Online Appendix for Assessing the Stabilizing Effects of Unemployment Benefit Extensions

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Appendix A presents derivations of the model equilibrium conditions, as well as the full equilibrium system. It also presents the derivation of the condition we use to calibrate the disutility of work. Finally, it discusses key aspects of the model that underlie its dynamics. Appendix B presents further proofs, derivations and results related to the transmission channels of unemployment insurance. Appendix C evaluates the ability of the model to track unemployment over a long sample when productivity shocks drive fluctuations. Appendix D reports additional tables and figures.

A Model Derivations

A.1 Household FOCs

Let λ_t^B, λ_t^{CN}, λ_t^{CUR}, λ_t^{CUN}, λ_t^{BC}, λ_t^A, λ_t^N, be the multipliers associated with the following constraints in the main text: the household budget constraint (equation (8)), the liquidity constraint for employed (equation (9)), the liquidity constraint for benefit recipients (equation (10)), the liquidity constraint for non-recipients (equation (11)), the borrowing constraint (equation (12)), the end-of-period asset constraint (equation (13)), the employment accumulation constraint (equation (14)). The household first-order conditions are:

w.r.t. x_t:

$$\lambda_t^B - \lambda_t^A + \lambda_t^{CN} + \lambda_t^{CUR} + \lambda_t^{CUN} = 0 \tag{A.1}$$

w.r.t. c_t^n:

$$n_t u'\left(c_t^n\right) - \lambda_t^{CN} + n_t \lambda_t^A = 0 \tag{A.2}$$

with

$$\lambda_t^{CN}\left(x_t + \left(1-\tau_t\right) w_t + \left(1-\tau_t\right) d_t - c_t^n\right) = 0 \tag{A.3}$$

w.r.t. c_t^{ur}:

$$\left(1-n_t\right)\nu_t u'\left(c_t^{ur}\right) - \lambda_t^{CUR} + \left(1-n_t\right)\nu_t \lambda_t^A = 0 \tag{A.4}$$

with

$$\lambda_t^{CUR}\left(x_t + \tau_t^u - c_t^{ur}\right) = 0 \tag{A.5}$$

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w.r.t. c_t^{un}:

$$\left(1-n_t\right)\left(1-\nu_t\right)u'\left(c_t^{un}\right)-\lambda_t^{CUN}+\left(1-n_t\right)\left(1-\nu_t\right)\lambda_t^{A}=0 \tag{A.6}$$

with

$$\lambda_t^{CUN}\left(x_t+\tau^s-c_t^{un}\right)=0 \tag{A.7}$$

w.r.t. b_{t+1}:

$$-\frac{1}{p_t}\lambda_t^{B}-\lambda_t^{BC}+\beta E_t\left\{\frac{\partial W\left(n_t,a_{t+1},b_{t+1}\right)}{\partial b_{t+1}}\right\}=0 \tag{A.8}$$

with

$$\lambda_t^{BC}\left(p_t\overline{b}_t-b_{t+1}\right)=0 \tag{A.9}$$

w.r.t. a_{t+1}:

$$\frac{1}{p_t}\lambda_t^{A}+\beta E_t\left\{\frac{\partial W\left(n_t,a_{t+1},b_{t+1}\right)}{\partial a_{t+1}}\right\}=0 \tag{A.10}$$

w.r.t. σ_t:

$$-\varsigma'\left(\sigma_t\right)\left(1-n_{t-1}\right)+\lambda_t^{N}f_t^{s}\left(1-n_{t-1}\right)\left(\varphi_{t-1}+\overline{\sigma}\left(1-\varphi_{t-1}\right)\right)=0 \tag{A.11}$$

w.r.t. n_t:

$$\begin{aligned}&\left(u\left(c_t^{n}\right)-\chi\right)-\left(\nu_t u\left(c_t^{ur}\right)+\left(1-\nu_t\right)u(c_t^{un})\right)+\beta E_t\left\{\frac{\partial W\left(n_t,a_{t+1},b_{t+1}\right)}{\partial n_t}\right\}-\lambda_t^{N}\\&-\left(1-\tau_t\right)D_t n_t^{-2}\lambda_t^{CN}-\lambda_t^{A}\left(\left(1-\tau_t\right)w_t-\tau_t^{u}\nu_t-\tau^{s}\left(1-\nu_t\right)-\left(c_t^{n}-\nu_t c_t^{ur}-\left(1-\nu_t\right)c_t^{un}\right)\right)=0\end{aligned} \tag{A.12}$$

The envelope conditions are:

$$\frac{\partial W\left(n_{t-1},a_t,b_t\right)}{\partial a_t}=-\frac{\left(1+i_t\right)}{p_t}\lambda_t^{B} \tag{A.13}$$

$$\frac{\partial W\left(n_{t-1},a_t,b_t\right)}{\partial b_t}=\frac{\left(1+i_t\right)}{p_t}\lambda_t^{B} \tag{A.14}$$

$$\frac{\partial W\left(n_{t-1},a_t,b_t\right)}{\partial n_{t-1}}=\varsigma\left(\sigma_t\right)+\lambda_t^{N}\left(\rho_t-f_t^{s}\sigma_t\left(\varphi_{t-1}+\overline{\sigma}\left(1-\varphi_{t-1}\right)\right)\right) \tag{A.15}$$

We next solve for the multipliers. In general, which among the inequality constraints are binding will depend on the calibration of the model. We are interested in the solution of the model that implies different consumption levels by employment states. In particular, we calibrate the model to have $\overline{c}^{n}>\overline{c}^{ur}>\overline{c}^{un}$ and a positive borrowing limit $\overline{b}$.[1] In that case, the liquidity constraints of unemployed workers are binding, while the liquidity constraint of employed is not. This implies $\lambda_t^{CN}=0$. Then, from (A.2), we get

$$\lambda_t^{A}=-u'\left(c_t^{n}\right), \tag{A.16}$$

from (A.4) we get

$$\lambda_t^{CUR}=\left(1-n_t\right)\nu_t\left(u'\left(c_t^{ur}\right)-u'\left(c_t^{n}\right)\right), \tag{A.17}$$

[1]We also check that the order of consumption levels is preserved in the dynamic simulations.

and from (A.6) we get

$$\lambda_t^{CUN} = (1-n_t)(1-\nu_t)\left(u'\left(c_t^{un}\right) - u'\left(c_t^{n}\right)\right). \tag{A.18}$$

Substitute these into (A.1) to obtain:

$$\begin{aligned}
\lambda_t^B &= \lambda_t^A - \left(\lambda_t^{CUR} + \lambda_t^{CUN}\right) \qquad \text{(A.19)}\\
&= -u'\left(c_t^n\right) - (1-n_t)\left[\nu_t\left(u'\left(c_t^{ur}\right) - u'\left(c_t^n\right)\right) + (1-\nu_t)\left(u'\left(c_t^{un}\right) - u'\left(c_t^n\right)\right)\right]\\
&= -n_t u'\left(c_t^n\right) - (1-n_t)\left(\nu_t u'\left(c_t^{ur}\right) + (1-\nu_t) u'\left(c_t^{un}\right)\right)
\end{aligned}$$

To solve for λ_t^{BC}, sum (A.8) and (A.10), using also (A.13) and (A.14), to obtain:

$$\begin{aligned}
\lambda_t^{BC} &= \frac{1}{p_t}\lambda_t^A - \frac{1}{p_t}\lambda_t^B \qquad \text{(A.20)}\\
&= -\frac{1}{p_t}u'\left(c_t^n\right) + \frac{1}{p_t}\left[n_t u'\left(c_t^n\right) + (1-n_t)\left(\nu_t u'\left(c_t^{ur}\right) + (1-\nu_t) u'\left(c_t^{un}\right)\right)\right]\\
&= \frac{1}{p_t}(1-n_t)\left(\nu_t u'\left(c_t^{ur}\right) + (1-\nu_t) u'\left(c_t^{un}\right) - u'\left(c_t^n\right)\right) > 0
\end{aligned}$$

Because the multiplier λ_t^{BC} is positive, the borrowing constraint must be binding.

To derive the Euler equation, combine (A.10) with (A.13) and use previous results:

$$\begin{aligned}
\frac{1}{p_t}\lambda_t^A &= -\beta E_t\left\{\frac{\partial W\left(n_t, a_{t+1}, b_{t+1}\right)}{\partial a_{t+1}}\right\} \qquad \text{(A.21)}\\
\frac{1}{p_t}\lambda_t^A &= \beta E_t\left\{\frac{1+i_{t+1}}{p_{t+1}}\lambda_{t+1}^B\right\}\\
\lambda_t^A &= \beta E_t\left\{\frac{1+i_{t+1}}{\pi_{t+1}}\lambda_{t+1}^B\right\}\\
u'\left(c_t^n\right) &= \beta E_t\left\{\frac{1+i_{t+1}}{\pi_{t+1}}\left[n_{t+1}u'\left(c_{t+1}^n\right) + (1-n_{t+1})\left(\nu_{t+1}u'\left(c_{t+1}^{ur}\right) + (1-\nu_{t+1}) u'\left(c_{t+1}^{un}\right)\right)\right]\right\}
\end{aligned}$$

To derive the optimal search condition, we first solve (A.11) for λ_t^N as:

$$\lambda_t^N = \frac{\varsigma'\left(\sigma_t\right)}{f_t^s\left(\varphi_{t-1} + \overline{\sigma}\left(1-\varphi_{t-1}\right)\right)} \tag{A.22}$$

We then use it in (A.12) together with expressions for other multipliers obtained above and the envelope condition (A.15):

$$\begin{aligned}
&\left(u\left(c_t^n\right) - \chi\right) - \left(\nu_t u\left(c_t^{ur}\right) + (1-\nu_t) u(c_t^{un})\right) \qquad \text{(A.23)}\\
&+\beta E_t\left\{\varsigma\left(\sigma_{t+1}\right) + \frac{\varsigma'\left(\sigma_{t+1}\right)}{f_{t+1}^s\left(\varphi_t + \overline{\sigma}\left(1-\varphi_t\right)\right)}\left(\rho_{t+1} - f_{t+1}^s\sigma_{t+1}\left(\varphi_t + \overline{\sigma}\left(1-\varphi_t\right)\right)\right)\right\}\\
&-\frac{\varsigma'\left(\sigma_t\right)}{f_t^s\left(\varphi_{t-1} + \overline{\sigma}\left(1-\varphi_{t-1}\right)\right)}\\
&+u'\left(c_t^n\right)\left((1-\tau_t) w_t - \tau_t^u\nu_t - \tau^s(1-\nu_t) - \left(c_t^n - \nu_t c_t^{ur} - (1-\nu_t) c_t^{un}\right)\right) = 0
\end{aligned}$$

$$\beta E_t \left\{ \frac{\varsigma'(\sigma_{t+1})}{f^s_{t+1}(\varphi_t + \overline{\sigma}(1-\varphi_t))} (\rho_{t+1} - f^s_{t+1}\sigma_{t+1}(\varphi_t + \overline{\sigma}(1-\varphi_t))) \right\}$$
$$- \frac{\varsigma'(\sigma_t)}{f^s_t(\varphi_{t-1} + \overline{\sigma}(1-\varphi_{t-1}))}$$
$$+ u'(c^n_t)((1-\tau_t) w_t - \xi_t) = 0$$

where the second step uses the definition of ξ_t

We finally derive the discount factor $\Lambda_{t,t+1}$ and the value of an additional employed member to the household $W_{n,t}$, equations (15) and (19) in the main text.

The discount factor is obtained as follows:

$$\begin{aligned} \Lambda_{t,t+1} &\equiv \beta E_t \left\{ \frac{\partial W(n_t, a_{t+1}, b_{t+1})}{\partial D_{t+1}} \Big/ \frac{\partial W(n_{t-1}, a_t, b_t)}{\partial D_t} \right\} \\ &= \beta E_t \left\{ \frac{\frac{(1-\tau_{t+1})}{n_{t+1}} \lambda^{CN}_{t+1} - (1-\tau_{t+1}) \lambda^A_{t+1}}{\frac{(1-\tau_t)}{n_t} \lambda^{CN}_t - (1-\tau_t) \lambda^A_t} \right\} \\ &= \beta E_t \left\{ \frac{(1-\tau_{t+1}) u'(c^n_{t+1})}{(1-\tau_t) u'(c^n_t)} \right\} \end{aligned} \tag{A.24}$$

The value of $W_{n,t}$ is obtained via the following steps:

$$\begin{aligned} W_{n,t} &\equiv \frac{\partial (W(n_{t-1}, a_t, b_t) + (1-n_{t-1}) \varsigma(\sigma_t))}{\partial n_t} \\ &= u(c^n_t) - \chi - (\nu_t u(c^{ur}_t) + (1-\nu_t) u(c^{un}_t)) - \lambda^N_t - (1-\tau_t) D_t n_t^{-2} \lambda^{CN}_t \\ &\quad - [(1-\tau_t) w_t - \tau^u_t \nu_t - \tau^s (1-\nu_t) - c^n_t + \nu_t c^{ur}_t + (1-\nu_t) c^{un}_t] \lambda^A_t \\ &\quad + \beta E_t \left\{ \frac{\partial W(n_t, a_{t+1}, b_{t+1})}{\partial n_t} \right\} \\ &= u(c^n_t) - \chi - (\nu_t u(c^{ur}_t) + (1-\nu_t) u(c^{un}_t)) \\ &\quad + [(1-\tau_t) w_t - \tau^u_t \nu_t - \tau^s (1-\nu_t) - c^n_t + \nu_t c^{ur}_t + (1-\nu_t) c^{un}_t] u'(c^n_t) \\ &\quad + \beta E_t \left\{ \frac{\partial (W(n_t, a_{t+1}, b_{t+1}) + (1-n_t) \varsigma(\sigma_{t+1}) - (1-n_t) \varsigma(\sigma_{t+1}))}{\partial n_t} \right\} \\ &= u'(c^n_t) [(1-\tau_t) w_t - \xi_t] + \beta E_t \left\{ W_{n,t+1} \frac{\partial n_{t+1}}{\partial n_t} \right\} \\ &= u'(c^n_t) [(1-\tau_t) w_t - \xi_t] + \beta E_t \left\{ [\rho_{t+1} - [\varphi_t + \overline{\sigma}(1-\varphi_t)] f^s_{t+1} \sigma_{t+1}] W_{n,t+1} \right\} \end{aligned} \tag{A.25}$$

where we have used:

$$\begin{aligned} \frac{\partial n_{t+1}}{\partial n_t} &= \frac{\partial \left(\rho_{t+1} n_t + f^s_{t+1} (1-n_t) \sigma_{t+1} (\varphi_t + \overline{\sigma}(1-\varphi_t)) \right)}{\partial n_t} \\ &= \rho_{t+1} - f^s_{t+1} \sigma_{t+1} (\varphi_t + \overline{\sigma}(1-\varphi_t)) \end{aligned} \tag{A.26}$$

RA Version of the Model

To obtain the representative agent version of our model we remove the liquidity constraints and have the household pool its members' incomes before taking consumption/saving decisions. The problem becomes:

$$W_t\left(n_{t-1},a_t,b_t\right) = \max\left\{n_t\left(u\left(c_t^n\right)-\chi\right)+\left(1-n_t\right)\left(\nu_t u\left(c_t^{ur}\right)+\left(1-\nu_t\right)u(c_t^{un})\right)\right. \\ \left. -\left(1-n_{t-1}\right)\varsigma(\sigma_t)+\beta E_t\left\{W_{t+1}\left(n_t,a_{t+1},b_{t+1}\right)\right\}\right\} \tag{A.27}$$

Subject to:

$$x_t=\frac{b_{t+1}}{p_t}+\left(1+i_t\right)\frac{a_t}{p_t}-\left(1+i_t\right)\frac{b_t}{p_t} \tag{A.28}$$

$$b_{t+1}\leq p_t\bar{b}_t \tag{A.29}$$

$$\frac{a_{t+1}}{p_t} = x_t+\left(1-\tau_t\right)w_t n_t+\left(1-\tau_t\right)d_t n_t+\tau_t^u\left(1-n_t\right)\nu_t+\tau^s\left(1-n_t\right)\left(1-\nu_t\right) \\ -\left(n_t c_t^n+\left(1-n_t\right)\nu_t c_t^{ur}+\left(1-n_t\right)\left(1-\nu_t\right)c_t^{un}\right) \tag{A.30}$$

$$n_t=\rho_t n_{t-1}+f_t^s s_t \tag{A.31}$$

The FOCs are:

w.r.t. x_t:

$$\lambda_t^B-\lambda_t^A=0 \tag{A.32}$$

w.r.t. c_t^n:

$$n_t u'\left(c_t^n\right)+n_t\lambda_t^A=0 \tag{A.33}$$

w.r.t. c_t^{ur}:

$$\left(1-n_t\right)\nu_t u'\left(c_t^{ur}\right)+\left(1-n_t\right)\nu_t\lambda_t^A=0 \tag{A.34}$$

w.r.t. c_t^{un}:

$$\left(1-n_t\right)\left(1-\nu_t\right)u'\left(c_t^{un}\right)+\left(1-n_t\right)\left(1-\nu_t\right)\lambda_t^A=0 \tag{A.35}$$

w.r.t. b_{t+1}:

$$-\frac{1}{p_t}\lambda_t^B-\lambda_t^{BC}+\beta E_t\left\{\frac{\partial W\left(n_t,a_{t+1},b_{t+1}\right)}{\partial b_{t+1}}\right\}=0 \tag{A.36}$$

with

$$\lambda_t^{BC}\left(p_t\bar{b}_t-b_{t+1}\right)=0 \tag{A.37}$$

w.r.t. a_{t+1}:

$$\frac{1}{p_t}\lambda_t^A+\beta E_t\left\{\frac{\partial W\left(n_t,a_{t+1},b_{t+1}\right)}{\partial a_{t+1}}\right\}=0 \tag{A.38}$$

w.r.t. σ_t:

$$-\varsigma'\left(\sigma_t\right)\left(1-n_{t-1}\right)+\lambda_t^N f_t^s\left(1-n_{t-1}\right)\left(\varphi_{t-1}+\bar{\sigma}\left(1-\varphi_{t-1}\right)\right)=0 \tag{A.39}$$

w.r.t. n_t:

$$\left(u\left(c_t^n\right)-\chi\right)-\left(\nu_t u\left(c_t^{ur}\right)+\left(1-\nu_t\right)u(c_t^{un})\right)+\beta E_t\left\{\frac{\partial W\left(n_t,a_{t+1},b_{t+1}\right)}{\partial n_t}\right\}-\lambda_t^N \\ -\lambda_t^A\left(\left(1-\tau_t\right)w_t-\tau_t^u\nu_t-\tau^s\left(1-\nu_t\right)-\left(c_t^n-\nu_t c_t^{ur}-\left(1-\nu_t\right)c_t^{un}\right)\right)=0 \tag{A.40}$$

The envelope conditions are:

$$\frac{\partial W\left(n_{t-1},a_t,b_t\right)}{\partial a_t}=-\frac{\left(1+i_t\right)}{p_t}\lambda_t^B \tag{A.41}$$

$$\frac{\partial W\left(n_{t-1},a_t,b_t\right)}{\partial b_t}=\frac{\left(1+i_t\right)}{p_t}\lambda_t^B \tag{A.42}$$

$$\frac{\partial W\left(n_{t-1},a_t,b_t\right)}{\partial n_{t-1}}=\varsigma\left(\sigma_t\right)+\lambda_t^N\left(\rho_t-f_t^s\sigma_t\left(\varphi_{t-1}+\overline{\sigma}\left(1-\varphi_{t-1}\right)\right)\right) \tag{A.43}$$

The solution implies that consumption in individual states is equalized (since $u'\left(c_t^n\right)=u'\left(c_t^{ur}\right)=u'\left(c_t^{ur}\right)=-\lambda_t^A$), the borrowing constraint is not binding (since $\lambda_t^{BC}=0$), and a similar optimal search condition subject to a different definition of ξ_t.

A.2 Nash Bargained Wage

Here we derive the expression for the Nash bargained wage in equation (36) in the main text.

The wage bargaining problem reads:

$$w_t^*=\arg\max\left(W_{n,t}\right)^{\eta}\left(F_{n,t}\right)^{1-\eta}, \tag{A.44}$$

where

$$F_{n,t}=q_tz_t-w_t+E_t\left\{\rho_{t+1}\Lambda_{t,t+1}F_{n,t+1}\right\}, \tag{A.45}$$

and

$$W_{n,t}=u'\left(c_t^n\right)\left(1-\tau_t\right)\left(w_t-\frac{\xi_t}{1-\tau_t}\right)+\beta E_t\left\{\left[\rho_{t+1}-\left[\varphi_t+\overline{\sigma}\left(1-\varphi_t\right)\right]f_{t+1}^s\sigma_{t+1}\right]W_{n,t+1}\right\}. \tag{A.46}$$

The solution of the bargaining problem implies the following sharing rule:

$$\left(1-\tau_t\right)u'\left(c_t^n\right)\eta F_{n,t}=\left(1-\eta\right)W_{n,t}. \tag{A.47}$$

Substitute the expressions for $F_{n,t}$ and $W_{n,t}$ and divide both sides by $\left(1-\tau_t\right)u'\left(c_t^n\right)$:

$$\begin{aligned}&\eta\left(q_tz_t-w_t^*+E_t\left\{\rho_{t+1}\Lambda_{t,t+1}F_{n,t+1}\right\}\right)\\&=\left(1-\eta\right)\left(\left(w_t^*-\frac{\xi_t}{1-\tau_t}\right)+\frac{1}{\left(1-\tau_t\right)u'\left(c_t^n\right)}\beta E_t\left\{\left[\rho_{t+1}-\left[\varphi_t+\overline{\sigma}\left(1-\varphi_t\right)\right]f_{t+1}^s\sigma_{t+1}\right]W_{n,t+1}\right\}\right).\end{aligned} \tag{A.48}$$

Use next period sharing rule, given by $W_{n,t+1}=\left(1-\tau_{t+1}\right)u'\left(c_{t+1}^n\right)\frac{\eta}{1-\eta}F_{n,t+1}$:

$$\begin{aligned}&\eta\left(q_tz_t-w_t^*+E_t\left\{\rho_{t+1}\Lambda_{t,t+1}F_{n,t+1}\right\}\right)\\&=\left(1-\eta\right)\left(\left(w_t^*-\frac{\xi_t}{1-\tau_t}\right)+\beta E_t\left\{\left[\rho_{t+1}-\left[\varphi_t+\overline{\sigma}\left(1-\varphi_t\right)\right]f_{t+1}^s\sigma_{t+1}\right]\frac{\left(1-\tau_{t+1}\right)u'\left(c_{t+1}^n\right)}{\left(1-\tau_t\right)u'\left(c_t^n\right)}\frac{\eta}{1-\eta}F_{n,t+1}\right\}\right).\end{aligned} \tag{A.49}$$

Use the expression of the discount factor, given by $\Lambda_{t,t+1} = \beta \frac{(1-\tau_{t+1})u'\left(c_{t+1}^{n}\right)}{(1-\tau_t)u'(c_t^n)}$:

$$\eta\left(q_t z_t - w_t^* + E_t\left\{\rho_{t+1}\Lambda_{t,t+1}F_{n,t+1}\right\}\right) \tag{A.50}$$
$$= (1-\eta)\left(\left(w_t^* - \frac{\xi_t}{1-\tau_t}\right) + E_t\left\{\left[\rho_{t+1} - \left[\varphi_t + \overline{\sigma}\left(1-\varphi_t\right)\right] f_{t+1}^s \sigma_{t+1}\right]\frac{\eta}{1-\eta}\Lambda_{t,t+1}F_{n,t+1}\right\}\right).$$

Solve for w_t^* and simplify, using also the firm's FOC at time $t+1$, given by $\kappa = f_{t+1}^v F_{n,t+1}$:

$$w_t^* = \eta\left(q_t z_t + E_t\left\{\Lambda_{t,t+1}\kappa\left[\varphi_t + \overline{\sigma}\left(1-\varphi_t\right)\right]\frac{f_{t+1}^s\sigma_{t+1}}{f_{t+1}^v}\right\}\right) + (1-\eta)\frac{\xi_t}{1-\tau_t}, \tag{A.51}$$

which gives equation (36) in the text.

A.3 Equilibrium System

Households:

Euler:

$$u'\left(c_t^n\right) = \beta E_t\left\{\frac{1+i_{t+1}}{\pi_{t+1}}\left[n_{t+1}u'\left(c_{t+1}^n\right) + \left(1-n_{t+1}\right)\left(\nu_{t+1}u'\left(c_{t+1}^{ur}\right) + \left(1-\nu_{t+1}\right)u'\left(c_{t+1}^{un}\right)\right)\right]\right\} \tag{A.52}$$

Constraints:

$$x_t = \frac{b_{t+1}}{p_t} + \left(1+i_t\right)\frac{a_t}{p_t} - \left(1+i_t\right)\frac{b_t}{p_t} \tag{A.53}$$

$$c_t^{ur} = x_t + \tau_t^u \tag{A.54}$$

$$c_t^{un} = x_t + \tau^s \tag{A.55}$$

$$\begin{aligned}\frac{a_{t+1}}{p_t} = \quad & x_t + \left(1-\tau_t\right)w_t n_t + \left(1-\tau_t\right)d_t n_t + \tau_t^u\left(1-n_t\right)\nu_t + \tau^s\left(1-n_t\right)\left(1-\nu_t\right) \\ & -\left(n_t c_t^n + \left(1-n_t\right)\nu_t c_t^{ur} + \left(1-n_t\right)\left(1-\nu_t\right)c_t^{un}\right)\end{aligned} \tag{A.56}$$

Employment accumulation:

$$n_t = \rho_t n_{t-1} + f_t^s s_t \tag{A.57}$$

Total efficiency units of search:

$$s_t = \left(1-n_{t-1}\right)\sigma_t\left[\varphi_{t-1} + \overline{\sigma}\left(1-\varphi_{t-1}\right)\right] \tag{A.58}$$

Optimal search effort:

$$\begin{aligned}\beta E_t\left\{\frac{\varsigma'\left(\sigma_{t+1}\right)}{f_{t+1}^s\left(\varphi_t + \overline{\sigma}\left(1-\varphi_t\right)\right)}\left(\rho_{t+1} - f_{t+1}^s\sigma_{t+1}\left(\varphi_t + \overline{\sigma}\left(1-\varphi_t\right)\right)\right)\right\} \\ -\frac{\varsigma'\left(\sigma_t\right)}{f_t^s\left(\varphi_{t-1} + \overline{\sigma}\left(1-\varphi_{t-1}\right)\right)} \\ +u'\left(c_t^n\right)\left(\left(1-\tau_t\right)w_t - \xi_t\right) = 0\end{aligned} \tag{A.59}$$

Assets market equilibrium:

$$\frac{b_{t+1}}{p_t} = \frac{a_{t+1}}{p_t} = \bar{b}_t \tag{A.60}$$

Firms:

Optimal hiring:

$$q_t z_t - w_t + E_t \left\{ \Lambda_{t,t+1} \rho_{t+1} \frac{\kappa}{f^v_{t+1}} \right\} = \frac{\kappa}{f^v_t} \tag{A.61}$$

Dividends definition:

$$d^w_t = q_t z_t n_t - w_t n_t - \kappa v_t \tag{A.62}$$

Desired price:

$$\frac{p^*_t}{p_t} = \frac{p^A_t}{p^B_t} \tag{A.63}$$

with

$$p^A_t = \frac{\epsilon}{(\epsilon - 1)} q_t Y_t + E \left\{ \Lambda_{t,t+1} (1 - \theta) (\pi_{t+1})^{\epsilon} p^A_{t+1} \right\} \tag{A.64}$$

and

$$p^B_t = Y_t + E \left\{ \Lambda_{t,t+1} (1 - \theta) (\pi_{t+1})^{\epsilon - 1} p^B_{t+1} \right\} \tag{A.65}$$

Inflation:

$$\pi_t = \left(\frac{1 - \theta}{1 - \theta \left(\frac{p^*_t}{p_t} \right)^{1-\epsilon}} \right)^{\frac{1}{1-\epsilon}} \tag{A.66}$$

Output:

$$\varsigma_t Y_t = z_t n_t \tag{A.67}$$

Output loss due to price dispersion:

$$\varsigma_t = (1 - \theta) s_{t-1} \pi^{\epsilon}_t + \theta \left(\frac{p^*_t}{p_t} \right)^{-\epsilon} \tag{A.68}$$

Total dividends:

$$D_t = Y_t - q_t z_t n_t + d^w_t \tag{A.69}$$

Government:

Government budget constraint:

$$\tau^u_t (1 - n_t) \nu_t + \tau^s (1 - n_t) (1 - \nu_t) = \tau_t w_t n_t + \tau_t d_t n_t \tag{A.70}$$

Taylor rule:

$$1 + i_{t+1} = \left(1 + \bar{i}\right) \left(\frac{p_t}{p_{t-1}} \right)^{\phi} e^{\varepsilon_{it}} \tag{A.71}$$

UI rules:

$$\nu_t = \nu^r_t + \nu^e_t \tag{A.72}$$

$$\nu_t^e = \overline{\nu}^e + \Gamma_\nu \log \frac{u_{t-1}}{\overline{u}} + \varepsilon_{\nu,t} \tag{A.73}$$

$$\nu_t^r = \overline{\nu}^r + \Gamma_{r,\varphi} \log \left(\frac{\varphi_{t-1}}{\overline{\varphi}} \right) + \Gamma_{r,u} \log \left(\frac{u_{t-1}}{\overline{u}} \right) + \varepsilon_{r,t} \tag{A.74}$$

$$\tau_t^u = \overline{\tau}^u + \Gamma_\tau \log \frac{u_{t-1}}{\overline{u}} + \varepsilon_{\tau,t} \tag{A.75}$$

Labor Market:

Job finding rate:

$$f_t^s = \alpha_m \left(\frac{v_t}{s_t} \right)^{1-\alpha} \tag{A.76}$$

Job filling rate:

$$f_t^v = \alpha_m \left(\frac{v_t}{s_t} \right)^{-\alpha} \tag{A.77}$$

Share of short-term unemployed:

$$\varphi_t = \frac{u_t^{ST}}{u_t^{LT} + u_t^{ST}} \tag{A.78}$$

Short- and long-term unemployed:

$$u_t^{ST} = u_{t-1}^{ST} \left(1 - f_t^s\right) \left(1 - \delta_t\right) + n_{t-1} \left(1 - \rho_t\right) \tag{A.79}$$

$$u_t^{LT} = u_{t-1}^{LT} \left(1 - f_t^s \overline{\sigma}\right) + u_{t-1}^{ST} \left(1 - f_t^s\right) \delta_t \tag{A.80}$$

Wages:

Bargained wage:

$$w_t^* = \eta \left(q_t z_t + E_t \left\{ \Lambda_{t,t+1} \kappa \left[\varphi_t + \overline{\sigma} \left(1 - \varphi_t\right) \right] \frac{f_{t+1}^s \sigma_{t+1}}{f_{t+1}^v} \right\} \right) + (1 - \eta) \frac{\xi_t}{(1 - \tau_t)} \tag{A.81}$$

Wage schedule:

$$w_t = \gamma w_t^* + (1 - \gamma) \overline{w} \tag{A.82}$$

Shocks:

Productivity:

$$\log(z_t) = (1 - \rho_z) \log(\overline{z}) + \rho_z \log(z_{t-1}) + \sigma_z \epsilon_{zt} \tag{A.83}$$

Separation:

$$\log(\rho_t) = \left(1 - \rho_\rho\right) \log(\overline{\rho}) + \rho_\rho \log(\rho_{t-1}) + \sigma_\rho \epsilon_{\rho t} \tag{A.84}$$

Borrowing:

$$\overline{b}_t = (1 - \rho_b) \overline{b} + \rho_b \overline{b}_{t-1} + \sigma_b \epsilon_{bt} \tag{A.85}$$

LTU:

$$\log(\delta_t) = (1 - \rho_\delta) \log\left(\overline{\delta}\right) + \rho_\delta \log(\delta_{t-1}) + \sigma_\delta \epsilon_{\delta t} \tag{A.86}$$

Benefits:

$$\varepsilon_{\nu t} = \rho_\nu \varepsilon_{\nu t-1} + \sigma_\nu \epsilon_{\nu t} \tag{A.87}$$

$$\varepsilon_{rt} = \rho_r \varepsilon_{rt-1} + \sigma_r \epsilon_{rt} \tag{A.88}$$

$$\varepsilon_{\tau t} = \rho_\tau \varepsilon_{\tau t-1} + \sigma_\tau \epsilon_{\tau t} \tag{A.89}$$

Monetary policy:

$$\varepsilon_{it} = \rho_i \varepsilon_{it-1} + \sigma_i \epsilon_{it} \tag{A.90}$$

A.4 Calibration of the Disutility of Work χ

The implicit first-order condition for the choice of hours is obtained by augmenting the setup with variable hours of work, h_t, and choosing them to maximize the total surplus. This gives

$$\max_{h_t} \left\{ W_{n,t}\left(h_t\right) + F_{n,t}\left(h_t\right) \right\}, \tag{A.91}$$

where $F_{n,t}\left(h_t\right)$ is given by

$$F_{n,t}\left(h_t\right) = q_t z_t h_t - w_t + E_t\left\{ \rho_{t+1} \Lambda_{t,t+1} F_{n,t+1}\left(h_{t+1}\right) \right\}, \tag{A.92}$$

and $W_{n,t}\left(h_t\right)$ is given by

$$W_{n,t}\left(h_t\right) = u'\left(c_t^n\right)\left(1-\tau_t\right)\left(w_t - \frac{\xi_t(h_t)}{1-\tau_t}\right) + \beta E_t\left\{ \left[\rho_{t+1} - \left[\varphi_t + \overline{\sigma}\left(1-\varphi_t\right)\right] f_{t+1}^s \sigma_{t+1}\right] W_{n,t+1}\left(h_{t+1}\right) \right\}, \tag{A.93}$$

with

$$\begin{aligned} \xi_t(h_t) \quad = \quad & \nu_t \tau_t^u + \left(1-\nu_t\right)\tau^s + \left[c_t^n - \left(\nu_t c_t^{ur} + \left(1-\nu_t\right) c_t^{un}\right)\right] \\ & + \left(\lambda_t^n\right)^{-1}\left[\left(\nu_t u\left(c_t^{ur}\right) + \left(1-\nu_t\right) u\left(c_t^{un}\right)\right) - U\left(c_t^n, h_t\right)\right] - \left(\lambda_t^n\right)^{-1} \beta E_t\left\{\varsigma(\sigma_{t+1})\right\} \end{aligned} \tag{A.94}$$

and $U\left(c_t^n, h_t\right) = u\left(c_t^n\right) - \chi(h_t)$.

The first-order condition reads

$$q_t z_t + \frac{\partial U\left(c_t^n, h_t\right)}{\partial h_t} = 0.$$

Assuming a labor disutility of the form

$$\chi\left(h_t\right) = \frac{\psi \tilde{\chi}}{1+\psi} h_t^{\frac{1+\psi}{\psi}},$$

and evaluating the first-order condition at steady state, gives

$$\tilde{\chi} \overline{h}^{\frac{1}{\psi}} = \overline{q},$$

which can be simplified to $\tilde{\chi} = \overline{q}$, after normalizing $\overline{h}$ to 1. Combining, we finally obtain $\chi = \frac{\psi \overline{q}}{1+\psi}$.

A.5 Model Characteristics

To gain some intuition, we discuss key aspects of our framework that underlie the dynamics of the model. Even though some aspects are shared with other selected models with heterogeneous agents and have been discussed in the literature, we briefly review their relevance within the context of our model.

A.5.1 Transmission of Desired Savings when Savings are Fixed

In our tractable model, the savings of employed workers are determined in equilibrium by the exogenous borrowing limit, so that employed workers cannot adjust consumption by changing savings. Thus, while in a richer heterogeneous agent model with a wealth distribution and variable savings, a change in individual desired savings also changes individual consumption, in our model it only results in adjustment of the equilibrium interest rate. While this is no different than in any standard representative agent model with zero or fixed aggregate assets, we briefly discuss the transmission of changes in desired savings to aggregate outcomes within the context of our model.

Consider for example a reduction in desired savings of employed workers for precautionary motives, caused in turn by a decrease in future unemployment risk. The higher consumption demand from employed workers raises aggregate demand and prompts firms to raise production by hiring more workers. The increase in hiring puts upward pressure on marginal costs, inducing firms who can change prices to raise them. The central bank responds to higher inflation by increasing nominal (and real) interest rates. Higher real rates counter the lower precautionary motives, ensuring that consumption of employed workers is consistent with fixed aggregate savings. In the meanwhile, however, aggregate consumption has increased and to a large extent due to composition effects, as employment has raised. Hence, the decrease in precautionary motive causes aggregate demand, employment and output to go up, despite fixed aggregate savings.

A.5.2 Amplification with Endogenous Idiosyncratic Risk

As any heterogeneous model with countercyclical idiosyncratic risk, our framework delivers amplification to aggregate shocks relative to a representative agent model.[2] We note that our model has *endogenous* countercyclical idiosyncratic risk due to unemployment.

Consider first the effect of a negative productivity shock within a RA version of our model (obtained by assuming that the household pools its members' incomes before choosing consumption, so that the liquidity constraints conditional on employment status in equations (9)-(11) are inoperative). The decrease in productivity reduces match surplus and induces firms to hire fewer workers and pay lower wages. At the same time, lower productivity raises marginal costs, so that firms that adjust prices will raise them. On the demand side, the central bank responds to higher inflation raising nominal (and real) interest rates. At the same time, lower employment and lower wages reduce the income of the household, who then wants to save less (or borrow more) to smooth consumption out of the temporary negative shock. The increase in interest rates, however, mitigates the desired reduction in savings to

[2]See Challe et al. (2017) and Ravn and Sterk (2017) for early analyses of how cyclical unemployment risk provides additional amplification to aggregate shocks relative to the case of exogenous idiosyncratic risk.

ensure that consumption decreases in line with the reduction in output. Overall, inflation increases and output and employment decrease.

Consider now our baseline model. Countercyclical idiosyncratic risk brings in additional effects. Because employment is now lower and will persist lower for some time, future idiosyncratic risk increases. Higher unemployment risk raises precautionary motives of employed workers, who want to reduce consumption. Relative to the RA version of the model, the reduction in demand for precautionary motives puts downward pressures on prices, so that inflation raises by less; at the same time, it leads to further reduction in hiring, further increase in risk and further reduction in demand, via a negative feed-back loop, so that output drops by more. Two opposite forces drive equilibrium interest rates: a positive pressure from the incentive to smooth consumption in face of the negative temporary shock and a negative pressure from the precautionary motive in face of higher risk. Amplification ceases when the reduction in interest rates due to the fall in inflation (relative to the initial increase) fully compensates the increase in precautionary saving motives due to higher risk. Overall, our baseline model predicts a larger response of output (and employment) and a smaller response of inflation to supply shocks. The impact on inflation can even switch sign if idiosyncratic risk is very countercyclical and the effect of precautionary motives on interest rates dominate that of aversion to intertemporal substitution.

A similar amplification process raises the response of output and inflation to demand shocks. The amplification can be analytically illustrated by comparison of the slopes of the aggregate demand curve in our baseline model and its RA version. Specifically, the countercyclicality of idiosyncratic risk reduces the slope of the aggregate demand curve and can even make it positive if it is strong enough. We next derive the aggregate demand relation that is implicit to our model, and perform a comparison of the slopes.

A.5.3 Aggregate Demand Formulation

The AD relation represents the equilibria of the assets market (or equivalently of the goods market) with the nominal interest rate governed by the monetary policy rule. In our setup, the assets market equilibrium implies $a_{t+1} = b_{t+1} = p_t\overline{b}$. Combining it with the household's budget constraint, the binding liquidity constraints for unemployed workers, and the end-of-period assets constraint, we can solve for the consumption of employed workers as a function of n_t (which we will use as the aggregate quantity in the formulation of the AD relation):

$$c_t^n(n_t) = (1-\tau_t)\,w_t + (1-\tau_t)\,d_t - \frac{1}{n_t}\overline{b} + \overline{b}. \tag{A.95}$$

In turn, consumption of employed workers satisfies the Euler equation, which we write using the consumption function $c_t^n(n_t)$ just derived, to obtain:

$$1 = \beta E_t\left\{\frac{1+i_{t+1}}{\pi_{t+1}}\frac{u'\left(c_{t+1}^n(n_{t+1})\right)}{u'\left(c_t^n(n_t)\right)}\Omega(n_t)\right\}, \tag{A.96}$$

where

$$\Omega(n_t) = \left(n_{t+1} + (1-n_{t+1})\,\nu_{t+1}\frac{u'\left(c_{t+1}^{ur}\right)}{u'\left(c_{t+1}^n\right)} + (1-n_{t+1})\,(1-\nu_{t+1})\,\frac{u'\left(c_{t+1}^{un}\right)}{u'\left(c_{t+1}^n\right)}\right). \tag{A.97}$$

Finally, substituting the monetary policy rule[3], given by

$$1 + i_{t+1} = \left(1 + \bar{i}\right) E_t \left\{\pi_{t+1}\right\}^{\phi}, \tag{A.98}$$

yields our formulation of the AD relation, in the space (n_t, π_{t+1}), given by

$$1 = \beta E_t \left\{ \left(1 + \bar{i}\right) \pi_{t+1}^{\phi - 1} \frac{u'\left(c_{t+1}^n\left(n_{t+1}\right)\right)}{u'\left(c_t^n\left(n_t\right)\right)} \Omega\left(n_t\right) \right\}. \tag{A.99}$$

We then compute the slope of the AD relation, given by the following derivative:

$$-\frac{u'\left(c_{t+1}^n\left(n_{t+1}\right)\right)}{\left(u'\left(c_t^n\left(n_t\right)\right)\right)^2} \Omega\left(n_t\right) u''\left(c_t^n\left(n_t\right)\right) \left(c^n\right)'\left(n_t\right) + \frac{u'\left(c_{t+1}^n\left(n_{t+1}\right)\right)}{u'\left(c_t^n\left(n_t\right)\right)} \Omega'\left(n_t\right) + \frac{u''\left(c_{t+1}^n\left(n_{t+1}\right)\right)}{u'\left(c_t^n\left(n_t\right)\right)} \Omega\left(n_t\right) \frac{\partial c^n\left(n_{t+1}\right)}{\partial n_t} \tag{A.100}$$

Evaluating the derivative around the steady state[4], it simplifies to:

$$-\left(c^n\right)'\left(n_t\right) \frac{\Omega\left(n\right)}{u'\left(c^n\left(n\right)\right)} u''\left(c^n\left(n\right)\right) \left(1 - \frac{\partial n_{t+1}}{\partial n_t}\right) + \Omega'\left(n_t\right) \tag{A.101}$$

The first component is related to consumption smoothing and is positive because the derivative of the consumption function is positive:

$$\left(c^n\right)'\left(n_t\right) = \left(1 - \tau_t\right) \frac{\partial w_t}{\partial n_t} + \left(1 - \tau_t\right) \frac{\partial d_t}{\partial n_t} + \frac{1}{\left(n_t\right)^2} \bar{b} > 0, \tag{A.102}$$

with $\frac{\partial n_{t+1}}{\partial n_t} < 1$. This component is the only component present in the RA version of the model (in which $\Omega\left(n\right) = 1$, given consumption equalization across states) and determines the negative slope of the AD curve. The second component is related to the cyclicality of risk and can be both positive and negative. To see this, compute its expression, given by:

$$\begin{aligned} \Omega'\left(n_t\right) \quad = \quad & \Bigg[1 - \nu_{t+1} \frac{u'\left(c_{t+1}^{ur}\right)}{u'\left(c_{t+1}^n\right)} - \left(1 - \nu_{t+1}\right) \frac{u'\left(c_{t+1}^{un}\right)}{u'\left(c_{t+1}^n\right)} \\ & - \left(\left(1 - n_{t+1}\right) \nu_{t+1} \frac{u'\left(c_{t+1}^{ur}\right)}{\left(u'\left(c_{t+1}^n\right)\right)^2} + \left(1 - n_{t+1}\right)\left(1 - \nu_{t+1}\right) \frac{u'\left(c_{t+1}^{un}\right)}{\left(u'\left(c_{t+1}^n\right)\right)^2} \right) u''\left(c_{t+1}^n\right) \frac{\partial c_{t+1}^n}{\partial n_{t+1}} \Bigg] \frac{\partial n_{t+1}}{\partial n_t} \gtrless 0 \end{aligned} \tag{A.103}$$

The first line in (A.103) captures the cyclicality of "pure" unemployment risk. Given consumption levels and their ranking, higher employment reduces the chance of being in the lower consumption states and hence the risk. Thus, the first line is negative. The second line, instead, captures the risk associated with cyclical consumption inequality. At given employment, a positive aggregate shock will likely increase the income of employed workers relative to that of unemployed workers, and hence raise consumption inequality. This raises risk and makes the second line positive. If the total derivative $\Omega'(n_t)$ is negative, meaning that unemployment risk (also accounting for cyclical consumption inequality) is countercyclical (as it is the case under our calibration), the slope of the AD curve becomes less negative (relative to the

[3] To simplify the exposition, we use future inflation and omit the monetary policy shock in the Taylor rule in this section.
[4] This is not needed for the argument, but simplifies the expression and makes the argument more transparent.

RA version of the model) and can even become positive if risk is very countercyclical. A less steep AD curve implies a stronger reaction of employment and output to aggregate shocks, relative to the RA model. It also implies a stronger reaction of inflation to demand shocks, but a weaker reaction to supply shocks.

B Unemployment Insurance Transmission Mechanisms

B.1 Proof that Labor Market Channel is Stronger with HA

In Section IV.A, we have argued that the destabilizing effect of the labor market channel, in response to both an increase in recipiency and compensation, is stronger in the HA model than in the RA version of the model. Here we formally prove that

$$\frac{\partial \xi_t}{\partial \nu_t} = \tau_t^u - \tau^s - \left(c_t^{ur} - c_t^{un}\right) + \frac{u\left(c_t^{ur}\right) - u\left(c_t^{un}\right)}{\lambda_t^n} \tag{B.1}$$

is larger than

$$\frac{\partial \xi_t}{\partial \nu_t} = \tau_t^u - \tau^s. \tag{B.2}$$

To do that, we need to show that $\frac{u(c_t^{ur}) - u(c_t^{un})}{\lambda_t^n} - \left(c_t^{ur} - c_t^{un}\right)$ is positive. We can rewrite it as:

$$\frac{u\left(c_t^{ur}\right) - \lambda_t^n c_t^{ur} - u\left(c_t^{un}\right) + \lambda_t^n c_t^{un}}{\lambda_t^n}. \tag{B.3}$$

Since $c_t^n > c_t^{ur} > c_t^{un}$, it is enough to show that the function $u\left(c_t\right) - \lambda_t^n c_t$ is increasing in $c_t \in \left[c_t^{un}, c_t^n\right]$ for $c_t < c_t^n$. Recall that $\lambda_t^n = u'\left(c_t^n\right)$, so the function is $u\left(c_t\right) - u'\left(c_t^n\right) c_t$. The derivative of the function is given by:

$$u'\left(c_t\right) - u'\left(c_t^n\right). \tag{B.4}$$

Because the second derivative of the utility function is negative, the derivative of the function will be positive as long as $c_t < c_t^n$. The function is increasing in c_t on the interval of interest. Because the function is increasing, the sum of the second and third terms of equation (B.1) must be positive.

B.2 Derivations of the Effects of Taxes

Consider the labor market channel. In Section IV.C, we describe the effect of taking into account the adjustment of taxes on the bargained wage from equation (39), via the opportunity cost of employment expressed in terms of net labor income, $\xi_t/(1-\tau_t)$. As we mention in the text, tax adjustments also change the partial derivative of ξ_t with respect to ν_t and τ_t, via their effect on the consumption of employed workers. Expanding equation (41) to account for taxes, we obtain

$$
\begin{aligned}
\frac{\partial \xi_t}{\partial \nu_t} &= \left(\tau_t^u - \tau^s\right) + \frac{\partial c_t^n}{\partial \tau_t}\frac{\partial \tau_t}{\partial \nu_t} - \left(c_t^{ur} - c_t^{un}\right) \\
&\quad + \frac{u\left(c_t^{ur}\right) - u\left(c_t^{un}\right) - u'\left(c_t^n\right)\frac{\partial c_t^n}{\partial \tau_t}\frac{\partial \tau_t}{\partial \nu_t}}{\lambda_t^n} \\
&\quad - \frac{\left[\nu_t u\left(c_t^{ur}\right) + \left(1-\nu_t\right) u\left(c_t^{un}\right) - \beta E_t\left\{\varsigma(\sigma_{t+1})\right\} - \left(u\left(c_t^n\right) - \chi\right)\right]}{\left(\lambda_t^n\right)^2}\frac{\partial \lambda_t^n}{\partial c_t^n}\frac{\partial c_t^n}{\partial \tau_t}\frac{\partial \tau_t}{\partial \nu_t}.
\end{aligned} \tag{B.5}
$$

Using $\lambda_t^n = u'\left(c_t^n\right)$ permits to simplify out the new terms in the first and the second line. Using also $\partial \lambda_t^n / \partial c_t^n = u''\left(c_t^n\right)$, we can write

$$
\begin{aligned}
\frac{\partial \xi_t}{\partial \nu_t} &= \left(\tau_t^u - \tau^s\right) - \left(c_t^{ur} - c_t^{un}\right) + \frac{u\left(c_t^{ur}\right) - u\left(c_t^{un}\right)}{\lambda_t^n} \\
&\quad - \frac{\left[\nu_t u\left(c_t^{ur}\right) + \left(1-\nu_t\right) u\left(c_t^{un}\right) - \beta E_t\left\{\varsigma(\sigma_{t+1})\right\} - \left(u\left(c_t^n\right) - \chi\right)\right]}{\left(\lambda_t^n\right)^2} u''\left(c_t^n\right)\frac{\partial c_t^n}{\partial \tau_t}\frac{\partial \tau_t}{\partial \nu_t},
\end{aligned} \tag{B.6}
$$

which gives us the same expression as in equation (41) minus an extra term, given by the second line above. The extra term can be both positive and negative, depending on the sign of the expression in squared parenthesis in the numerator. Under our calibration, this expression is positive, so that the extra term is negative (given strict concavity of period utility, a negative partial derivative of c_t^n with respect to τ_t, and a positive partial derivative of τ_t with respect to ν_t). Accounting for taxes and their effect on the consumption of employed workers hence reduces the impact of recipiency on ξ_t.

We can similarly compute how taxes change the effect of benefit compensation on the opportunity cost of employment, expanding equation (43) to obtain

$$
\begin{aligned}
\frac{\partial \xi_t}{\partial \tau_t^u} &= \nu_t - \nu_t\frac{\partial c_t^{ur}}{\partial \tau_t^u} + \frac{\partial c_t^n}{\partial \tau_t}\frac{\partial \tau_t}{\partial \tau_t^u} + \nu_t\frac{\lambda_t^{ur}}{\lambda_t^n}\frac{\partial c_t^{ur}}{\partial \tau_t^u} - \frac{u'\left(c_t^n\right)\frac{\partial c_t^n}{\partial \tau_t}\frac{\partial \tau_t}{\partial \tau_t^u}}{\lambda_t^n} \\
&\quad - \frac{\left[\nu_t u\left(c_t^{ur}\right) + \left(1-\nu_t\right) u\left(c_t^{un}\right) - \beta E_t\left\{\varsigma(\sigma_{t+1})\right\} - \left(u\left(c_t^n\right) - \chi\right)\right]}{\left(\lambda_t^n\right)^2}\frac{\partial \lambda_t^n}{\partial c_t^n}\frac{\partial c_t^n}{\partial \tau_t}\frac{\partial \tau_t}{\partial \tau_t^u} \\
&= \nu_t - \nu_t\frac{\partial c_t^{ur}}{\partial \tau_t^u} + \nu_t\frac{\lambda_t^{ur}}{\lambda_t^n}\frac{\partial c_t^{ur}}{\partial \tau_t^u} \\
&\quad - \frac{\left[\nu_t u\left(c_t^{ur}\right) + \left(1-\nu_t\right) u\left(c_t^{un}\right) - \beta E_t\left\{\varsigma(\sigma_{t+1})\right\} - \left(u\left(c_t^n\right) - \chi\right)\right]}{\left(\lambda_t^n\right)^2} u''\left(c_t^n\right)\frac{\partial c_t^n}{\partial \tau_t}\frac{\partial \tau_t}{\partial \tau_t^u}.
\end{aligned} \tag{B.7}
$$

The extra term is analogous to that in equation (B.6). Under our calibration, accounting for taxes reduces the impact of benefit compensation on the opportunity cost.

The effect of adjustment in taxes on aggregate demand effects due to redistribution from recipiency can be illustrated by expanding equation (47). Formally, we expand equation (47), capturing the effect of extensions on aggregate consumption, to take into account the effect of ν_t on taxes (via the government budget constraint) and the effect of taxes on the consumption of employed workers (via their liquidity constraint). This gives:

$$\begin{aligned}
\frac{\partial c_t}{\partial \nu_t} &= (1-n_t)\left(\tau_t^u - \tau^s\right) + n_t \frac{\partial c_t^n}{\partial \tau_t}\frac{\partial \tau_t}{\partial \nu_t} \\
&= (1-n_t)\left(\tau_t^u - \tau^s\right) + n_t \frac{\partial c_t^n}{\partial \tau_t}\frac{\left(\tau_t^u - \tau^s\right)(1-n_t)}{(w_t+d_t)\,n_t} \\
&= (1-n_t)\left(\tau_t^u - \tau^s\right)\left(1 + \frac{\partial c_t^n}{\partial \tau_t}\frac{1}{w_t+d_t}\right) \\
&= (1-n_t)\left(\tau_t^u - \tau^s\right)\left(1 + \frac{\partial c_t^n}{\partial Y_t^n}\frac{\partial Y_t^n}{\partial \tau_t}\frac{1}{w_t+d_t}\right) \\
&= (1-n_t)\left(\tau_t^u - \tau^s\right)\left(1 - \frac{\partial c_t^n}{\partial Y_t^n}\right).
\end{aligned} \tag{B.8}$$

where $Y_t^n \equiv x_t + (1-\tau_t)(w_t+d_t)$ denotes total income of employed workers and we use the partial derivative of taxes from the government budget constraint in equation (31) with respect to the recipiency rate obtained as:

$$\frac{\partial \tau_t}{\partial \nu_t} = \frac{\left(\tau_t^u - \tau^s\right)(1-n_t)}{(w_t+d_t)\,n_t}, \tag{B.9}$$

The term in the last parenthesis of the bottom line in equation (B.8) represents the difference in the marginal propensities to consume of unemployed and employed workers.

We can similarly expand equation (49) to account for the adjustment of taxes, as following:

$$\begin{aligned}
\frac{\partial c_t}{\partial \tau_t^u} &= (1-n_t)\,\nu_t + n_t \frac{\partial c_t^n}{\partial \tau_t}\frac{\partial \tau_t}{\partial \tau_t^u} \\
&= (1-n_t)\,\nu_t + n_t \frac{\partial c_t^n}{\partial \tau_t}\frac{\nu_t(1-n_t)}{(w_t+d_t)\,n_t} \\
&= (1-n_t)\,\nu_t\left(1 + \frac{\partial c_t^n}{\partial \tau_t}\frac{1}{w_t+d_t}\right) \\
&= (1-n_t)\,\nu_t\left(1 - \frac{\partial c_t^n}{\partial Y_t^n}\right),
\end{aligned} \tag{B.10}$$

where we have used the partial derivative of taxes from the government budget constraint with respect to the benefit amount, given by

$$\frac{\partial \tau_t}{\partial \tau_t^u} = \frac{\nu_t(1-n_t)}{(w_t+d_t)\,n_t}. \tag{B.11}$$

Equations (B.8) and (B.10) show that the response of consumption of employed workers to balanced-budget tax adjustments dampens the effect of unemployment insurance on aggregate consumption.

Finally the effects of tax adjustments on the precautionary saving motive can be seen by expanding equation (52):

$$\begin{aligned}
\frac{\partial \Omega_{t+1}}{\partial \nu_{t+1}} &= (1-n_{t+1})\frac{u'\left(c_{t+1}^{ur}\right) - u'\left(c_{t+1}^{un}\right)}{u'\left(c_{t+1}^{n}\right)} \\
&\quad - (1-n_{t+1})\left(\nu_{t+1}u'\left(c_{t+1}^{ur}\right) + (1-\nu_{t+1})\,u'\left(c_{t+1}^{un}\right)\right)\frac{u''\left(c_{t+1}^{n}\right)}{\left(u'\left(c_{t+1}^{n}\right)\right)^2}\frac{\partial c_{t+1}^n}{\partial \tau_{t+1}}\frac{\partial \tau_{t+1}}{\partial \nu_{t+1}}.
\end{aligned} \tag{B.12}$$

This gives us equation (52) minus an extra term. This extra term is unambiguously negative, so taking into account the tax adjustments makes the derivative even more negative comparing to the case with fixed taxes. This means that tax adjustments amplify the reduction in precautionary motive in response to benefit extensions.

Similarly, we can adjust equation (53):

$$\begin{aligned}\frac{\partial \Omega_{t+1}}{\partial \tau^u_{t+1}} &= (1-n_{t+1})\,\nu_{t+1}\frac{u''\left(c^{ur}_{t+1}\right)}{u'\left(c^{n}_{t+1}\right)} \\ &\quad -(1-n_{t+1})\left(\nu_{t+1}u'\left(c^{ur}_{t+1}\right)+(1-\nu_{t+1})\,u'\left(c^{un}_{t+1}\right)\right)\frac{u''\left(c^{n}_{t+1}\right)}{\left(u'\left(c^{n}_{t+1}\right)\right)^2}\frac{\partial c^n_{t+1}}{\partial \tau_{t+1}}\frac{\partial \tau_{t+1}}{\partial \tau^u_{t+1}}.\end{aligned} \tag{B.13}$$

Also here the extra term is negative and the precautionary motive effects are stronger with tax adjustments.

B.3 Precautionary Saving Channel in a Model with Individual Savings and Persistent States

In this section, we compare the effects on saving for precautionary motives of changes in perceived future risk, in our setup and in one where agents have individual savings and persistent employment states. In the second setup, we aggregate the responses of individual agents who make heterogeneous saving decisions. In both setups, we consider the problems of the households in a partial equilibrium setting and subject the agents to shocks to expected future risk, modeled as shocks to expected future transition rates with no realized changes. This way, we abstract from both general equilibrium effects and compositional effects associated to changes in transition rates. Hence, we isolate the change in aggregate consumption that is due to precautionary saving effects and assess how close it is in the two setups. We further abstract in both setups from variable search intensity, as the response of search to risk would also alter the composition of the labor force.

Baseline Model with Household Savings and *iid* States. The objects of interest from our model are aggregate savings, a_{t+1}, and aggregate consumption, c_t, given by $c_t = n_t c^n_t + (1-n_t)\left(\nu_t c^{ur}_t + (1-\nu_t)\,c^{un}_t\right)$. We also recall that the solution of our model implies a household's Euler equation of the form

$$u'\left(c^n_t\right) = \beta E_t\left\{\frac{1+i_{t+1}}{\pi_{t+1}}\left[n_{t+1}u'\left(c^n_{t+1}\right)+(1-n_{t+1})\left(\nu_{t+1}u'\left(c^{ur}_{t+1}\right)+(1-\nu_{t+1})\,u'\left(c^{un}_{t+1}\right)\right)\right]\right\}.$$

Alternative Model with Individual Savings and Persistent States. Relative to the baseline model, we make the following changes. First, we remove the household structure and instead have consumption/saving decisions taken by individual workers. Second, we relax the *iid* assumption for individual labor market states and instead make individual states persistent. Third, we introduce duration-dependence in transitions from short-term to long-term unemployment. Specifically, we assume 14 labor market states: employment (*e*), 6 states for unemployed recipients (*ur1* to *ur6*), 6 states for unemployed non-recipients (*un1* to *un6*), and long-term unemployment (*ltu*). When employed, a worker loses her job with probability $1-\rho_t$. Upon losing her job, she becomes recipient with probability ρ^{ur}_t, short-term non-recipient with probability ρ^{un}_t, and goes directly to long-term unemployment with complementary probability $1-\rho_t^{ur}-\rho_t^{un}$.

When unemployed, a worker finds a job with probability, f_t^s, if short-term unemployed, and f_t^l, if long-term unemployed, with $f_t^l=\overline{\sigma} f_t^s$. Each worker maximizes her individual utility given her assets level, a_t, and realized employment state, e_t.

Start with an employed worker. Her problem states:

$$
\begin{aligned}
&W\left(a_t, e_t=e\right)=u\left(c_t\left(a_t, e_t=e\right)\right) \\
&+\beta E_t\left\{\rho_{t+1} W\left(a_{t+1}, e_{t+1}=e\right)+\left(1-\rho_{t+1}\right) \rho_{t+1}^{ur} W\left(a_{t+1}, e_{t+1}=ur1\right)\right\} \\
&+\beta E_t\left\{\left(1-\rho_{t+1}\right) \rho_{t+1}^{un} W\left(a_{t+1}, e_{t+1}=un1\right)\right\} \\
&+\beta E_t\left\{\left(1-\rho_{t+1}\right)\left(1-\rho_{t+1}^{ur}-\rho_{t+1}^{un}\right) W\left(a_{t+1}, e_{t+1}=ltu\right)\right\}
\end{aligned}
$$

$$
c_t\left(a_t, e_t=e\right)+a_{t+1}=\left(1-\tau_t\right) w_t+\left(1-\tau_t\right) d_t+\frac{1+i_t}{\pi_t} a_t
$$

$$
a_{t+1} \geq \underline{a}
$$

The solution to the problem implies the following Euler equation:

$$
\begin{aligned}
&u^{\prime}\left(c_t\left(a_t, e_t=e\right)\right)= \\
&\beta E_t\left\{\frac{1+i_{t+1}}{\pi_{t+1}}\left(\rho_{t+1} u^{\prime}\left(c_{t+1}\left(a_{t+1}, e_{t+1}=e\right)\right)+\left(1-\rho_{t+1}\right) \rho_{t+1}^{ur} u^{\prime}\left(c_{t+1}\left(a_{t+1}, e_{t+1}=ur1\right)\right)\right)\right\} \\
&+\beta E_t\left\{\frac{1+i_{t+1}}{\pi_{t+1}}\left(1-\rho_{t+1}\right) \rho_{t+1}^{un} u^{\prime}\left(c_{t+1}\left(a_{t+1}, e_{t+1}=un1\right)\right)\right\} \\
&+\beta E_t\left\{\frac{1+i_{t+1}}{\pi_{t+1}}\left(1-\rho_{t+1}\right)\left(1-\rho_{t+1}^{ur}-\rho_{t+1}^{un}\right) u^{\prime}\left(c_{t+1}\left(a_{t+1}, e_{t+1}=ltu\right)\right)\right\}
\end{aligned}
$$

Next, the problem of an unemployed recipient in her first month of unemployment reads:

$$
\begin{aligned}
&W\left(a_t, e_t=ur1\right)=u\left(c_t\left(a_t, e_t=ur1\right)\right) \\
&+\beta E_t\left\{f_{t+1}^s W\left(a_{t+1}, e_{t+1}=e\right)+\left(1-f_{t+1}^s\right) W\left(a_{t+1}, e_{t+1}=ur2\right)\right\}
\end{aligned}
$$

$$
c_t\left(a_t, e_t=ur1\right)+a_{t+1}=\tau_t^u+\frac{1+i_t}{\pi_t} a_t
$$

$$
a_{t+1} \geq \underline{a}
$$

The problem implies the following Euler equation:

$$
\begin{aligned}
&u^{\prime}\left(c_t\left(a_t, e_t=ur1\right)\right)= \\
&\beta E_t\left\{\frac{1+i_{t+1}}{\pi_{t+1}}\left(f_{t+1}^s u^{\prime}\left(c_{t+1}\left(a_{t+1}, e_{t+1}=e\right)\right)+\left(1-f_{t+1}^s\right) u^{\prime}\left(c_{t+1}\left(a_{t+1}, e_{t+1}=ur2\right)\right)\right)\right\}
\end{aligned}
$$

An unemployed recipient in unemployment for 2 to 6 months (*ur2* to *ur6*) has a similar problem as the one above with her future state, if failing to find a job, given by *ur3* to *ur6* for current state *ur2* to *ur5*, and given by *ltu* for current state *ur6*. This structure parallels the U.S. system whereby a worker loses unemployment benefits after 26 weeks of recipiency and concurrently transitions into long-term

Steady-state/parameter	Baseline model	Alternative model	
		Same targets	Same parameters
β	0.9725	0.99185	0.9725
τ^s	0.1626	0.2216	0.1626
ν	0.3956	0.3956	0.3956
STU share	0.7352	0.7352	0.7352
$\frac{\nu c^u + (1-\nu) c^{ui}}{c^n}$	0.72	0.7201	0.4547
$\frac{c^u - c^{ui}}{c^n}$	0.17	0.17	0.2292
Total consumption	0.9224	0.9224	0.9224
Net savings	0	0	0

Table B.1: Calibration comparison

unemployment.

The problem of a short-term unemployed non-recipient is again similar to the one above with the worker receiving the safety net transfer, τ^s, instead of the unemployment benefit, τ_t^u, and her current and future states given by, respectively, *un1* to *un6* and *un2* to *ltu*. Finally, the problem of a long-term unemployed differs from the problem of a short-term non-recipient as she finds jobs with probability f_t^l, rather than f_t^s, and as she stays in *ltu* if she fails to find a job.

The variables of interest in this model are again aggregate consumption and savings, computed as:

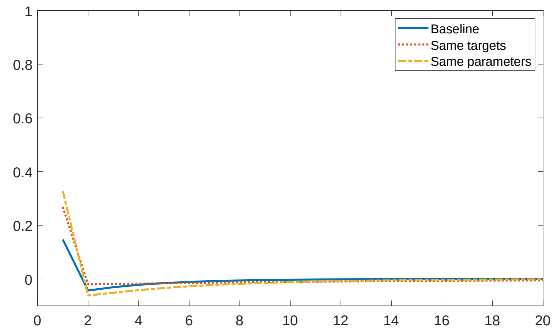
$$C_t = \int_{a_t} \int_{e_t} c_t\left(a_t, e_t\right) dF\left(a_t, e_t\right)$$

$$A_{t+1} = \int_{a_t} \int_{e_t} a_{t+1}\left(a_t, e_t\right) dF\left(a_t, e_t\right)$$

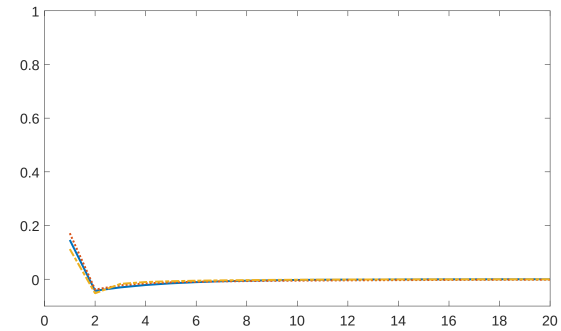
Calibration. We consider two alternative calibrations of the model with individual savings. In the first, we keep the same targets. In particular, we adjust the discount factor to target a relative consumption expenditure of unemployed to employed workers of 72 percent and set the safety net transfer, τ^s, to target a consumption difference of benefit recipients and non-recipients of 17 percent of the consumption of employed. The first target is instead achieved in our baseline model via the intra-period household transfer. We recover $\beta = 0.99185$ and $\tau^s = 0.2216$. In the second version of the calibration, we keep the same parameters. As a result, the model delivers a lower relative consumption of unemployed to employed (45% vs. 72%) and a higher consumption difference of recipients and non-recipients (23% vs. 17% of the consumption of employed). Finally, given the focus on comparing aggregate consumption and savings across models, we calibrate the borrowing limit to have zero aggregate net savings. Table B.1 presents the steady-state and parameter values of interest in our baseline model and the two versions of the individual savings model.

Experiments. As we said, we subject the models to shocks to the expected future transition rates, $E_t\left\{\rho_{t+1}\right\}$ and $E_t\left\{f_{t+1}^s\right\}$. These shocks are not realized, i.e., next period the future transition rates remain at their steady state levels. Figure B.1 plots the responses of aggregate consumption and assets to the shocks, with both responses normalized by steady-state aggregate consumption.[5] As we explain below, to assess the relative size of the responses, we set the size of both shocks to match a response of

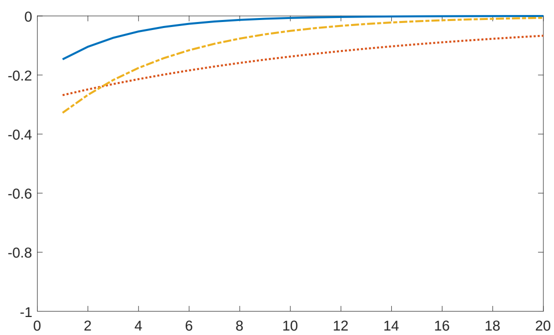
[5]This way, the impact responses of consumption and assets are fully symmetric.



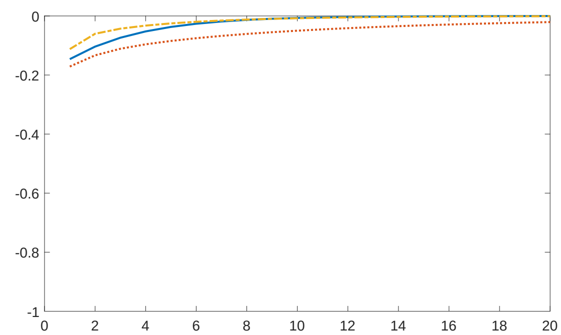
(a) Expected retention rate, consumption



(b) Expected job-finding rate, consumption



(c) Expected retention rate, assets



(d) Expected job-finding rate, assets

Figure B.1: Impulse responses to shocks to expected transition rates

aggregate consumption to the respective realized shock equal to 1 percent on impact in each model, and plot the responses on a scale up to 1 percent.

The two panels on the left of Figure B.1 focus on the shock to the expected retention probability, those on the right on the shock to the expected job finding probability. The two panels on the top plot the response of aggregate consumption, those on the bottom the response of aggregate assets. We emphasize two results. First, the figure shows that in response to both shocks, our model predicts responses of both consumption and assets that are of the same order of magnitude of the responses predicted by the two versions of the alternative model. Put differently, our model is able to match to a reasonable degree the power of the precautionary saving channel. Second, the responses plotted in Figure B.1 are small if compared to the responses to actual (realized) shocks, which are caused by both precautionary saving and composition effects. As emphasized by the choice of the scale, precautionary savings account for only 11 to 33 percent of the overall impact response, depending on the shock. That composition effects largely prevail in these partial equilibrium experiments, further suggests that the extent to which we may miss the strength of the precautionary saving channel will not have large effects on the overall results.

B.4 Opportunity Cost of Employment with Individual-Level Assets and Bargaining

We consider a model with individual-level assets and bargaining. We show that the average opportunity cost implied by this model is equal to the sum of the opportunity cost ξ_t from equation (40) in the main text and an additional component which is associated to individual asset positions. We argue that the predictions of the model for the effect of benefit extensions on the opportunity cost are robust to abstracting from this component.

Consider a worker with beginning-of-period assets, a_t, who is eligible for unemployment insurance. The value of being employed, $W_t^n(a_t)$, is defined as

$$W_t^n(a_t) = u(c_t^n) - \chi + \beta E_t \left\{ \rho_{t+1} W_{t+1}^n(a_{t+1}^n) + (1-\rho_{t+1}) W_{t+1}^{ur}(a_{t+1}^n) \right\}, \tag{B.14}$$

with budget constraint given by

$$c_t^n + a_{t+1}^n = (1-\tau_t) w_t + (1+r_t) a_t. \tag{B.15}$$

The value of being unemployed benefit recipient, $W_t^{ur}(a_t)$, is defined as

$$W_t^{ur}(a_t) = u(c_t^{ur}) - \varsigma(\sigma_t^{ur}) + \beta E_t \left\{ f_{t+1}^s \sigma_t^{ur} W_{t+1}^n(a_{t+1}^{ur}) + (1 - f_{t+1}^s \sigma_t^{ur}) W_{t+1}^{ur}(a_{t+1}^{ur}) \right\}, \tag{B.16}$$

with budget constraint given by

$$c_t^{ur} + a_{t+1}^{ur} = \tau_t^u + (1+r_t) a_t. \tag{B.17}$$

The surplus from employment, $W_{n,t}(a_t)$, is the difference between the value functions defined by (B.14) and (B.16) and can be computed to be equal to[6]

$$\begin{aligned} W_{n,t}(a_t) &= W_t^n(a_t) - W_t^{ur}(a_t) \\ &= u'(c_t^n)(1-\tau_t)\left(w_t - \frac{\tilde{\xi}_t^{ur}}{1-\tau_t}\right) + \beta E_t \left\{ (\rho_{t+1} - f_{t+1}^s \sigma_t^{ur}) W_{n,t+1}(a_{t+1}^n) \right\}, \end{aligned} \tag{B.18}$$

which is the analog of our expression in equation (19) in the main text, and a function of the opportunity cost of employment, $\tilde{\xi}_t^{ur}$.

The opportunity cost, in turn, can be written as the sum of two components,

$$\tilde{\xi}_t^{ur} = \xi_t^{ur} + \xi_t^{ur,a}, \tag{B.19}$$

with the first given by

$$\xi_t^{ur} = \tau_t^u + (c_t^n - c_t^{ur}) - \frac{u(c_t^n) - \chi - u(c_t^{ur})}{\lambda_t^n} - \frac{\varsigma(\sigma_t^{ur})}{\lambda_t^n}, \tag{B.20}$$

and equivalent to the expression in equation (40) in the main text subject to a different labor market timing assumption; and the second an additional component associated with different asset positions among employed and unemployed, and given by

$$\begin{aligned} \tilde{\xi}_t^{ur,a} = &\ (a_{t+1}^n - a_{t+1}^{ur}) \\ &- \beta E_t \left\{ f_{t+1}^s \sigma_t^{ur} \left(W_{t+1}^n(a_{t+1}^n) - W_{t+1}^n(a_{t+1}^{ur}) \right) + (1 - f_{t+1}^s \sigma_t^{ur}) \left(W_{t+1}^{ur}(a_{t+1}^n) - W_{t+1}^{ur}(a_{t+1}^{ur}) \right) \right\}. \end{aligned} \tag{B.21}$$

We can similarly derive the opportunity cost of employment for non-recipients, $\tilde{\xi}_t^{un}$, as the sum of a

[6] See Chodorow-Reich and Karabarbounis (2016) for similar derivations.

component equivalent again to the expression from equation (40) in the main text,

$$\xi_t^{un} = \tau^s + (c_t^n - c_t^{un}) - \frac{u(c_t^n) - \chi - u(c_t^{un})}{\lambda_t^n} - \frac{\varsigma(\sigma_t^{un})}{\lambda_t^n} \tag{B.22}$$

and an extra component,

$$\begin{aligned} \xi_t^{un,a} &= (a_{t+1}^n - a_{t+1}^{un}) \\ &-\beta E_t \left\{ f_{t+1}^s \sigma_t^{un} \left(W_{t+1}^n(a_{t+1}^n) - W_{t+1}^n(a_{t+1}^{un}) \right) + (1 - f_{t+1}^s \sigma_t^{un}) \left(W_{t+1}^{un}(a_{t+1}^n) - W_{t+1}^{un}(a_{t+1}^{un}) \right) \right\}. \end{aligned} \tag{B.23}$$

Analogously to Chodorow-Reich and Karabarbounis (2016), the extra terms defined in (B.21) and (B.23) have each two components. The first is a budgetary loss associated to higher future assets chosen by the employed workers and the second is the welfare gain from having higher assets in the future.

While computing the extra components is beyond the scope of this paper, we note that they entail both a loss and a gain, changing $\tilde{\xi}_t$ in opposite directions, and that they should not be largely affected by changes in benefit duration and compensation. If unemployed workers are borrowing constrained and thus choose their asset at the limit, changes in duration and compensation will not affect their asset accumulation. Hence, the components with a_{t+1}^{ur} and a_{t+1}^{un} will not be affected. This will likely hold for most unemployed workers, but especially for those who already had a long enough unemployment spell to have exhausted their savings, i.e. for the vast majority of those impacted by extensions. The components with a_{t+1}^n could in theory be affected by changes in compensation and extensions through changes in precautionary motives. The effect, however, is likely to be quantitatively small in this case, since the workers considered here are newly employed workers, hence unlikely to be eligible for benefits in the near future.

Finally, note that ξ_t^{ur} and ξ_t^{un} are individual opportunity costs. What drives hiring, instead, is the opportunity cost averaged across unemployed workers. The average will depend on the average transfers weighted by recipiency shares, as well as average consumption levels, utilities, and assets.

C Tracking Unemployment: Long Sample with Productivity Shocks

In keeping with most of the literature and to allow for comparisons, we consider a version of the model with productivity as the single driving force. We take productivity to be quarterly real output per person in the non-farm business sector, from the Bureau of Labor Statistics (BLS), and estimate an AR(1) process on the HP-filtered log productivity series. (See Section D of the Online Appendix for the plot of the estimated productivity process). We then feed-in the residual into the model, assuming that the autocorrelation coefficient and the variance of the process is known to the agents, and obtain the simulated unemployment rate. We similarly feed-in the estimated recipiency processes.[7]

Figure C.1 plots actual unemployment (blue solid line) against unemployment from the model (red dotted line). For completeness, we also plot the trend from HP filtering the data (grey thin line). The figure shows that the model matches the behavior of unemployment reasonably well over the almost

[7]We calibrate the model to 1972-2018 averages for unemployment (6.29 percent) and the STU share (81 percent), given that these are available starting 1972. Results are fully robust to using the targets in Table 2 of the paper.

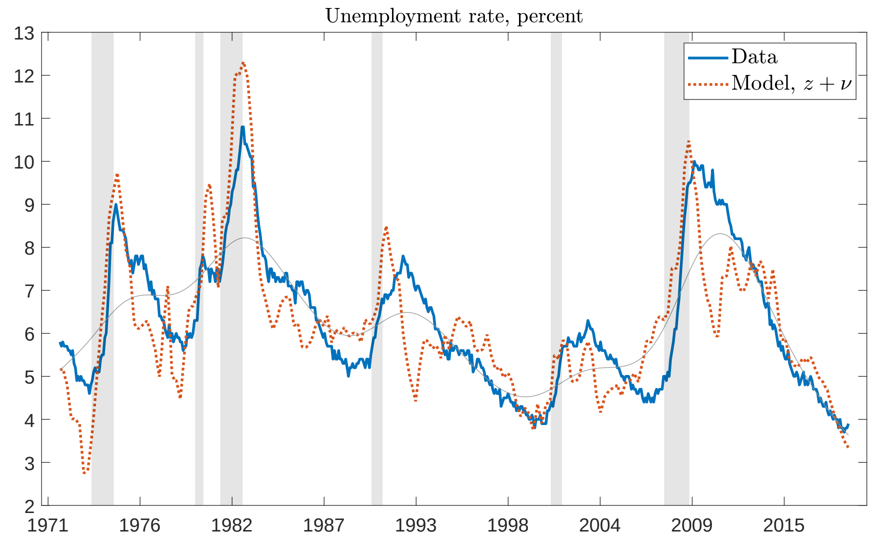


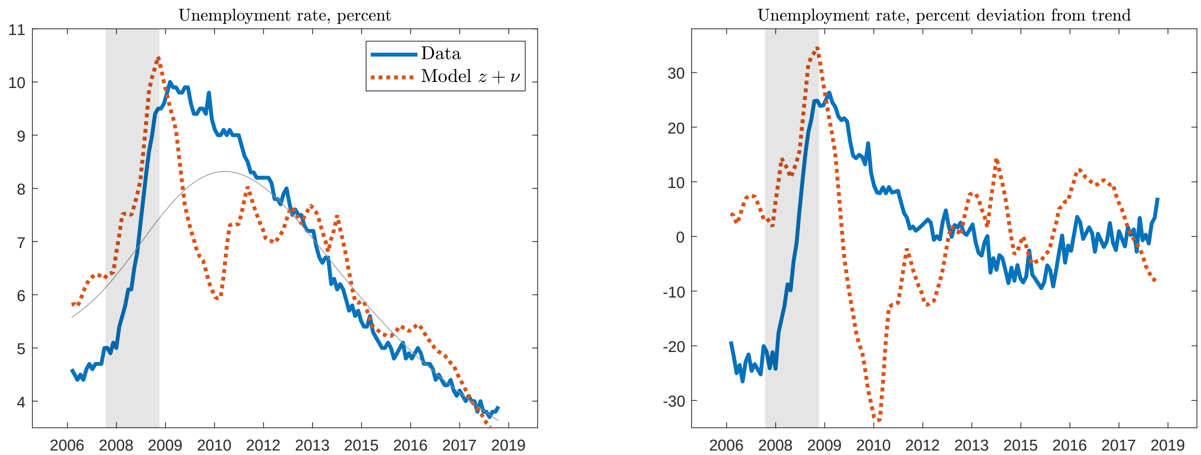
Figure C.1: Actual vs. model unemployment, with productivity shocks

50-years sample considered. Remarkably, the standard deviation of unemployment in the model (not targeted) is very close to that in the data (1.68 versus 1.59). The correlation between the model's unemployment rate and the actual rate is 0.8001, but only 0.4060 if we consider their cyclical components. Overall, unemployment from the model tracks actual unemployment closely at the beginning of the sample, but less so starting the 1990s and especially during the Great Recession.

Figure C.2 zooms in on the Great Recession. Panel C.2a plots the levels of unemployment in the data and from the model as in Figure C.1, in percent of the labor force. Panel C.2b plots the cyclical components, in percent deviation from the trend. The figure clearly indicates that productivity shocks are not a good candidate to explain unemployment during the Great Recession. The timing of unemployment dynamics that is induced by the productivity shock is off: the productivity rebounds fast after the end of the recession and drives down unemployment from the model, while actual unemployment persists elevated into the recovery. The correlation between the model and the actual rate during the five years following the 2007 business cycle peak is 0.3210 and drops to 0.1252 if we consider the cyclical components.

D Additional Figures and Tables

Table D.1 presents the estimated parameters for the exogenous processes used in simulations.



(a) Percent of labor force

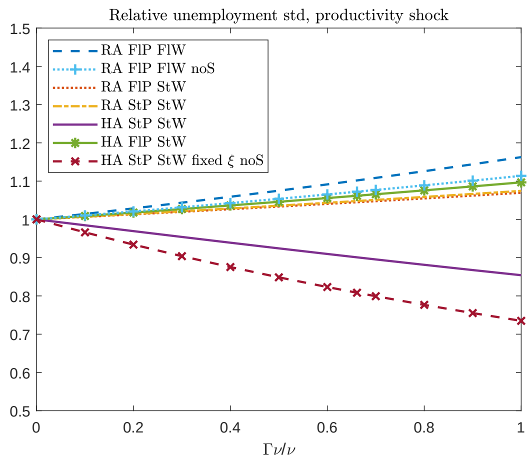
(b) Percent deviation from trend

Figure C.2: Great Recession, with productivity shocks

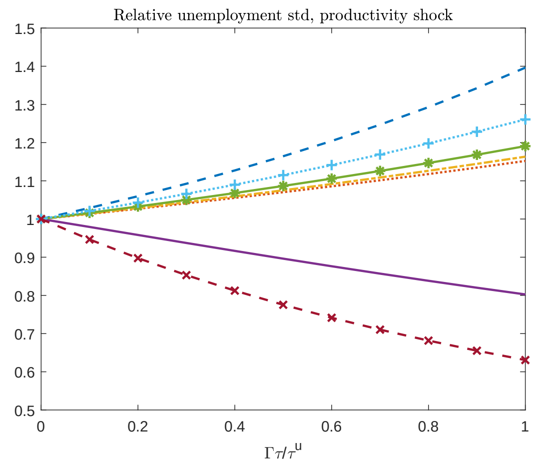
Parameter	Description	Value	Target
σ_z	STD, productivity shock	0.0024	Estimated, BLS, 1972-2018
ρ_z	AC, productivity shock	0.9190	Estimated, BLS, 1972-2018
σ_ρ	STD, retention shock	0.0008	Estimated, JOLTS, 2001-2018
ρ_ρ	AC, retention shock	0.6603	Estimated, JOLTS, 2001-2018
σ_b	STD, borrowing shock	0.0031	Estimated, Fed Board, 2001-2018
ρ_b	AC, borrowing shock	0.9530	Estimated, Fed Board, 2001-2018
σ_δ	STD, LTU shock	0.0487	Estimated, BLS, 2001-2018
ρ_δ	AC, LTU shock	0.8675	Estimated, BLS, 2001-2018
σ_{ve}	STD, recipiency shock Ext	0.0072	Estimated, U.S. Department of Labor, 1972-2018
ρ_{ve}	AC, recipiency shock Ext	0.9661	Estimated, U.S. Department of Labor, 1972-2018
σ_{vr}	STD, recipiency shock Reg	0.0067	Estimated, U.S. Department of Labor, 1972-2018
ρ_{vr}	AC, recipiency shock Reg	0.8918	Estimated, U.S. Department of Labor, 1972-2018
σ_i	STD, monetary shock	0.0013	From McKay and Reis (2016)
ρ_i	AC, monetary shock	0.8527	From McKay and Reis (2016)

Table D.1: Calibration, exogenous processes

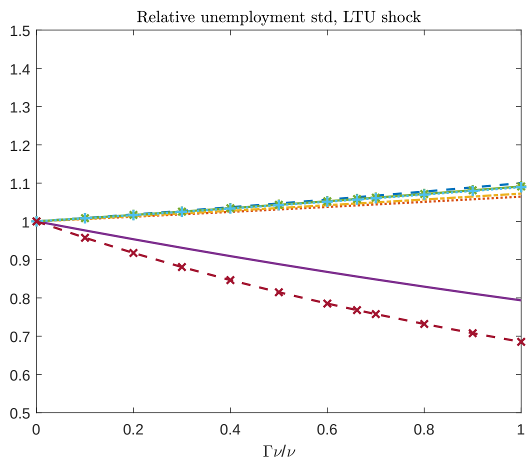
Figure D.1 presents the results for additional shocks discussed in Section III.



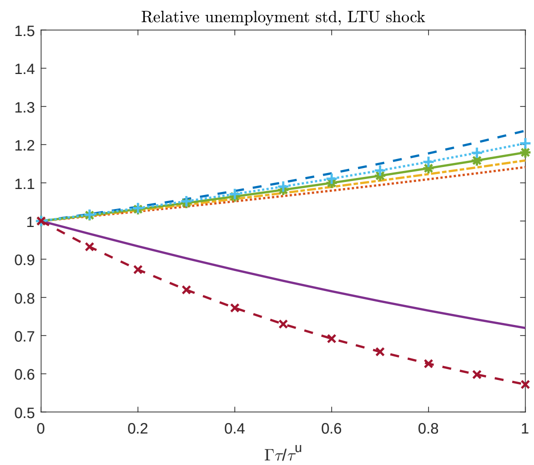
(a) Benefit duration, product. shock



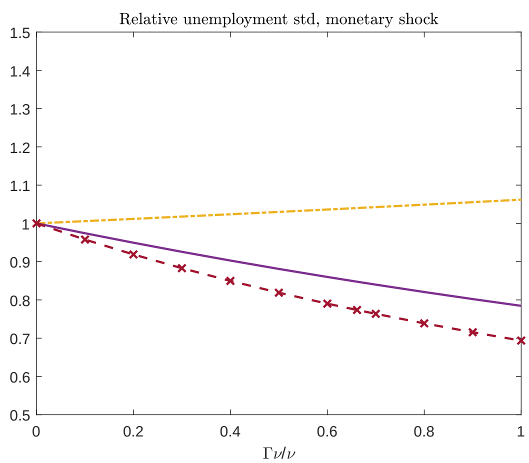
(b) Benefit compensation, product. shock



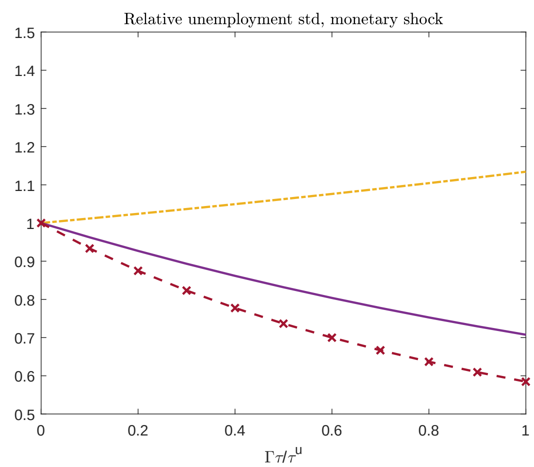
(c) Benefit duration, LTU shock



(d) Benefit compensation, LTU shock



(e) Benefit duration, monetary shock



(f) Benefit compensation, monetary shock

Figure D.1: Unemployment volatility as a function of benefit elasticities, additional shocks

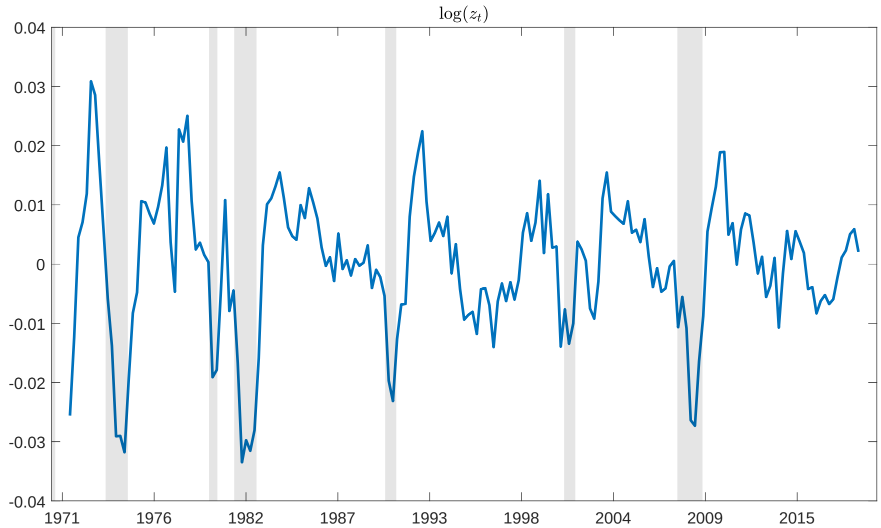
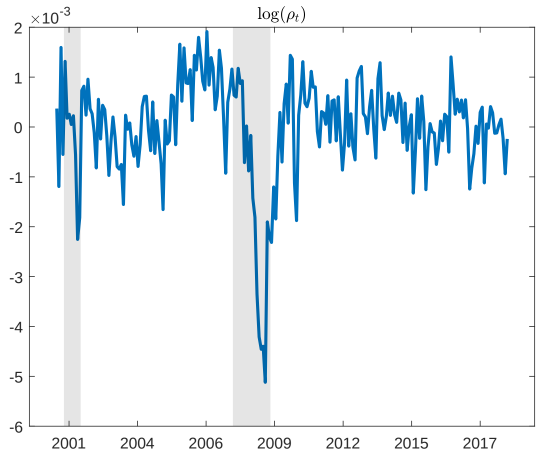


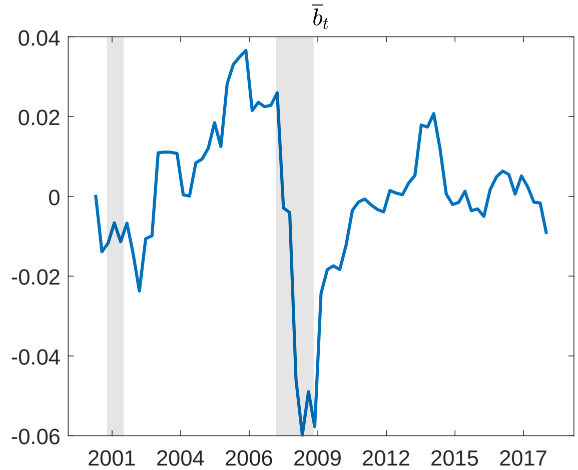
Figure D.2: Productivity shock ($\rho = 0.9190$, $\sigma = 0.0024$)

Figure D.2 presents the productivity shock used in the simulations in Section C of the Online Appendix.

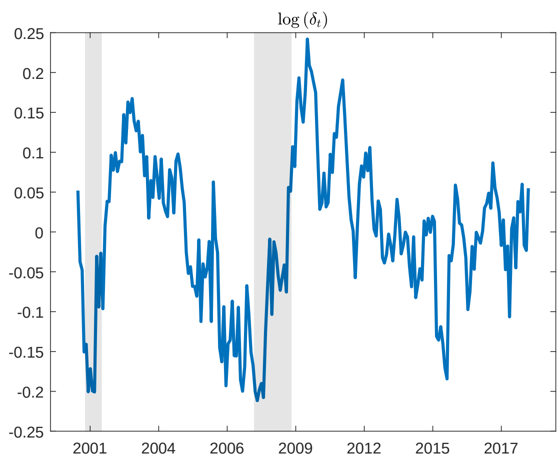
Figure D.3 presents the labor market and the borrowing shocks used in the simulations in Section V.B.



(a) Separation (retention rate) shock



(b) Borrowing shock



(c) LTU inflow rate shock

Figure D.3: Shocks from the data, short sample

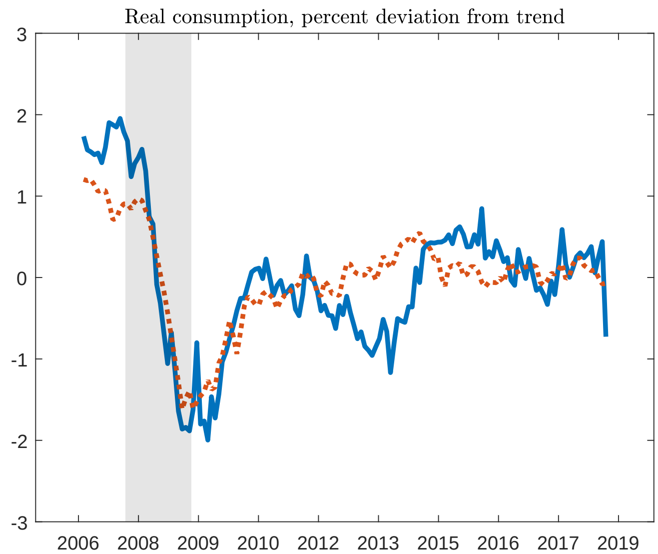
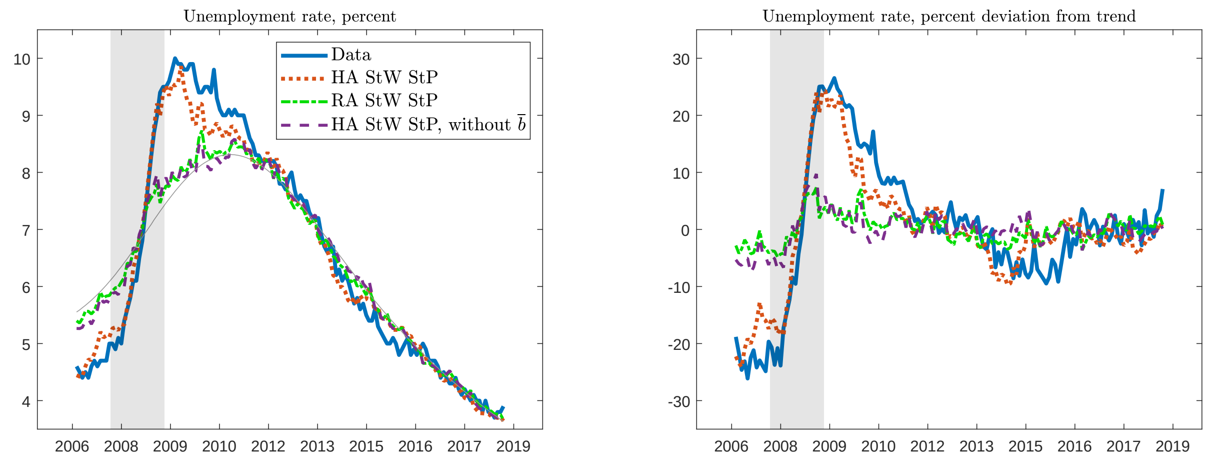


Figure D.4: Real consumption in the data and the model

Figure D.4 presents the fit of the real consumption in the baseline model and the data. For the data we used the real personal consumption expenditures from the U.S. Bureau of Economic Analysis (PCEC96 series on FRED, U.S. Bureau of Economic Analysis (2022)). The figure plots the percent deviation from HP-trend in the data and percent deviation from the steady state in the model. The correlation between real consumption from the model and in the data in the five years that follow the 2007 business cycle peak is 0.9326.

Figure D.5 presents the comparison of HA model with labor market and with or without the borrowing shock and the RA model with the three shocks that we discuss in Section V.B.

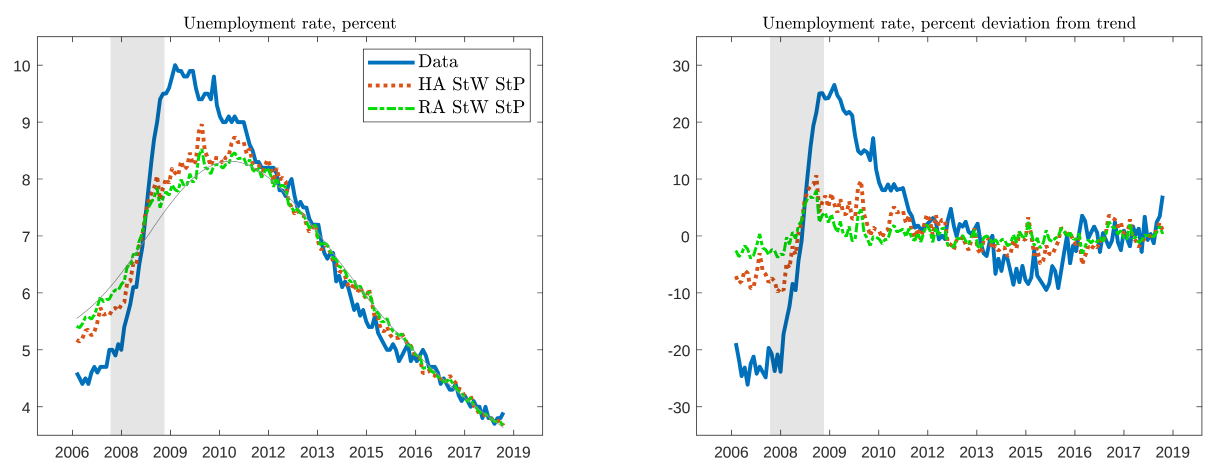
Figure D.6 presents the comparison of the HA and RA models with only the labor market shocks (without discretionary or automatic extensions) that we discuss in Section V.B.



(a) Percent of labor force

(b) Percent deviation from trend

Figure D.5: HA vs. RA Model: the role of credit tightening



(a) Percent of labor force

(b) Percent deviation from trend

Figure D.6: HA vs. RA Model: the role of amplification from AD (separation and LTU shocks)

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