Appendix to: "The Macroeconomic Effects of Lockdown Policies"

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A Sensitivity analysis

A.1 Lockdown shock

We report the impulse responses after a (separation) lockdown shock under alternative calibrations of interest.

First, since the Euro Area was already very close to the ZLB on the nominal interest rate before the Covid-19 outbreak, it is natural to investigate the effects of lockdown policies for a calibration where the nominal rate is closer to the ZLB. We recalibrate the model so that it produces a steady-state nominal rate that is slightly above zero. The lockdown shock, pushing the desired real rate down, makes the nominal rate hit the ZLB instantly. Technically, we increase the discount factor to $0.99739^{1/3}$ (against $0.993^{1/3}$ in the baseline calibration) to obtain a close-to-zero steady-state nominal rate, and adjust $\kappa = 0.2442$ (instead of $\kappa = 0.1915$ in the baseline) to keep on hitting the target value of bargaining power of workers ($\theta = 0.75$). A lower steady-state real rate is associated with a larger precautionary motive, a larger consumption loss upon unemployment and larger consumption inequality among workers (15% against 10.5% in the baseline). Figure 1 shows that the ZLB is hit immediately, which magnifies the negative output, unemployment and welfare effects of the lockdown shock. Deflationary pressures are also amplified. Aggregate welfare losses peak at 7.5%, against 6.58% in the baseline experiment, in part because of the larger effects of the shock, but also because utility losses are discounted using a much higher discount factor. Table 1 also shows that hitting the ZLB essentially magnifies the individual welfare losses from employed workers (1.03% against 0.64% in the baseline), and the losses from newly unemployed workers ($\zeta_T - \zeta'_T = 1.25\%$ against 1% in the baseline).

Second, Figure 2 compares the effects of a lockdown (separation) shock under the baseline calibration with and a calibration that implies a more aggressive monetary policy ($\rho_i = 0$). When monetary policy is more aggressive, the macroeconomic effects and the welfare losses are amplified, because the nominal rate hits the ZLB on impact, which results in further deflationary pressures, with depressing effects on output and employment.

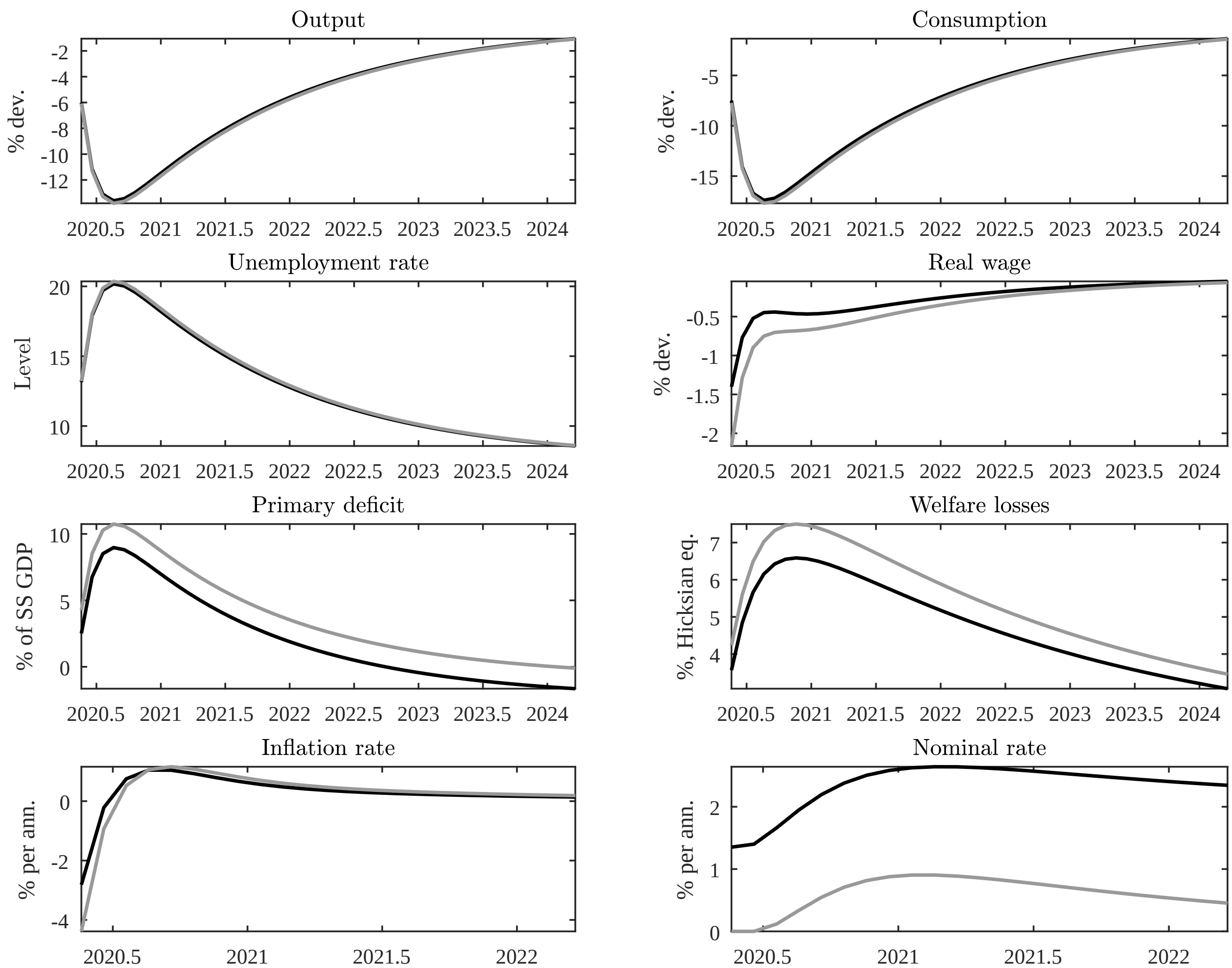
A.2 Government policies

Figure 3 and 4 respectively report the net effects of the two policy measures conditional on the lockdown shock under the two alternative calibrations: one that brings the steady-state nominal rate closer to the ZLB, and one that makes monetary policy respond more aggressively to inflation ($\rho_i = 0$).

Figure 3 the effects of government policies are not very different from those implied by the baseline calibration. The chief reason is the short duration of the ZLB episode (3 to 4 months), because the lockdown shock is not very persistent. If anything, the net effects of government policies are more persistent. Table 1 shows that the structure of welfare losses is broadly unchanged, all agents experiencing larger losses or smaller gains, mostly because utility flow are discounted using a larger discount factor.

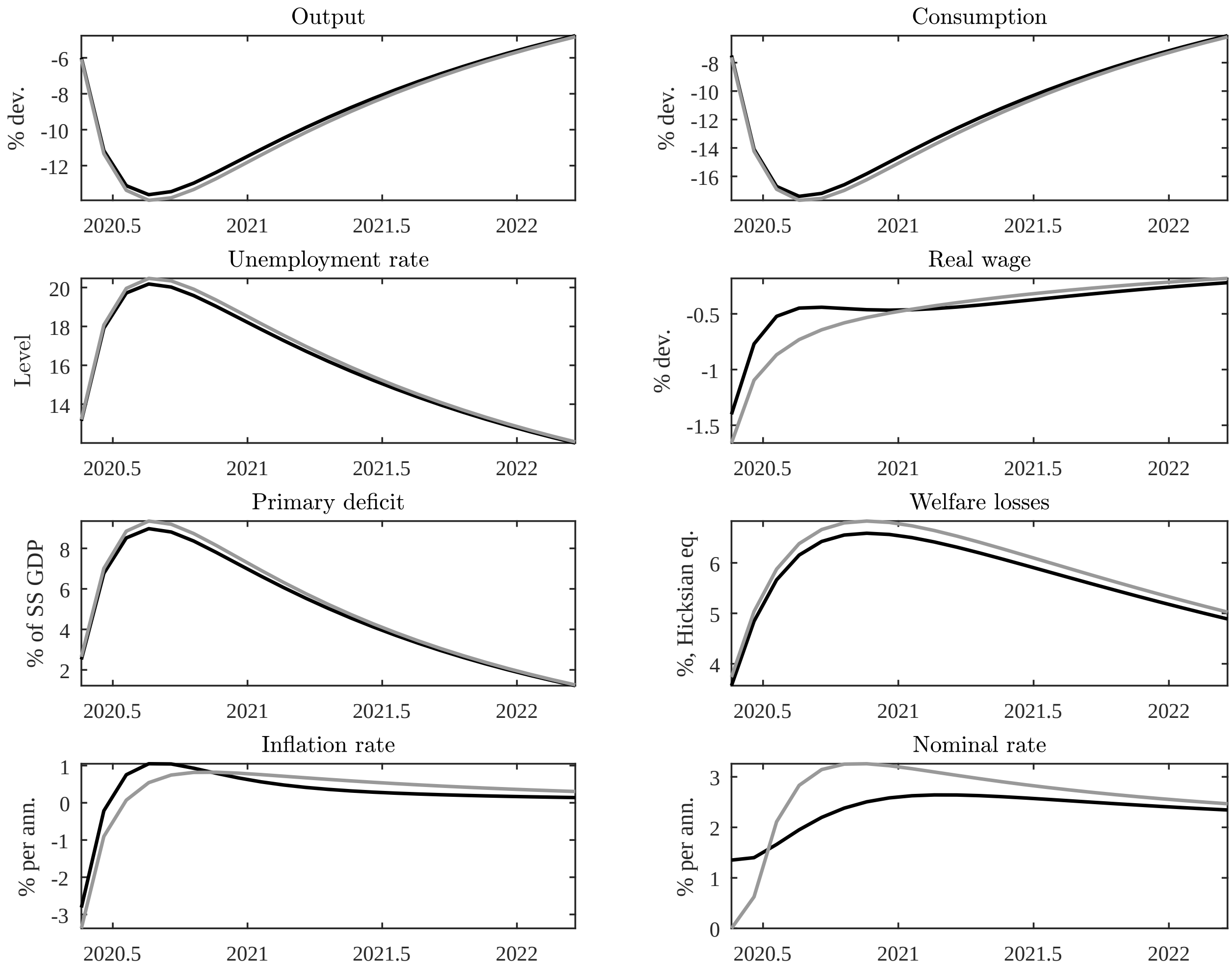
Under a more aggressive monetary policy, Figure 4 (dashed lines) shows that raising the level of UI benefits is slightly more effective in raising output and lowering unemployment than in the

Figure 1: Lockdown policies close to the ZLB.



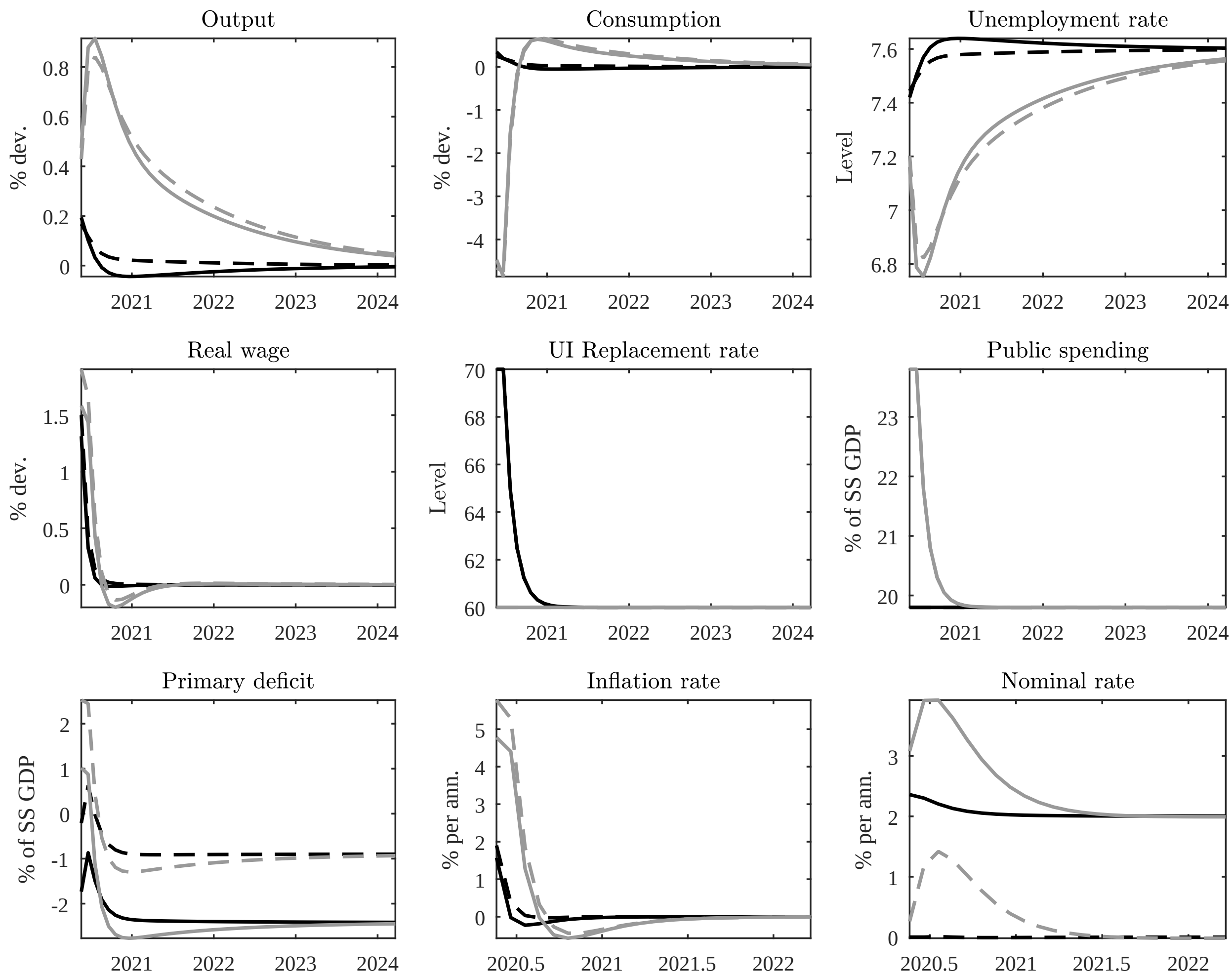
Solid black: Baseline calibration. Grey: Close to the ZLB. The horizon is shorter for inflation and the nominal rate.

Figure 2: Effects of lockdown policies under aggressive monetary policy.



Black: Baseline. Grey: Aggressive monetary policy ($\rho_i = 0$). The horizon is shorter for inflation and the nominal interest rate.

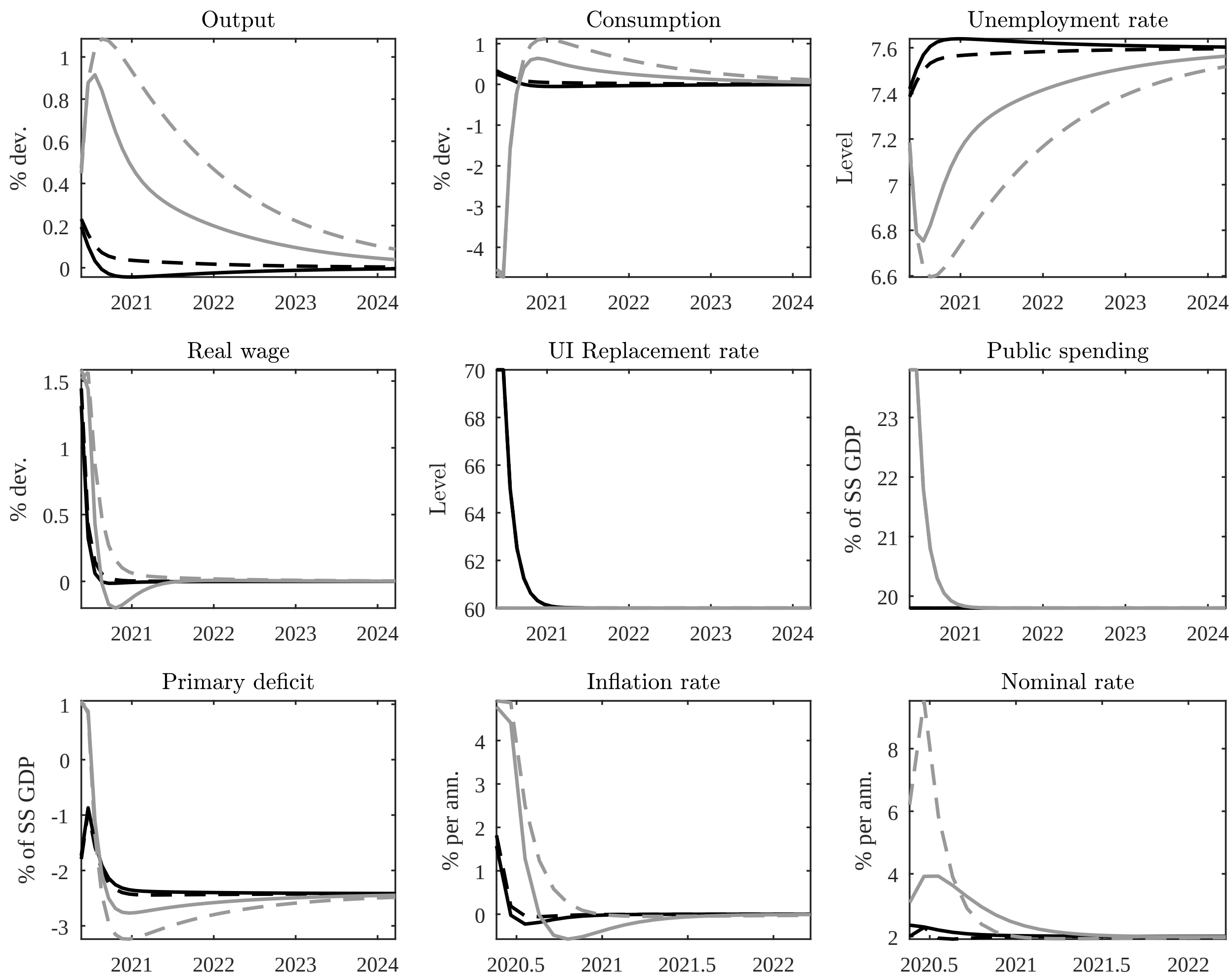
Figure 3: Net effects of government policies conditional on lockdown close to the ZLB.



Black: UI replacement rate shock. Grey: government spending shock. Solid: conditional on lockdown, baseline calibration. Dashed: conditional on lockdown, close to the ZLB. The horizon is shorter for inflation and the nominal interest rate.

baseline calibration. Further, the effects of government spending are much larger. The main explanation is that the Central Bank offers a more efficient stabilization of the rise in inflation implied by the spending shock, which contributes to attenuate the fall in the consumption of employed workers and reduces the crowding-out effect. This case actually yields the lowest aggregate welfare losses from the lockdown shock (5.11% against 6.59% in the baseline case with passive policies and 5.13% in the baseline case with rising government spending).

Figure 4: Net effects of government policies conditional on lockdown under aggressive monetary policy.



Solid: Baseline. Dashed: aggressive monetary policy ($\rho_i = 0$). Black: UI replacement rate shock. Grey: government spending shock. The horizon is shorter for inflation and the nominal interest rate.

Table 1: Welfare losses under alternative calibrations, in percents

	Peak ($p = \arg\max\{\zeta_t\}_{t=0}^{t=\infty}$)					Lifetime (∞)				
	ζ_p	ζ_p^e	ζ_p^u	ζ_p^f	ζ_p'	ζ_∞	ζ_∞^e	ζ_∞^u	ζ_∞^f	ζ_∞'
Passive gvt policies										
$\uparrow s_t$ - ZLB	7.50	1.03	0.00	52.68	6.25	0.79	0.09	0.00	6.65	0.64
$\uparrow s_t$ - $\rho_i = 0$	6.83	0.88	0.00	50.19	5.82	0.81	0.07	0.00	7.20	0.67
Raise g_t										
$\uparrow s_t$ - ZLB	6.10	−1.16	−1.55	56.02	4.86	0.71	0.00	−0.06	6.71	0.56
$\uparrow s_t$ - $\rho_i = 0$	5.11	−1.33	−1.46	51.39	4.12	0.68	−0.04	−0.08	7.02	0.55
Raise b_t^r										
$\uparrow s_t$ - ZLB	6.77	0.70	−5.34	54.81	5.93	0.76	0.08	−0.22	6.80	0.63
$\uparrow s_t$ - $\rho_i = 0$	6.06	0.55	−5.36	52.12	5.47	0.77	0.06	−0.25	7.35	0.65

Note: the peak p is case-specific.

B List of model equations

Euler on private assets (employed)	:	$\mathrm{E}_t \left\{ \beta \left(1 + r_t\right) \frac{(1-\sigma_{t+1}) u_c\left(c^e_{t+1}, g_{t+1}\right) + \sigma_{t+1} u_c\left(c^u_{t+1}, g_{t+1}\right)}{u_c(c^e_t, g_t)} \right\} = 1$
Euler on gov. bonds (firm owners)	:	$\mathrm{E}_t \left\{ \beta \left(1 + r^d_t\right) \Delta_{t,t+1} \right\} = 1$
Subjective discount factor (firm owners)	:	$\Delta_{t,t+1} = \beta \widetilde{u}_c(c^f_{t+1}, g_{t+1}) / \widetilde{u}_c(c^f_t, g_t)$
Individual consumption (unemployed)	:	$c^u_t = b_t$
Individual consumption (employed)	:	$c^e_t = (1-\tau)\, w_t$
Aggregate production function	:	$y_t = \chi n_t \xi_t z_t$
Aggregate profits	:	$\Pi_t = y_t \left(1 - \phi \pi^2_t / 2\right) - \chi n_t w_t - \kappa_t v_t$
Marginal value of a job filled	:	$J_t = \varphi_t z_t \xi_t - w_t + \mathrm{E}_t \left\{ \Delta_{t,t+1} \left(1 - s_t\right) J_{t+1} \right\}$
New Keynesian Phillips Curve	:	$\eta - 1 = \eta \varphi_t - \phi \left(\pi_t (1 + \pi_t) - \mathrm{E}_t \left\{ \Delta_{t,t+1} \pi_{t+1} (1 + \pi_{t+1}) y_{t+1} / y_t \right\} \right)$
Free-entry condition	:	$\max\left(v_t, 0\right) \left(q_t J_t - \kappa_t\right) = 0$
Law of motion of employment	:	$n_t = (1 - \sigma_t)\, n_{t-1} + f_t \left(1 - n_{t-1}\right)$
Matching function	:	$m_t = \psi \left(u_{t-1} + s_t n_{t-1}\right)^{\gamma} v_t^{1-\gamma}$
Job finding probability	:	$f_t = \min\left(\max\left(\psi \left(\frac{v_t}{u_{t-1} + s_t n_{t-1}} \right)^{1-\gamma}, 0 \right), 1 \right)$
Worker-finding probability	:	$q_t = \max\left(\min\left(\psi \left(\frac{u_{t-1} + s_t n_{t-1}}{v_t} \right)^{\gamma}, 1 \right), 0 \right)$
Accounting on labor market	:	$n_t + u_t = 1$
Net separation rate	:	$\sigma_t = s_t \left(1 - f_t\right)$
Marginal value of being employed	:	$S_t = \log \widetilde{c}^e_t - \log \widetilde{c}^u_t + \beta \mathrm{E}_t \left\{ \left(1 - \sigma_{t+1} - f_{t+1}\right) S_{t+1} \right\}$
Notional real wage	:	$w^n_t = \varphi_t z_t \xi_t + \mathrm{E}_t \left\{ \Delta_{t,t+1} \left(1 - s_t\right) \kappa_{t+1} / q_{t+1} \right\} - \frac{(1-\theta) S_t}{\theta (1-\tau) u_c(c^e_t, g_t)}$
Effective real wage	:	$w_t = w^{\alpha} \left(w^n_t\right)^{1-\alpha}$
Individual consumption	:	$c^f_t = \left(\left(1 + r^d_{t-1}\right) d_{t-1} - d_t + \Pi_t - T_t \right) / \left(1 - \chi\right)$
Goods market clearing condition	:	$y_t \left(1 - \phi \pi^2_t / 2\right) = \chi \left(n_t c^e_t + u_t c^u_t\right) + (1 - \chi)\, c^f_t + g_t + \kappa_t v_t$
Taylor-type rule	:	$i^n_t = \max\left(r + \rho_i i^n_{t-1} + (1 - \rho_i)\, d_\pi \pi_t, 0\right)$
Fisher equation	:	$1 + r_t = \mathrm{E}_t \left\{ \left(1 + i^n_t\right) / \left(1 + \pi_{t+1}\right) \right\}$
Public debt dynamics	:	$\left(1 + r^d_{t-1}\right) d_{t-1} + def_t = d_t$
Primary government deficit	:	$def_t = g_t + \chi u_t b_t - \tau \chi n_t w_t - T_t$
Lump-sum tax rule	:	$T_t = d_T \left(d_{t-1} - d\right) / (12 y)$
Marg. utility of cons. (employed)	:	$u_c\left(c^e_t, g_t\right) = (1 - \Upsilon) \left(c^e_t / \widetilde{c}^e_t\right)^{\nu} / c^e_t$
Marg. utility of cons. (unemployed)	:	$u_c\left(c^u_t, g_t\right) = (1 - \Upsilon) \left(c^u_t / \widetilde{c}^u_t\right)^{\nu} / c^u_t$
Marg. utility of cons. (firm owners)	:	$\widetilde{u}_c \left(c^f_t, g_t\right) = (1 - \Upsilon) \left(c^f_t / \widetilde{c}^f_t\right)^{\nu} \left(\widetilde{c}^f_t\right)^{1-\rho_f} / c^f_t$
Consumption bundle (employed)	:	$\tilde{c}^e_t = \left((1 - \Upsilon) \left(c^e_t\right)^{\nu} + \Upsilon g^{\nu}_t \right)^{\frac{1}{\nu}}$
Consumption bundle (unemployed)	:	$\tilde{c}^u_t = \left((1 - \Upsilon) \left(c^u_t\right)^{\nu} + \Upsilon g^{\nu}_t \right)^{\frac{1}{\nu}}$
Consumption bundle (firm owners)	:	$\tilde{c}^f_t = \left((1 - \Upsilon) \left(c^f_t\right)^{\nu} + \Upsilon g^{\nu}_t \right)^{\frac{1}{\nu}}$
Aggregate welfare	:	$\mathcal{W}_t = \mathcal{U}_t + \beta \mathrm{E}_t \left\{ \mathcal{W}_{t+1} \right\}$
Aggregate utility	:	$\mathcal{U}_t = \chi \left(n_t \log \tilde{c}^e_t + u_t \log \tilde{c}^u_t\right) + (1 - \chi) \left(\tilde{c}^f_t\right)^{1-\rho_f} / (1 - \rho_f)$
Unemployment benefits	:	$b_t = b^r_t w$
Public spending shock	:	$g_t = (1 - \rho_L)\, g + \rho_L g_{t-1} + \epsilon^g_t$
Replacement rate shock	:	$b^r_t = (1 - \rho_L)\, b^r + \rho_L b^r_{t-1} + \epsilon^b_t$
Separation shock	:	$s_t = (1 - \rho_L)\, s + \rho_L s_{t-1} + \epsilon^s_t$
Labor utilization shock	:	$\xi_t = (1 - \rho_L) + \rho_L \xi_{t-1} + \epsilon^{\xi}_t$
Vacancy posting cost shock	:	$\kappa_t = (1 - \rho_L)\, \kappa + \rho_L \kappa_{t-1} + \epsilon^{\kappa}_t$
Productivity shock	:	$z_t = (1 - \rho_z)\, z + \rho_z z_{t-1} + \epsilon^z_t$

Note: ρ_L is the common persistence parameter of lockdown (s_t, ξ_t and κ_t) and policy (g_t and b^r_t) shocks.