate under the benchmark UI scheme. Individuals who are eligible for benefits will thus choose to remain in state U_b if they prefer state E over state O. In other words, only agents who want to work will want to participate in the unemployment insurance program (i.e. non-searchers, and individuals who would anyway be unemployed because they have low wealth).

1.2 Competitive Equilibrium

Definition *Denote $X \equiv (a, \epsilon)$. The competitive equilibrium in the bachelor model is a collection of prices (w, r), taxes and benefits (τ, ξ) and policy functions $c_S(X), a'_S(X)$ for $S \in \{O, U, U_b, E, E_b\}$, $c_R(X), a'_R(X)$ and $S^{*,k}(X)$, $k \in \{n, n_b, e, e_b\}$. It also consists of quantities (K, L, C) and lifetime utilities $V^S(X)$ $S \in \{O, U, U_b, E, E_b\}$, $V^R(X)$ and $Q^k(X)$ $k \in \{n, n_b, e, e_b\}$. Finally, it consists of a measure Γ of households across state variables such that:*

- *$V^S(X)$ and $V^R(X)$ solve the Bellman equations and the optimal policies $c_S(X), a'_S(X)$ for $S \in \{O, U, U_b, E, E_b\}$ and $c_R(X), a'_R(X)$ derive. $S^{*,k}(X)$, $k \in \{n, n_b, e, e_b\}$ solves $Q^k(X)$ in (5)*
- *The representative firm maximizes profits: $w = (1-\alpha)K^{\alpha}L^{-\alpha}$ and $r = \alpha K^{\alpha-1}L^{1-\alpha}$*
- *Markets clear: Aggregate capital is given by*

$$K = \int_{\mathcal{X}} \sum_{S \in \{O,U,U_b,E,E_b\}} a'_S(X) d\Gamma^S(X) + \int_{\mathcal{X}} a'_R(X) d\Gamma^R(X)$$

[7] The reader should think of this as the standard moral hazard argument that effort is unobserved by the government (e.g. Hopenhayn and Nicolini, 1997). We will later make a comparison between the complete and incomplete market model along these lines.

Aggregate labor is given by:

$$L = \int_{\mathcal{X}} \sum_{S \in \{E, E_b\}} \epsilon \overline{h} d\Gamma^S(X)$$

The aggregate resource constraint satisfies:

$$K' = (1-\delta)K + K^{\alpha}L^{1-\alpha} - \int_{\mathcal{X}} \sum_{S \in \{O,U,U_b,E,E_b\}} c^S(X) d\Gamma^S(X) - \int_{\mathcal{X}} c^R(X) d\Gamma^R(X)$$

- T*he government balances the budget. Taxes and benefits satisfy in equilibrium:*

$$\int_{\mathcal{X}} \xi \epsilon \overline{h} w d\Gamma^{U_b} = \sum_{S \in \{E, E_b\}} \int \tau \epsilon \overline{h} w d\Gamma^S$$

- *The measure* Γ *is consistent.*

Let $\mathcal{X} \equiv \mathcal{A} \times \mathcal{E}$ *denote the state space of assets and productivity. Let* $\widetilde{\mathcal{A}} \subset \mathcal{A}$ *and* $\widetilde{\mathcal{E}} \subset \mathcal{E}$ *(subsets of the state space). Define also* ω_S^k *the transition probability from state* S *to state* $k \in \{n, n_b, e, e_b\}$ *conditional on not retiring. For example,* $\omega_E^{e_b} = (1-\chi)(1-\theta_E)$, $\omega_O^e = p(\underline{s})$ *and so on. The law of motion of the measure* Γ *can be represented as follows:*

$$\Gamma_{t+1}^k(\widetilde{\mathcal{A}}, \widetilde{\mathcal{E}}) = (1-\phi_R) \sum_{S \in \{O,U,U_b,E,E_b\}} \left(\int_{a'_S \in \widetilde{\mathcal{A}}, \epsilon' \in \widetilde{\mathcal{E}}} \omega_{(S)}^k \; d\pi_{\epsilon'|\epsilon} \, d\Gamma_t^{(S)} \right)$$

gives the measure of households with wealth in $\widetilde{\mathcal{A}}$ *and productivity is* $\mathcal{E}$ *and which are in state* $k \in \{n_b, e, e_b\}$ *in the beginning of* $t+1$. *For state* n *we have:*

$$\Gamma_{t+1}^n(\widetilde{\mathcal{A}}, \widetilde{\mathcal{E}}) = (1-\phi_R) \sum_{S \in \{O,U,U_b,E,E_b\}} \left(\int_{a'_S \in \widetilde{\mathcal{A}}, \epsilon' \in \widetilde{\mathcal{E}}} \omega_S^{nn} \; d\pi_{\epsilon'|\epsilon} \, d\Gamma_t^S \right) + \phi_A \int_{a'_R \in \widetilde{\mathcal{A}}, \epsilon' \in \widetilde{\mathcal{E}}} d\pi_{\epsilon'|\epsilon} \, d\Gamma_t^R$$

Given the above, the measure of households in state S *can be constructed from the policy functions which solve (5). For example, we have:*

$$\Gamma_{t+1}^{(E)}(\widetilde{a}', \epsilon') = \Gamma_{t+1}^e(\widetilde{a}', \epsilon') \mathcal{I}\left(S^{*,e}(\widetilde{a}', \epsilon') = E\right) + \Gamma_{t+1}^{e_b}(\widetilde{a}', \epsilon') \mathcal{I}\left(S^{*,e_b}(\widetilde{a}', \epsilon') = E\right)$$

gives the measure of households in state E *for all* $a' \in \widetilde{\mathcal{A}}$ *and* $\epsilon' \in \widetilde{\mathcal{E}}$ *given* $\Gamma_{t+1}^e(\widetilde{a}', \epsilon')$. $\mathcal{I}(x)$ *takes the value 1 when* x *holds and zero otherwise. Analogously, we can construct the remaining conditional cdfs which we omit for the sake of brevity. Finally, we have:*

$$\Gamma_{t+1}^R(\widetilde{\mathcal{A}}, \widetilde{\mathcal{E}}) = \phi_R \sum_{S \in \{O,U,U_b,E,E_b\}} \left(\int_{a'_S \in \mathcal{A}, \epsilon' \in \widetilde{\mathcal{E}}} d\pi_{\epsilon'|\epsilon} d\Gamma_t^S \right) + (1-\phi_A) \int_{a'_R \in \widetilde{\mathcal{A}}, \epsilon' \in \widetilde{\mathcal{E}}} d\pi_{\epsilon'|\epsilon} d\Gamma_t^R,$$

1.3 Program of the Couple

We now consider the case where the household consists of two agents. Let S be the joint labor market status. Hence, $S = (S^1, S^2)$, $S^i \in \{O, U, U_b, E, E_b\}$ for $i = 1, 2$ and $S \in \{O, U, U_b, E, E_b\} \times \{O, U, U_b, E, E_b\} \equiv \mathcal{S}$. Notice that in this case the number of value functions which need to be resolved is 25 (+1 for the retirement state). We will therefore not summarize analytically all of these objects here. To make the notation more succinct, consider the following mapping between the states S and the options (Qs) that couple has in each state. First, number the states from 1 to 26 (the elements of $\mathcal{S} \cup R$). Second, denote by Q^{kl}, $kl \in \{n, n_b, e, e_b\} \times \{n, n_b, e, e_b\} \cup R$ the (corresponding) option values that the couple may have in the beginning of the period. Notice that there are 16 (meaningful) options $\{n, n_b, e, e_b\} \times \{n, n_b, e, e_b\}$, but to simplify the exposition we add the retirement state option Q^R.[8]

The remaining objects are defined in a standard fashion. For example, a couple in state (U, U) (both members are unemployed without benefits) will be in nn in the beginning of the next period if neither of its members receives an offer. Then the option is $Q^{nn} = \max\{V^{OO}, V^{UO}, V^{OU}, V^{UU}\}$. These definitions should be clear from the discussion offered in the main text and the program of the bachelor household analyzed in the previous section.

Define the transition matrix $\widetilde{Pr}_{j,kl}$ from state $j \in \mathcal{S} \cup R$ to the beginning of period state kl. Clearly not all elements of $\widetilde{Pr}_{j,:}$ are positive. For example, a couple in state (U, U) today will not be in state $(n_b n_b)$ tomorrow (or it will reach this state with zero probability). Analogously, a couple in state (U_b, U_b) will have the option value Q^{nn} when both of its members lose their benefits. With the notation we followed previously, this will occur with probability $(1 - p(\overline{s}))^2(1 - \phi_R)(1 - \theta_U)^2$. Analogously, this couple will have options $Q^{n_b n_b}$ with $(1 - p(\overline{s}))^2(1 - \phi_R)\theta_U^2$, options Q^{ee} with $p(\overline{s})^2(1 - \phi_R)$ and so on.

Given the above, the Bellman equations can be written as:

$$V_j(a, \epsilon) = \max_{c^i, a' \geq 0} \sum_{i-1,2} u(c^i, l^i_s) + \beta \int \sum_{kl \in \{n,n_b,e,e_b\} \times \{n,n_b,e,e_b\} \cup R} \widetilde{Pr}_{j,kl} Q^{kl}(a', \epsilon') dF(\epsilon', \epsilon) \tag{6}$$

$$s.t : a' = (1 + r)a + \mathcal{Y}_j - \sum_{i=1,2} c^i$$

$$\text{and} \quad l^i \quad \text{consistent with } j \tag{7}$$

where $\mathcal{Y}_j$ denotes the income of the couple in j. We have: $\mathcal{Y}_j = 0$ in states (O, O), (U, O), (O, U) (U, U) and R. $\mathcal{Y}_j = w\overline{h}\epsilon^1(1 - \tau)$ in state (E, O), (E, U) and (E_b, U), (E_b, O). The remaining values for $\mathcal{Y}_j$ are defined similarly.

Equation (6) can be further simplified by defining the function:

$$\mathcal{E}\mathcal{V}_j(a', \epsilon) \equiv \int \sum_{kl \in \{n,n_b,e,e_b\} \times \{n,n_b,e,e_b\} \cup R} \widetilde{Pr}_{j,kl} Q^{kl}(a', \epsilon') dF(\epsilon', \epsilon), \tag{8}$$

which is the conditional expectation of the continuation utility evaluated at a' and given the current

[8] Clearly, $Q^R = V^R$ since the couple's only option in retirement is to remain in state R.

state j. In this way, (6) can be written as follows:

(9)
$$V_j(a,\epsilon) = \max_{c^i, a' \geq 0} \sum_{i-1,2} u(c^i, l^i_s) + \beta \mathcal{E}\mathcal{V}_j(a', \epsilon)$$
$$s.t : a' = (1+r)a + \mathcal{Y}_j - \sum_{i=1,2} c^i$$
$$\text{and} \quad l^i \quad \text{consistent with } j.$$

1.3.1 Computation

The numerical algorithm we followed to solve program (9) is the following:

1. Guess the values of β, $\mathcal{Y}_j$[9] and $V_j(a,\epsilon)$ $j \in \mathcal{S} \cup R$. With the matrix $\widetilde{Pr}$ and the transition probabilities from ϵ to ϵ', compute the conditional expectation function $\mathcal{E}\mathcal{V}_j(a,\epsilon)$.

2. Solve program (9) for each j over a discretized grid for assets.

   Standard arguments apply here. On every iteration a new function $\mathcal{E}\mathcal{V}_j(a,\epsilon)$ must be computed and the value functions V_j are updated. This process continues until two successive guesses for V_j are 'close enough'.[10]

3. Update the value of β and the elements of $\mathcal{Y}_j$.

   As in the benchmark model, the value of β needs to be updated until the equilibrium where aggregate assets are consistent with the interest rate r is found. This means that the optimal policy functions have to be recovered from (9) and the behavior of a large number of households needs to be simulated.

   The elements of $\mathcal{Y}_j$ need to be updated until the tax rate τ is consistent with budget balance.

1.4 Calibration

1.4.1 Calibration of the Couple Model

We now discuss the choice parameters and functional forms. As in the benchmark model, we assume that $u(c^i, l^i) = \frac{({c^i}^{\eta} {l^i}^{1-\eta})^{1-\gamma}}{1-\gamma}$. We set $\gamma = 2$ as Hansen and İmrohoroğlu (1992) do, and choose a value of η such that the model is consistent with an employment population ratio of 62%. We obtain $\eta = 0.457$. Moreover, we calibrate the value of κ so that the unemployment rate is in the steady state equal to 6.2%. Notice that in the economy with benefits, more individuals want to be unemployed. Therefore, we need to increase κ to hit the unemployment target. We obtain $\kappa = 0.373$.

The unemployment benefit scheme is calibrated to match key features of the US scheme. First, we set $\theta_U = \frac{5}{6}$ so that the average duration of unemployment benefits is two quarters. Second, we let the benefit replacement ratio equal 0.45 as in Mitman and Rabinovich (2015). Finally, as discussed above, in the benchmark version of the model we assume $1 - \theta_E = 1$ (all employed agents qualify for unemployment insurance when their jobs are terminated). We will subsequently experiment with values for $\theta_E > 0$.

[9] Guessing $\mathcal{Y}_j$ amounts to guessing the equilibrium tax rate, since productivity and hours are given.
[10] In practice, the distance is the maximum of the absolute difference between the initial guess and the update of the value function on the discretized state space.

The labor income tax rate is adjusted so that the government runs a balanced budget in the steady state. In the experiments below we will consider different levels of unemployment benefits and study their impact on the economy and on welfare. In each case we will consider the effects of changes in the UI scheme in the long run steady state of the model.[11] When we change the level of benefits we continue to assume that taxes are such that the budget is balanced. In the benchmark case we obtain $\tau = 0.02$.

As with the incomplete market models we studied in the text, to find the equilibrium in the economy we pin down the value of β such that $r = 0.0041$ at the monthly horizon. We find that $\beta = 0.992$.[12] Panels B and Ci) in Table 1 summarize the values.

Finally, a number of parameters are taken directly from the model without unemployment benefits studied in the text. These are the idiosyncratic productivity process, the parameters which govern retirement and the labor market frictions. Panel A in Table 1 reminds the reader of the values of these parameters.

1.4.2 Calibration of the Bachelor Model

The baseline parameters in the bachelor economy are set to hit the same targets as in the couple model. The calibrated values for η, κ, β etc are obviously different from the couple model, since the household's structure differs. Again, β is smaller in the bachelor model due to the stronger precautionary savings motive of the households. We summarize the parameter values in the bachelor model in Panel C ii) of Table 1.

[11] This follows Krusell et al. (2010) and Wang and Williamson (2002), among many others.

[12] In the economy with unemployment insurance, β increases since the incentive to accumulate precautionary savings weakens. However, this effect is quantitatively small, significant only at the 4th digit.

Table 1: The Model Parameters (Monthly Values)

Parameter	Symbol	Value
A: Parameters from The Baseline Model		
Share of Capital	α	0.33
Depreciation Rate	δ	0.0083
Time Working	$\overline{h}$	$\frac{1}{3}$
AR(1) of idiosyncratic productivity	ρ_ϵ	0.98
Standard Dev. of idiosyncratic productivity	σ_ϵ	0.11
Retirement Rate	ϕ_R	0.00945
Reentry Rate	ϕ_A	0.0507
Offer Rate: O	$p(\underline{s})$	0.16
Offer Rate: U and U_b	$p(\overline{s})$	0.26
Exogenous Separation Rate	χ	0.02
B: Parameters for the UI Model Couples and Bachelors		
Replacement Ratio	ξ	0.45
Expire Rate Benefits	$1-\theta_U$	$\frac{1}{6}$
Eligibility for employed	$1-\theta_E$	1
C i): Parameters for the UI Model Couples (Preferences and Taxes)		
Consumption Weight	η	0.457
Cost of Search	κ	0.373
Discount Factor	β	0.992
Tax Rate	τ	0.020
C ii): Parameters for the UI model Bachelors (Preferences and Taxes)		
Consumption Weight	η	0.422
Cost of Search	κ	0.343
Discount Factor	β	0.990
Tax Rate	τ	0.0199

Note: The table summarizes the values of the model parameters under the baseline calibration of the UI model. Panel A lists parameters whose values are the same as in the baseline model without unemployment benefits in text (technology, endowments and search frictions). Panel *B* gives parameters which are common across models with unemployment insurance (e.g. couple and bachelor models). These include the replacement ratio ξ and the values for the eligibility lotteries. Panel C reports preference parameters which differ across models (see the main text for further details).

2 Effects of Unemployment Benefits

2.1 Optimal Policy Rules

2.1.1 Optimal Policy Rules: Bachelors

We begin by investigating how household optimization is affected by the presence of unemployment insurance provided by the government. In Figure 1 we show the decision rules of bachelor households. The top panels correspond to the case where the government provides unemployment insurance (steady state calibration). In the bottom panels unemployment benefits are set equal to zero. The graphs on the left show the policy rules when agents have job offers and on the right when agents do not have offers.[13]

The top right panel shows two distributions: The solid line corresponds to non-employed agents who do not receive unemployment benefits (states U and O), the dashed line is unemployed agents with benefits. The vertical (black) line in the figure shows the cutoff wealth level above which agents who do not receive benefits leave unemployment to flow to out of the labor force. The shaded area in the top right panel shows wealth levels at which agents who receive benefits continue being unemployed. Therefore, non-eligible agents drop to O after point A. Benefit recipients opt out of the UI scheme and drop to O after point B. Moreover, when benefits expire, agents from the dashed line distribution will join the solid line. They will therefore become out of the labor force if wealth falls within the shaded area (between A and B). In this case we will observe a spike in the outflow from the LF at the time benefits expire, consistent with the empirical evidence discussed above.

Now consider the labor supply response of the 'unemployed with benefits' to a job offer. The shaded area in the top left panel shows the wealth region over which it is optimal to quit employment and flow to O. At any wealth level below 220 thousand dollars, individuals accept the job offer. This tells us that unemployed individuals with benefits will always accept job offers, and when their benefits expire they will become non-searchers.[14]

The bottom panels, which set $\xi = 0$, illustrate two properties of the model. First, since in the absence of benefits states U and U_b become equivalent, the impact of eliminating benefits is to increase the fraction of agents which drop to O after a separation shock and would flow back to E if a job offer arrived. Agents who have been represented in the top right panel by the dashed line in the shaded area and have a wealth level above point A' are now non-searchers. Second, in the left panel the region over which individuals remain employed (non-shaded) now becomes wider. This reveals the impact of distortionary taxes on the labor supply of individuals. Higher taxes reduce the desired work time and shorten the job tenure of high wealth households. From the graph it follows immediately that this effect concerns primarily the non-searchers, since these are sufficiently wealthy and hence are close to the E-O threshold.[15]

[13] Recall that in the benchmark model state e_b is equivalent to state e since $\theta_E = 0$.

[14] As discussed above, costly job search makes moral hazard argument described in Hansen and İmrohoroğlu (1992) unimportant in our model. When agents in state U_b receive offers they will always prefer to move to state E to avoid paying the search costs. If these costs are equal to zero (as in Hansen and İmrohoroğlu, 1992), then some individuals would want to 'cheat' the UI agency and hide their offers.

[15] Notice that taxes here rise to 2 percent from 0 when $\xi = 0.45$. Hence the effect is not as large as when we will later set $\xi = 1$ (see subsequent paragraphs and tables). It is well known that the distortions from taxation are convex in these models.

Moreover, when benefits change, prices (interest rates and wages) and the wealth distribution also change. Hence, the policy rules are influenced by several forces simultaneously, which make it difficult to isolate the impacts. This is

2.1.2 Optimal Policy Rules: Couples

Figure 2 summarizes the behavior of couples under the baseline UI scheme. In the top left panel, both household members have job offers; in the top right agent 1 (the more productive) has an offer. The bottom left considers the case where agent 2 has an offer and agent 1 does not, and the bottom right the case where both household members do not have offers. The shaded region (above point A) in the top left panel denotes the wealth levels at which the household withdraws agent 2 from the market (flow to O). Agent 1 remains employed (top right panel, state (E_b, O)) until the arrival of a separation shock. If this shock arrives and at the same time agent 2 receives an offer, then the couple moves to the bottom left panel. This panel plots two distributions. The solid line corresponds to the optimal policy when agent 1 does not receive unemployment benefits, and the dashed line to the case where he receives benefits.

The shaded area in the bottom left panel corresponds to the region where it is optimal for agent 2 to remain employed when agent 1 does not receive unemployment benefits. If the household's wealth exceeds point C (then the agent 2 will quit his job and flow to out of the labor force and at the same time agent 1 will also move to state O. The vertical solid line in the graph shows the wealth level (at point B) at which the agent 2 quits his job if agent 1 receives unemployment compensation. Since $B < C$ unemployment benefits reduce (precautionary) desired labor supply by secondary earners.

Notice further that the policy rules in the bottom left panel suggest that when agent 1's benefits expire he will not withdraw from the labor force. This property is important; in the couples model it will mostly be secondary earners who will remain unemployed when they are paid benefits, and drop to out of the labor force when the benefits expire. Primary earners will of course also engage in this behavior,[16]. However, most of the increase in the unemployment rate at higher benefits which we will subsequently document will derive from keeping less productive individuals in the LF.

In the main text we used the analogue of Figure 2 to illustrate the AWE. Since point A is a lower wealth level than point C, agent 2 accepts an offer that he would not have accepted had agent 1 remained employed. In this case, the AWE involves a direct transition into employment. This continues to hold when agent 1 is paid unemployment benefits. Since $B > A$, there is a region where agent 2 accepts the offer; however, this region is now smaller. Unemployment benefits crowd out (postpone) the AWE.

To complete this section, we consider in Figure 3 the same household types as in Figure 2, but now assume $\xi = 0$. We observe the following from the figure. First, the region over which couples keep both members in employment now becomes larger because of the lack of the safety net provided by unemployment benefits. To show this effect clearly, we depict in the top left panel point A' (which represents the new cutoff wealth level under $\xi = 0$) and A, which is the old cutoff. Clearly $A' > A$, since desired labor supply decreases. Second, in the bottom left panel we show cutoffs B and C and the cutoff C', the new wealth level at which agent 2 drops to O if agent 1 is unemployed. In the

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not an issue in models which do not feature wealth as a state variable.

Finally, note that lower benefits imply a stronger incentive on the part of households to accumulate savings. This effect is standard in models of heterogeneous agents and wealth accumulation and should also be captured in the figure. It is mitigated by the drop in the level of interest rates at $\xi = 0$ (see Tables 4 and 5).

[16] Consider the bottom right panel. In the shaded area, individuals who do not receive benefits quit unemployment to flow to out of the labor force. Individuals who receive benefits, however, remain in U_b in this region. Hence, agent 1 will move from U_b to O when his benefits expire and wealth exceeds point D. Notice, however, that this concerns a small fraction of the population.

economy without unemployment insurance, agent 2 increases his attachment to employment because of the lower tax but also in order to provide insurance.

2.2 Aggregate Effects of Unemployment Benefits

2.2.1 Unemployment Insurance in the Couples Model

We now analyze the impact of various tax financed reforms in the UI scheme. The first set of experiments we consider varies the level of unemployment benefits, keeping the average duration constant. This is performed in the top panel of Table 2, where we show the results of varying the replacement rate from 0% (no UI benefits) to 100%. Subsequently, we will also study the effects of varying the duration of UI (e.g. middle and bottom panels of Table 2).

Consider the top panel of Table 2, which has $\theta_U = \frac{5}{6}$, so that benefits expire in six months on average. The first row shows labor market aggregates, capital, interest rates and tax rates in the benchmark version of the model. The remaining rows report these statistics under alternative UI schemes. In row 2 we eliminate UI from the economy; in rows 3-5 we increase unemployment benefits to ξ =0.1, 0.2 and 0.3 respectively and finally, in rows 6-8 we consider higher levels of benefits than in the benchmark (we set ξ =0.6, 0.9 and 1 respectively).

The effects of changes in the UI scheme can be summarized as follows. First, the impact of UI on the aggregate employment rate is negligible. At zero, benefits employment drops by 0.05 percentage points; when benefits equal 1, it drops by 0.16 percentage points. The effect is non-monotonic since employment peaks at $\xi = 0.3$. However, the changes are in any case very small. Second, the unemployment rate rises sharply as benefits increase. For example, when $\xi = 0$ the U-rate is 4.46%; when $\xi = 1$ it becomes 7%. By the property that benefits leave aggregate employment unchanged, the change in the U-rate is accounted for by changes in labor force participation. Therefore, higher UI increases participation. From $\xi = 0$ to $\xi = 1$, the participation rate increases by roughly 2.4 percentage points.

The third column in Table 2 shows that the rise in participation is fully accounted for by a fall in the number of non-searchers. Recall that these are individuals who want to hold jobs, but they are not willing to search actively for them. They do not search because their productivity is low relative to the productivity of the other member of the household and because family wealth is sufficiently high. For these individuals, unemployment insurance does not provide a substantial consumption smoothing benefit.

Notice that, in contrast to the standard moral hazard argument (UI decreases the search intensity of unemployed agents) here, benefits increase the search effort of UI recipients. As non-searchers, individuals exert $\underline{s}$ units of effort; as unemployed agents, they exert $\overline{s}$ units. Overall, in the economy, search intensity increases by $2.5\%(\overline{s} - \underline{s})$ (rise in the unemployment population ratio times the change in search effort) when benefits rise from 0 to 1.

First best The rise in search intensity is not (necessarily) socially optimal. Consider, for instance, the planning program under complete markets. As explained above in this case the government (planner) can i) use lump-sum transfers across households to equate the marginal utilities of consumption and ii) can set search intensity and labor supply separately for each individual type to maximize efficiency. Relative to this benchmark, the couple model adds three types of distortions:

1) markets are incomplete and therefore the marginal utilities are not equal across individuals who live in separate households 2) the government cannot directly control the search intensity of individuals, it derives from the optimization of households and hence becomes an additional constraint for the government and 3) the means that the government has at its disposal are distortionary taxes and unemployment benefits. Benefits can insure unemployed workers but not out of the labor force individuals; moreover, benefits are constrained to last for two quarters in the couple economy.[17]

In spite of these significant differences, it is instructive to consider the optimal level of search intensity in the complete market model. When we assume the same preferences as in the couples economy, we find the level of employment rate is 0.568 and unemployment rate 3.67%. Search intensity is considerably higher under the benchmark UI scheme in the economy with incomplete financial markets.

Welfare outcomes in the couple model

In the last column of Table 2 we report the percentage increment(s) in consumption that the average household must experience to be as well off in the benchmark UI scheme as under each of the alternative UI schemes considered. Denote the increment by $\widetilde{w}$. We construct the statistic $\widetilde{w}$ reported in the table as follows:

$$\mathcal{V}\left(\xi = 0.45, \widetilde{w}(\overline{\xi})\right) \equiv \sum_{(S^1,S^2)\in\{O,U,U_b,E,E_b\}\times\{O,U,U_b,E,E_b\}} \int E \sum_{t=0}^{\infty} \sum_{i=1,2} u(c^i(1+\frac{\widetilde{w}}{100}), l^i) d\Gamma^{(S^1,S^2)}(\xi = 0.45)$$

$$= \mathcal{V}_(\xi = \overline{\xi}, 0) \sum_{(S^1,S^2)\in\{O,U,U_b,E,E_b\}\times\{O,U,U_b,E,E_b\}} \int E \sum_{t=0}^{\infty} \sum_{i=1,2} u(c^i, l^i) d\Gamma^{(S^1,S^2)}(\xi = \overline{\xi})$$

$$\text{for} \qquad \overline{\xi} \in \{0.0, 0.1, 0.2, ..., 1.0\}$$

and notice that we exclude retired households from the calculations.[18] The welfare patterns are as follows. Households lose when benefits increase relative to the benchmark and they win when benefits are lowered. Even in the case where UI is eliminated from the economy, households are better off. Welfare is maximized at low levels of benefits (0.1 in terms of the discretized grid we consider). However, the welfare gains are relatively small.

More specifically, the welfare gains at low levels of benefits are as follows. Relative to the economy where $\xi = 0.0$ (no unemployment insurance), households need to be compensated with an increase in consumption of 0.149% to want to remain under the benchmark scheme. They want to experience an increase in consumption of 0.173% in the benchmark model to be indifferent with the case $\xi = 0.1$. Moreover, to avoid living under a regime which sets $\xi = 0.6$ ($\xi = 1.0$), households are willing to give

[17] The reader should interpret 1) to 3) as follows. Assume that the government maximizes the welfare of a single household. For the moment, also disregard retirement and further assume that the government can extract (initially) the assets of the household. The problem then becomes similar to Hopenhayn and Nicolini (1997). Without 2), the government can insure the marginal utility of consumption completely; when the constraint in 2) is taken into account, the optimal insurance contract will feature decreasing consumption during the unemployment spell (if it is optimal to induce high effort). The sequence of taxes and benefits which can decentralize this program will not resemble the sequences in 3). Finally, incomplete markets add heterogeneity across households and therefore further complicate the policy program, since one instrument is used for all household types.

[18] In this expression $\mathcal{V}\left(\xi = 0.45, \widetilde{w}(\overline{\xi})\right)$ denotes the average welfare in the long run steady state with $\xi = 0.45$. $\widetilde{w}(\overline{\xi}$ is indexed by $\overline{\xi}$ because the value changes with level $\overline{\xi}$. Clearly $\widetilde{w}(0.45) = 0$. Notice that the value functions, steady state distributions, consumption and leisure functions ought to be indexed by the level of benefits. For the sake of the exposition, we only index the first two objects.

up 0.095% (0.287%) of their consumption. These welfare changes are in the same order of magnitude as the analogous gains and loses documented in several papers which consider the impact of UI in heterogeneous agents models (for example, Wang and Williamson, 2002; Young, 2004; Krusell et al., 2010).

Interpretation As discussed in the main text, these results tell us that the tradeoff the government faces in the economy with endogenous participation is indeed very steep. On the one hand, unemployment insurance is beneficial to households that need it urgently. These are households that would exert high effort even when unemployment benefits were zero. However, as the level of benefits rises, wealthier individuals are induced to remain in the labor force and receive unemployment compensation. These individuals drop out of the LF when benefits expire. For this reason, we continue to refer to them as non-searchers. Overall, their presence in the model increases substantially the cost of financing the UI scheme.

If we had left the participation margin outside the model, then we would have an economy in which all individuals want to work; the frictions would determine the transitions between employment and unemployment. At rate χ agents lose their jobs and at a constant rate $p(\bar{s}) = 0.26$ they move back to employment. This model resembles the model of Aiyagari (1994). Unemployment insurance exerts no influence on the aggregate labor market statistics, and taxes are not distortionary. Welfare monotonically increases with the level of unemployment insurance.[19]

Recall that in the text we showed that the behavior of the primary earners can be adequately captured by this setup. This (for example) was also illustrated in Figure 2; too few primary earners drop to out of the labor force when benefits expire. For these agents, therefore, the analysis of Aiyagari (1994) will predict that they prefer higher levels of benefits over more moderate levels. When we add the participation margin and the second household member, however, these predictions are not validated by the new model because households want benefits to be low.

A number of recent papers have recovered welfare effects from changes in UI similar to those we obtain from our model, at the same time showing that households prefer low levels of benefits. Krusell et al. (2010) consider a model where unemployment to employment transitions are governed by a matching technology. The firm hiring policies are influenced by the level benefits, with more generous UI reducing the employment opportunities in the economy. Wang and Williamson (2002) consider an environment where unemployed and employed individuals exert effort, the former to find jobs and the latter to keep their jobs. Higher benefits both increase the outflow from employment and lower the outflow from unemployment. Young (2004) completes their analysis through adding general equilibrium effects. He finds that the optimal replacement rate equals zero. Our findings

[19] Notice that if we maintain preferences of the form $\frac{(c^{\eta}(1-\bar{h})^{1-\eta})^{1-\gamma}-1}{1-\gamma}$, then the participation margin is present in the model. Individuals with high wealth or low productivity do not want to work. Hansen and İmrohoroğlu (1992) consider a model of optimal UI with these preferences. They distinguish between cases where individuals can hide the offers they receive from the government, and cases where they cannot. In the latter (no moral hazard) cases, they obtain a large optimal benefit level. Recall that we also did not allow agents to cheat and reject job offers. In our model with costly search, this constraint never binds, but if we eliminate the search costs, agents will want to engage in this sort of behavior. With our preferences and no moral hazard, we again would obtain a large benefit level as the optimal policy. To construct a model as in Aiyagari (1994) we would also need to assume $\eta = 1$.

The claim that welfare monotonically increases with the level of UI in the Aiyagari (1994) model is backed up by standard results in the literature (see, for example, Krusell et al., 2010). In such an environment it is optimal for the government to bring the allocation as close as possible to the complete market outcome. The redistributive effects of changes in UI are of second order in the steady state.

suggest that the endogenous participation margin also lowers the welfare gains from unemployment insurance.

Behavior of capital and interest rates. Columns 5-6 show that, whereas unemployment insurance increases the equilibrium interest rate, the asset supply by households displays a non-monotonic pattern. Aggregate capital is lower when $\xi = 0$ than in the benchmark, and peaks at $\xi = 0.2$. It drops again at higher levels of benefits. This behavior is determined by the balance of two forces in the model. On the one hand, higher benefits reduce precautionary savings and therefore reduce aggregate capital. On the other, we have seen that aggregate employment first rises with benefits; subsequently it drops as benefits continue to increase. Intuitively, aggregate employment rises initially as the unemployment rate increases with higher benefits. But subsequently it drops due to higher taxes and to the fact that the increase in participation concerns individuals who were previously non-searchers (and hence are not strongly attached to the labor force).[20] These forces explain why the capital-labor ratio decreases monotonically in ξ but aggregate capital does not.

The effects of unemployment duration in the couples model We now turn to the joint impact of benefit level and duration. In the middle and bottom panels of Table 2, we consider two scenarios: the middle panel shows the case where benefits are paid forever to unemployed job seekers, and the bottom panel considers the case where benefits are paid only for one period (hence $\theta_U = 1$). Though both scenarios are extreme, they can help us identify whether the tradeoff facing the government changes with the duration of UI.

It does not. As can be seen from the last column in both panels, households continue to prefer lower benefit levels over higher levels. The welfare gains and losses are somewhat larger (in absolute value) in the case of permanent unemployment benefits. However, the qualitative patterns are not changed and the differences are not substantial. What explains these findings? As can be seen from the third row of the table, permanent benefits increase the unemployment rate sharply, thereby bringing a larger fraction of previously non-searchers into the pool of unemployment. Though individuals who are unemployed and have low wealth can gain more from high and permanent benefits, the costs of taxation leads to a welfare loss for households, that do not stand to gain considerably from unemployment insurance. Therefore, households on average still prefer low benefit levels. In the bottom panel, the rise in the U-rate with ξ is less pronounced because non-searchers now drop faster to O. However, the insurance value of unemployment benefits is also smaller, because benefits are paid out for only one period. Therefore, households which stand to gain from UI now receive a considerably smaller amount of money from the government. They are more exposed to the risk of suffering a prolonged unemployment spell. Overall, households still prefer low levels of unemployment insurance.

The remaining model quantities behave similarly as in the benchmark version of the model. We conclude that the duration of benefits does not alter the tradeoff facing the government when it provides unemployment compensation in an economy with endogenous participation.

'Experience Rating' As discussed above, unemployed individuals in the US must have worked

[20] As we have seen, higher levels of benefits induce wealthier individuals to claim UI. As benefits continue to rise the wealth threshold below which agents claim benefits increases. There is thus a selection effect since the average wealth level of UI recipients increases. With higher taxes the E-O wealth threshold drops, and job tenures are on average shorter.

for at least 20 weeks in the previous year before they can qualify for unemployment insurance. This policy aims at discouraging individuals from taking jobs that they do not want to hold, simply to separate after a short tenure and receive unemployment compensation. We ruled out this sort of behavior from the model when we assumed that only workers who are hit by a χ shock can receive benefits (and not workers who separate voluntarily due to productivity shocks, as in (Hopenhayn and Nicolini, 2009). In the model we laid out, however, individuals who have higher wealth levels (e.g. the non-searchers) are prone to drop to out of the labor force faster after having received a job offer. This holds because, at high wealth, desired labor supply is more sensitive to productivity shocks and also because once a job is found and assets increase sufficiently, then individuals will drop to O even without having experienced a drop in productivity.

We complete our analysis with the following experiment. We set $1-\theta_E = 0.33$ so that agents need to work on average for one quarter before they can qualify for unemployment insurance. We want to see whether this empirically motivated policy margin can alter our conclusions about the scope of unemployment insurance in the economy. It cannot: in Table 3 we repeat all the experiments of Table 2 under the assumption $1-\theta_E = 0.333$ and the same parameters for preferences as previously. Notice that as the level of unemployment benefits increases, the rise in the unemployment rate becomes smaller. This shows that the tradeoff for the government indeed improves somewhat. Fewer non-searchers become unemployed at high benefit levels than when $\theta_E = 0$. However, the U-rate still increases from 4.46% ($\xi = 0$) to 6.78% when $\xi = 1.0$ when we assume that benefits expire after six months (top panel). Under $\theta_E = 0$ the U-rate was 7.0% when $\xi = 1.0$. These differences are not substantial.

Most importantly in terms of welfare outcomes the model with 'experience rating' does not dramatically change the distribution of gains across the different policies considered. We observe, for instance, that the welfare losses are somewhat smaller in magnitude at high levels of benefits, but also that the welfare gains are more moderate.[21] This can be explained by the fact that, with $1-\theta_E = 0.333$, some unemployed agents who experience early separation shocks do not qualify for unemployment insurance. For these groups UI is most valuable, and being deprived of the safety net provided by the government increases consumption risk.

To reiterate, our model implies that low amounts of UI are preferable because at high levels of benefits, non-searchers remain in the labor force. This increases the costs of financing the scheme and therefore increases (distortionary) taxation. A central feature of the US scheme, that workers must have worked sufficiently, does not significantly alter this tradeoff.

2.2.2 Unemployment Insurance in the Bachelors Model

How are these findings impacted when we switch to the bachelor model? Recall that bachelor households can also engage in job hoarding behavior. In this model, as individuals accumulate large amounts of wealth and are hit by exogenous job destruction shocks, they flow to out of the labor force. They want to work, and if a job offer arrives they will accept it.

[21] Note that we kept the baseline in Table 2 as the benchmark for welfare evaluation here. However, the results will not change significantly if we treat the $\xi = 0.45$ with experience rating case as the new benchmark. This for example, can be seen clearly from the results in Table 3. Individuals require an increase in consumption of 0.015 to remain in the economy without experience rating than to move in the economy with experience rating when $\xi = 0.45$ (see top panel in Table 3). This is a small difference.

In Figure 1 we documented that unemployment benefits affect the behavior of these individuals (e.g. top right panel). Higher benefit levels keep them in unemployment. Therefore, given the employment and labor force participation targets, we have a large fraction of agents engaging in this sort of behavior.

In Tables 4 and 5 we repeat our previous analysis applied to the bachelor economy. The results confirm that bachelor households give a steep tradeoff between unemployment insurance and participation in the labor market. For example, consider the top panel of Table 4. As the replacement ratio rises from 0 to 1, the unemployment rate increases from 4.11% to 7.09%. This range is even wider than in the couple model. When benefits are permanent (middle panel), unemployment rises to 8.42%.

The welfare gains reported in the final rows of the tables are similar qualitatively to the couple model. However, and in spite of the wider range of the responses of unemployment, the magnitude of the welfare effects is somewhat smaller. When we set $\xi = 0.1$, for example, the welfare gain relative to the benchmark policy of $\xi = 0.45$ is 0.103%; the welfare loss from $\xi = 1.0$ is -0.249%. Hence, the differences across the two models are not substantial and are explained by the different wealth distributions and preference parameters across the two models. In the end, as in the couple model, households in the bachelor economy prefer to be in a regime with low unemployment benefits.

Table 2: Unemployment Insurance with Endogenous Participation

UI Scheme	E-rate	U-rate	Non-searchers	K	$r+\delta$	τ	$\widetilde{w}$
Benchmark $\xi = 0.45$	61.91	6.20%	0.102	43.24	1.240%	2.00%	0
			A: Duration of Benefits: 6 months				
$\xi = 0.0$	61.86%	4.46%	0.119	43.21	1.236%	0.00%	0.149
$\xi = 0.1$	61.90%	4.98%	0.114	43.27	1.237%	0.32%	0.173
$\xi = 0.2$	61.94%	5.42%	0.109	43.29	1.238%	0.76%	0.142
$\xi = 0.3$	61.94%	5.78%	0.106	43.28	1.239%	1.24%	0.087
$\xi = 0.6$	61.83%	6.51%	0.099	43.17	1.241%	2.78%	-0.095
$\xi = 0.9$	61.82%	6.89%	0.095	43.08	1.243%	4.35%	-0.231
$\xi = 1.0$	61.75%	7.00%	0.094	43.03	1.244%	4.88%	-0.287
			B: Duration of Benefits: Indefinite				
$\xi = 0.1$	61.90%	5.24%	0.111	43.28	1.238%	0.45%	0.177
$\xi = 0.2$	61.97%	5.90%	0.104	43.31	1.239%	1.09%	0.120
$\xi = 0.3$	61.98%	6.42%	0.099	43.30	1.241%	1.79%	0.042
$\xi = 0.45$	61.93%	7.04%	0.093	43.23	1.242%	2.89%	-0.088
$\xi = 0.6$	61.90%	7.48%	0.088	43.17	1.244%	4.03%	-0.218
$\xi = 0.9$	61.88%	8.09%	0.082	43.05	1.245%	6.32%	-0.438
$\xi = 1.0$	61.81%	8.28%	0.081	43.00	1.248%	7.09%	-0.525
			C: Duration of Benefits: 1 month				
$\xi = 0.1$	61.88%	4.65%	0.117	43.24	1.236%	0.13%	0.165
$\xi = 0.2$	61.85%	4.82%	0.116	43.23	1.237%	0.30%	0.146
$\xi = 0.3$	61.89%	4.95%	0.114	43.22	1.237%	0.49%	0.135
$\xi = 0.45$	61.87%	5.11%	0.113	43.22	1.238%	0.79%	0.098
$\xi = 0.6$	61.89%	5.23%	0.112	43.21	1.238%	1.09%	0.075
$\xi = 0.9$	61.83%	5.39%	0.111	43.14	1.239%	1.71%	0.015
$\xi = 1.0$	61.83%	5.42%	0.110	43.13	1.240%	1.91%	0.004

Note: The table shows the impact of various benefit schemes in the couples model. The top panel assumes that benefits expire (probabilistically) after six months. The middle panel assumes that benefits never expire. The bottom panel assumes that unemployed agents are paid benefits during the first month in unemployment; thereafter they receive zero benefits. See the online appendix for an extensive discussion of the choice of parameters and functional forms.

Table 3: Various UI Schemes: Couple Model with 'Experience Rating'

UI Scheme	E-rate	U-rate	Non-searchers	K	$r+\delta$	τ	$\widetilde{w}$
			A: Duration of Benefits: 6 months				
$\xi = 0.0$	61.86%	4.46%	0.119	43.20	1.236%	0.00%	0.149
$\xi = 0.1$	61.89%	5.95%	0.114	43.27	1.237%	0.30%	0.171
$\xi = 0.2$	61.93%	5.36%	0.110	43.29	1.238%	0.70%	0.138
$\xi = 0.3$	62.02%	5.68%	0.106	43.30	1.239%	1.16%	0.101
$\xi = 0.45$	61.98%	6.07%	0.103	43.25	1.240%	1.86%	0.015
$\xi = 0.6$	61.98%	6.34%	0.099	43.21	1.241%	2.59%	-0.062
$\xi = 0.9$	62.02%	6.69%	0.096	43.13	1.243%	4.04%	-0.187
$\xi = 1.0$	62.05%	6.78%	0.095	43.11	1.244%	4.53%	-0.220
			B: Duration of Benefits: Indefinite				
$\xi = 0.1$	61.95%	5.19%	0.111	43.31	1.237%	0.42%	0.186
$\xi = 0.2$	62.20%	5.79%	0.105	43.33	1.239%	1.01%	0.134
$\xi = 0.3$	62.21%	6.28%	0.099	43.32	1.240%	1.66%	0.057
$\xi = 0.45$	62.08%	6.84%	0.094	43.27	1.242%	2.64%	-0.054
$\xi = 0.6$	62.09%	7.24%	0.090	43.22	1.244%	3.75%	-0.174
$\xi = 0.9$	62.11%	7.79%	0.084	43.11	1.246%	5.86%	-0.380
$\xi = 1.0$	62.16%	7.95%	0.082	43.07	1.247%	6.58%	-0.441
			C: Duration of Benefits: 1 Month				
$\xi = 0.1$	61.88%	4.64%	0.117	43.24	1.236%	0.12%	0.164
$\xi = 0.2$	61.89%	4.79%	0.116	43.24	1.237%	0.28%	0.153
$\xi = 0.3$	61.88%	4.91%	0.115	43.23	1.237%	0.46%	0.131
$\xi = 0.45$	61.87%	5.06%	0.113	43.22	1.238%	0.73%	0.098
$\xi = 0.6$	61.89%	5.17%	0.112	43.20	1.238%	1.02%	0.074
$\xi = 0.9$	61.92%	5.30%	0.111	43.17	1.239%	1.59%	0.033
$\xi = 1.0$	61.92%	5.33%	0.110	43.15	1.239%	1.78%	0.021

Note: The table shows the impact of various benefit schemes in the couple model. The top panel assumes that benefits expire (probabilistically) after six months. The middle panel assumes that benefits never expire. The bottom panel assumes that unemployed agents are paid benefits during the first month in unemployment; thereafter, they receive zero benefits. Contrary to Table 2, we assume here that not all employed agents automatically become eligible for UI. We have set $\theta_E = .3333$, so that employed agents have to work on average for three months before they can become eligible for benefits when they separate from their employers. Welfare is expressed relative to the benchmark model in the second row of Table 2.

Table 4: Various UI Schemes: Effects on Aggregates and Welfare, Bachelor Model

UI Scheme	E-rate	U-rate	Non-searchers	K	$r+\delta$	τ	$\widetilde{w}$
Benchmark $\xi = 0.45$	62.22	6.18%	0.089	43.12	1.240%	1.99%	0
			A: Duration of Benefits: 6 Months				
$\xi = 0.0$	61.92%	4.11%	0.111	43.00	1.233%	0.00%	0.016
$\xi = 0.1$	62.12%	4.82%	0.103	43.12	1.235%	0.29%	0.103
$\xi = 0.2$	62.22%	5.35%	0.098	43.16	1.238%	0.73%	0.100
$\xi = 0.3$	62.16%	5.78%	0.094	43.14	1.239%	1.21%	0.043
$\xi = 0.6$	62.15%	6.55%	0.086	43.03	1.242%	2.79%	-0.102
$\xi = 0.9$	62.26%	6.97%	0.082	42.99	1.243%	4.41%	-0.174
$\xi = 1.0$	62.07%	7.09%	0.081	42.93	1.244%	4.95%	-0.249
			B: Duration of Benefits: Indefinite				
$\xi = 0.1$	62.23%	5.13%	0.100	43.17	1.237%	0.41%	0.153
$\xi = 0.2$	62.22%	5.95%	0.092	43.13	1.240%	1.05%	0.085
$\xi = 0.3$	62.19%	6.56%	0.086	43.11	1.242%	1.76%	0.016
$\xi = 0.45$	62.37%	7.20%	0.079	43.09	1.244%	2.89%	-0.056
$\xi = 0.6$	62.48%	7.69%	0.074	43.07	1.245%	4.06%	-0.127
$\xi = 0.9$	62.20%	8.34%	0.067	42.93	1.247%	6.41%	-0.365
$\xi = 1$	62.44%	8.42%	0.066	42.99	1.247%	7.17%	-0.346
			C: Duration of Benefits: 1 Month				
$\xi = 0.1$	61.99%	4.44%	0.108	43.08	1.235%	0.12%	0.062
$\xi = 0.2$	62.04%	4.59%	0.106	43.09	1.236%	0.29%	0.054
$\xi = 0.3$	62.08%	4.74%	0.104	43.10	1.236%	0.48%	0.051
$\xi = 0.45$	62.14%	4.92%	0.102	43.09	1.237%	0.78%	0.034
$\xi = 0.6$	62.16%	5.04%	0.101	43.08	1.237%	1.10%	0.021
$\xi = 0.9$	61.98%	5.22%	0.100	42.97	1.239%	1.72%	-0.054
$\xi = 0.9$	62.00%	5.25%	0.099	42.96	1.239%	1.93%	-0.059

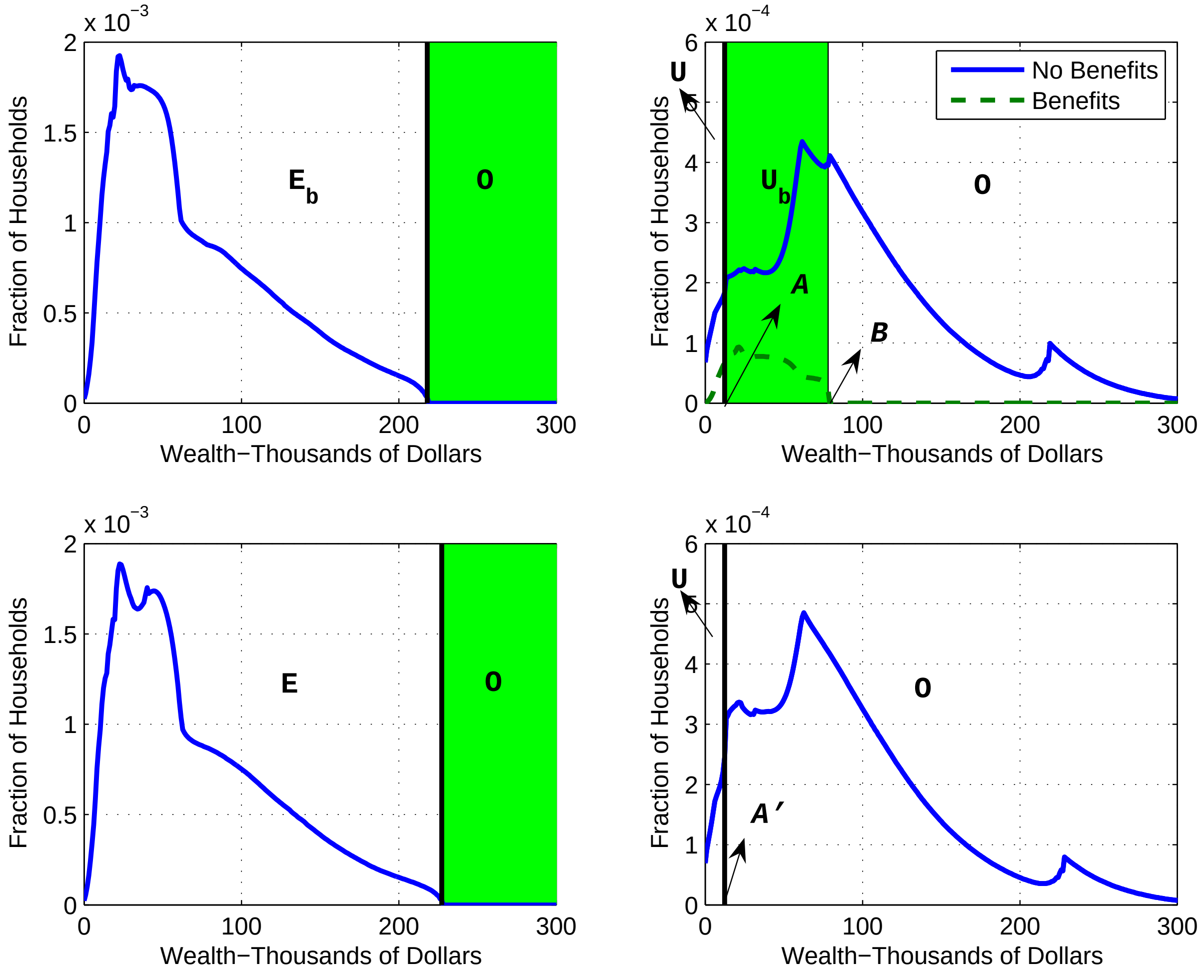
Note: The table shows the impact of various benefit schemes on the bachelor model. The top panel assumes that benefits expire (probabilistically) after six months. The middle panel assumes that benefits never expire. The bottom panel assumes that unemployed agents are paid benefits during the first month in unemployment; thereafter, they receive zero benefits.

Table 5: Various UI Schemes: Bachelor Model with 'Experience Rating'

UI Scheme	E-rate	U-rate	Non-searchers	K	$r+\delta$	τ	$\widetilde{w}$
			A: Duration of Benefits: 6 Months				
$\xi = 0.0$	61.92%	4.11%	0.111	43.01	1.235%	0.00%	0.018
$\xi = 0.1$	62.10%	4.78%	0.104	43.14	1.236%	0.26%	0.104
$\xi = 0.2$	62.24%	5.29%	0.099	43.19	1.237%	0.67%	0.113
$\xi = 0.3$	62.18%	5.67%	0.095	43.17	1.238%	1.13%	0.062
$\xi = 0.45$	62.22%	6.08%	0.091	43.14	1.240%	1.85%	-0.002
$\xi = 0.6$	62.23%	6.35%	0.088	43.11	1.241%	2.59%	-0.050
$\xi = 0.9$	62.23%	6.77%	0.084	43.00	1.243%	4.09%	-0.186
$\xi = 1,0$	62.26%	6.84%	0.083	42.98	1.243%	4.59%	-0.212
			B: Duration of Benefits: Indefinite				
$\xi = 0.1$	62.20%	5.06%	0.101	43.17	1.237%	0.37%	0.147
$\xi = 0.2$	62.39%	5.80%	0.093	43.21	1.239%	0.97%	0.133
$\xi = 0.3$	62.35%	6.37%	0.087	43.18	1.241%	1.63%	0.062
$\xi = 0.45$	62.38%	7.02%	0.081	43.13	1.243%	2.69%	-0.046
$\xi = 0.6$	62.45%	7.44%	0.076	43.09	1.245%	3.77%	-0.133
$\xi = 0.9$	62.63%	8.02%	0.070	43.08	1.246%	5.90%	-0.246
$\xi = 1.0$	62.66%	8.08%	0.069	43.07	1.246%	6.67%	-0.292
			C: Duration of Benefits: 1 Month				
$\xi = 0.1$	61.99%	4.38%	0.108	43.07	1.235%	0.11%	0.052
$\xi = 0.2$	62.03%	4.56%	0.106	43.09	1.236%	0.27%	0.051
$\xi = 0.3$	62.07%	4.70%	0.105	43.11	1.236%	0.44%	0.051
$\xi = 0.45$	62.12%	4.86%	0.103	43.09	1.237%	0.72%	0.026
$\xi = 0.6$	62.15%	4.98%	0.102	43.07	1.237%	1.02%	0.010
$\xi = 0.9$	62.18%	5.12%	0.101	43.03	1.238%	1.60%	-0.007
$\xi = 1.0$	62.04%	5.17%	0.100	42.97	1.239%	1.79%	-0.060

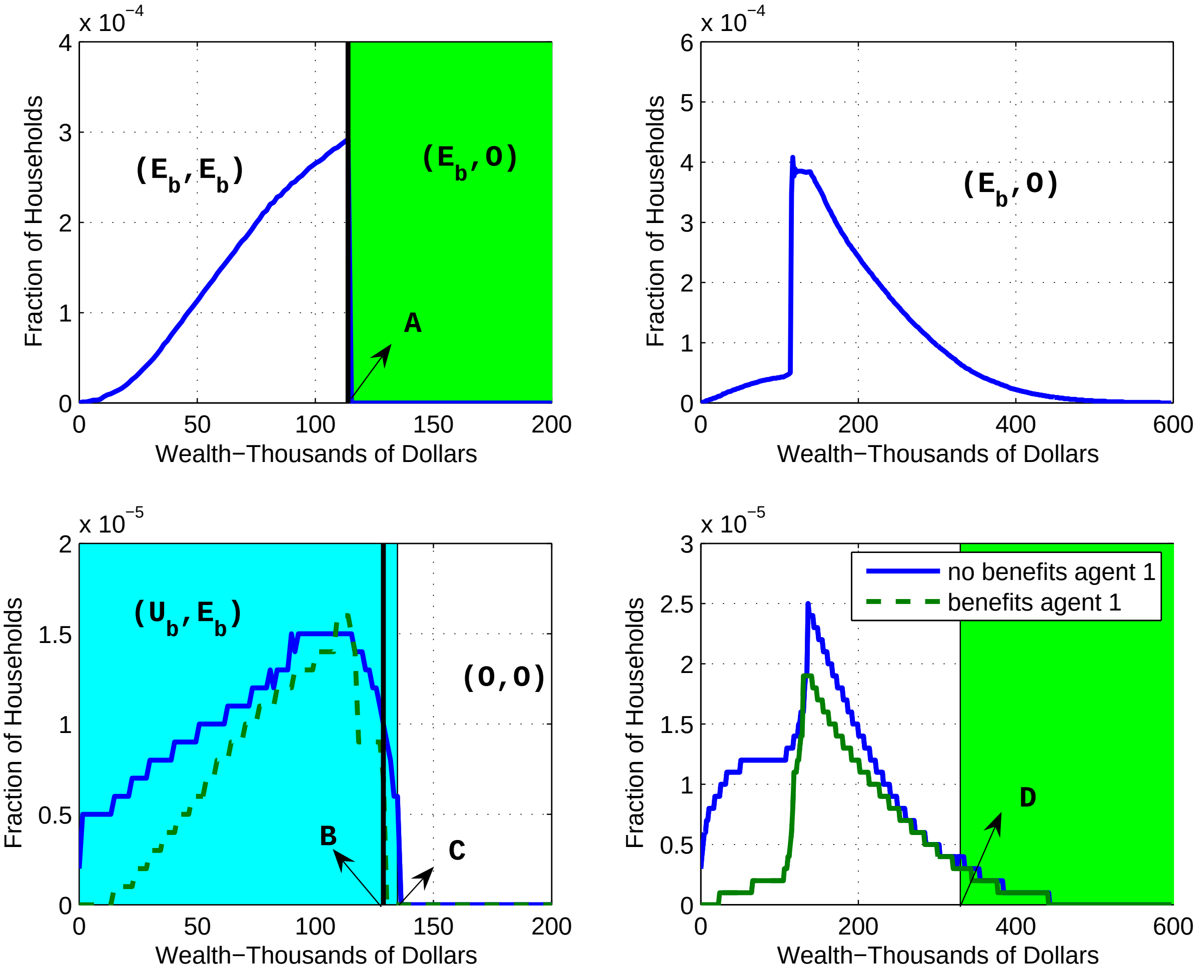
Note: The table shows the impact of various benefit schemes on the bachelor model. The top panel assumes that benefits expire (probabilistically) after six months. The middle panel assumes that benefits never expire. The bottom panel assumes that unemployed agents are paid benefits during the first month in unemployment; thereafter, they receive zero benefits. Contrary to Table 4, we assume here that not all employed agents automatically become eligible for UI. We have set $\theta_E = .3333$, so that employed agents have to work on average for three months before they can become eligible for benefits when they separate from their employers. Welfare is expressed relative to the benchmark model in the second row of Table 4.

Figure 1: **Labor Supply Policy Rule: Impact of Unemployment Benefits – Bachelors Model**



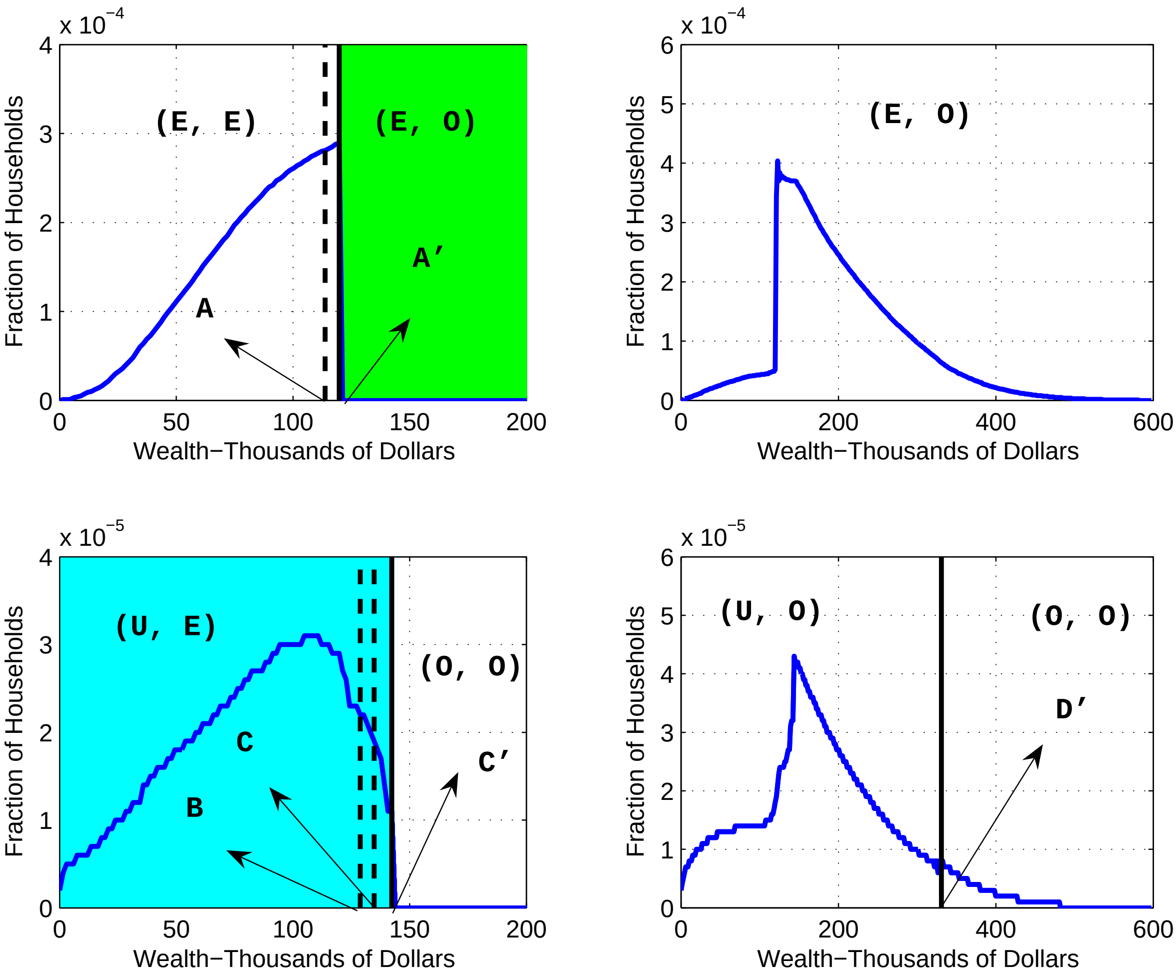
Note: The figure plots the optimal labor market status in the bachelor household model. The top panels consider the case where $\xi = 0.45$ (benchmark calibration). In the bottom panels we set $\xi = 0$. The left panels show the optimal status S^k when $k = e_b$ (when the agent has a job offer in hand and is entitled to receive unemployment benefits when he becomes unemployed). The right panels correspond to the case where agents are non-employed. The dashed line at the top right is the distribution of agents who receive benefits. The solid line is agents without benefits. The shaded areas are defined in the text.

Figure 2: **Labor Supply Policy Rule: Impact of Unemployment Benefits – Couples Model**



Note: The figure plots the optimal labor market status in the couple household model. We set $\xi = 0.45$ (benchmark calibration). In the top left panel, both household members have job offers. In the top right, agent 1 (the most productive) has an offer. The bottom left shows the case where agent 2 has an offer and the bottom right panel the case where both agents are non-employed. The dashed lines correspond to distributions of households in which agent 1 receives benefits. The solid lines in the bottom panels is agents without benefits. The shaded areas are defined in the text.

Figure 3: **Labor Supply Policy Rule: Zero Unemployment Benefits-Couple Model**



Note: The figure plots the optimal labor market status in the couple household model. We set $\xi = 0$. Each of the four panels is constructed to correspond to the same household types as in Figure 2. The shaded areas are further explained in the text.

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