Unwinding Quantitative Easing: State Dependency and Household Heterogeneity

Online Appendix

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A Borrower-saver model derivations

This appendix provides details on the derivations of the model presented in Section 2.

A.1 Household problem

Each household of type $j = \{B, S\}$ faces the following optimization problem:

$$\max_{c_t^j, N_t^j, b_t^j, b_t^{j,L}} \mathbb{E}_t \sum_{t=0}^{\infty} \left(\beta^j\right)^t \theta_t \left(\frac{(c_t^j)^{1-\frac{1}{\sigma}}}{1-\frac{1}{\sigma}} - \zeta^j \frac{(N_t^j)^{1+\varphi}}{1+\varphi} \right) \quad \text{subject to}$$

$$\begin{aligned} c_t^j + b_t^j + b_t^{j,L} &\leq r_{t-1} b_{t-1}^j + r_t^L b_{t-1}^{j,L} + w_t N_t^j + d_t^j - t_t - \frac{\nu}{2} \left(\delta^j \frac{b_t^j}{b_t^{j,L}} - 1 \right)^2 + tr^j , \\ 0 &\leq \mathbb{I}^j \left(b_t^B + b_t^{B,L} + \bar{D} \right) , \end{aligned}$$

where $d_t^B = \tau^D d_t / \lambda$, $d_t^S = \left(1 - \tau^D\right) / (1 - \lambda) \, d_t$, $tr^B = tr/\lambda$, and $tr^S = -tr/(1-\lambda)$. Moreover, $\mathbb{I}^j$ is an indicator function with values $\mathbb{I}^S = 0$ and $\mathbb{I}^B = 1$.

The resulting optimality conditions for each agent are:

$$\begin{aligned} U_{c,t}^j &= \theta_t (c_t^j)^{-\frac{1}{\sigma}} , \\ U_{N,t}^j &= -\theta_t \zeta^j (N_t^j)^{\varphi} , \\ w_t &= -\frac{U_{N,t}^j}{U_{c,t}^j} , \\ U_{c,t}^j + U_{c,t}^j \frac{\nu \delta^j}{b_t^{j,L}} \left(\delta^j \frac{b_t^j}{b_t^{j,L}} - 1 \right) &= \beta^j R_t \mathbb{E}_t \left[U_{c,t+1}^j \frac{1}{\Pi_{t+1}} \right] + \mathbb{I}^j \psi_t^B , \\ U_{c,t}^j - U_{c,t}^j \frac{\nu \delta^j b_t^j}{\left(b_t^{j,L}\right)^2} \left(\delta^j \frac{b_t^j}{b_t^{j,L}} - 1 \right) &= \beta^j \mathbb{E}_t \left[U_{c,t+1}^j \frac{R_{t+1}^L}{\Pi_{t+1}} \right] + \mathbb{I}^j \psi_t^B , \\ 0 &= \mathbb{I}^j \psi_t^B \left(b_t^B + b_t^{B,L} + \bar{D} \right) , \end{aligned}$$

where $\psi_t^B \geq 0$ is the Lagrangian multiplier on the borrowing constraint. It holds that $\psi_t^B > 0$ whenever the constraint is binding.

From the expressions above, we can derive the following Euler equations for short-term and long-term bonds, where we already imposed $\delta^S = \delta^B = \delta$ as specified in the description of the steady state:

$$\begin{aligned} 1 &= \beta^j R_t \mathbb{E}_t \left[\frac{\theta_{t+1}}{\theta_t} \left(\frac{c_{t+1}^j}{c_t^j} \right)^{-\frac{1}{\sigma}} \frac{1}{\Pi_{t+1}} \right] - \frac{\nu \delta}{b_t^{j,L}} \left(\delta \frac{b_t^j}{b_t^{j,L}} - 1 \right) + \mathbb{I}^j \psi_t^B \theta_t^{-1} \left(c_t^j \right)^{\frac{1}{\sigma}} , \\ 1 &= \beta^j \mathbb{E}_t \left[\frac{\theta_{t+1}}{\theta_t} \left(\frac{c_{t+1}^j}{c_t^j} \right)^{-\frac{1}{\sigma}} \frac{R_{t+1}^L}{\Pi_{t+1}} \right] + \frac{\nu \delta b_t^j}{\left(b_t^{j,L}\right)^2} \left(\delta \frac{b_t^j}{b_t^{j,L}} - 1 \right) + \mathbb{I}^j \psi_t^B \theta_t^{-1} \left(c_t^j \right)^{\frac{1}{\sigma}} . \end{aligned}$$

Combining the two equations leads to an expression for the nominal return on long-term bonds as a function of the nominal rate on short-term bonds and the bond holdings of households:

$$\mathbb{E}_t R^L_{t+1} = \frac{1 - \frac{\delta\, b^j_t}{\left(b^{j,L}_t\right)^2}\, \widetilde{\Psi}^j_t - \mathbb{I}^j\, \psi^B_t\, \theta_t^{-1} \left(c^j_t\right)^{\frac{1}{\sigma}}}{1 + \frac{\delta}{b^{j,L}_t}\, \widetilde{\Psi}^j_t - \mathbb{I}^j\, \psi^B_t\, \theta_t^{-1} \left(c^j_t\right)^{\frac{1}{\sigma}}}\, R_t \,,$$

where $\widetilde{\Psi}^j_t = \nu \left(\delta\, \frac{b^j_t}{b^{j,L}_t} - 1\right)$. This equation is a no-arbitrage condition between the two types of bonds and captures the key impact channel of asset market operations on bond returns. When the central bank buys or sells long-term bonds, it changes the quantity of assets available to the rest of the economy. Holding bond supply fixed, this implies that households' portfolio mix is not at the desired level and induces costly portfolio rebalancing. The impact of the adjustment cost and of changes in bond demands is directly visible from the equation above. It can be shown that the fraction is larger than one whenever $\delta < b^{j,L}_t / b^j_t$, and smaller than one otherwise.

A.2 Intermediate goods producer problem

The price-setting problem of an intermediate goods firm is

$$\max_{\{P_{t+k}(i)\}_{k=0}^{\infty}} \mathbb{E}_t \sum_{k=0}^{\infty} \Lambda_{t,t+k} \left[\left(1+\tau^S\right) \frac{P_{t+k}(i)}{P_{t+k}}\, y_{t+k}(i) - mc_{t+k}\, y_{t+k}(i) - \frac{\phi_p}{2} \left(\frac{P_{t+k}(i)}{P_{t-1+k}(i)} - 1 \right)^2 y_{t+k} - t^F_{t+k} \right]$$
$$\text{s.t.} \quad y_{t+k}(i) = \left(\frac{P_{t+k}(i)}{P_{t+k}} \right)^{-\varepsilon} y_{t+k} \,,$$

where $\Lambda_{t,t+k} = (\beta^S)^k \left(\frac{U^S_{c,t+k}}{U^S_{c,t}} \right)$ is the stochastic discount factor for payoffs in period $t+k$. The optimality condition of this optimization problem is

$$\mathbb{E}_t \left\{ \Lambda_{t,t} \left[\left(1+\tau^S\right) (1-\varepsilon)\, P_t(i)^{-\varepsilon} P_t^{\varepsilon-1}\, y_t + mc_t\, \varepsilon\, P_t(i)^{-\varepsilon-1} P_t^{\varepsilon}\, y_t - \phi_p \left(\frac{P_t(i)}{P_{t-1}(i)} - 1 \right) \frac{y_t}{P_{t-1}(i)} \right] \right.$$
$$\left. + \Lambda_{t,t+1}\, \phi_p \left(\frac{P_{t+1}(i)}{P_t(i)} - 1 \right) \frac{P_{t+1}(i)}{P_t(i)^2}\, y_{t+1} \right\} = 0 \,.$$

Since firms are identical and face the same demand from final goods producers, they will all set the same price. This yields the following optimal price-setting condition:

$$\phi_p \left(\Pi_t - 1\right) \Pi_t - \mathbb{E}_t \left[\Lambda_{t,t+1}\, \phi_p \left(\Pi_{t+1} - 1\right) \Pi_{t+1} \frac{y_{t+1}}{y_t} \right] = \left(1+\tau^S\right)(1-\varepsilon) + \varepsilon\, mc_t \,.$$

A.3 Steady state

For the approximation of the model around a deterministic steady state, we assume a long-run inflation rate of unity ($\Pi = 1$), normalize output to one (by setting $z = N = 1$), and set $\theta = 1$.

The Euler equations of the saver give $R = R^L = \left(\beta^S\right)^{-1}$. Using this in the Euler equations of the borrower implies that the borrowing constraint binds in steady state ($\psi^B > 0$) because we assumed $\beta^S > \beta^B$. We further impose for labor supply that $N^B = N^S = N$. Together with the steady-state transfer on the part of households, this results in $c^B = c^S = c$. Finally, the optimal subsidy to firms induces $mc = 1$ and thus zero profits ($d = 0$).

For the real returns, we get $r = R$ and $r^L = R^L$, which pins down the nominal bond price $V = 1/\left(R^L - \chi\right)$. The weights on hours are found through the labor supply equations, $\zeta^j = w\left(N^j\right)^{-\varphi}\left(c^j\right)^{\sigma}$ with $j = \{B,S\}$ and where $w = y$ from the expression for labor demand. Due to equalized levels of labor supply and consumption across household types, $\zeta^S = \zeta^B$. Lastly, as portfolio adjustment costs are zero in steady state ($\Psi^j = 0$), the aggregate resource constraint determines consumption through $c = (1 - g/y)\,y$.

With respect to the bond-related variables, we impose $\delta^S = \delta^B = \delta = b^{H,L}/b^H$. This expression can be rewritten by using bond market clearing as $b^L = \delta\, b/(1-q)$, where we define $\tilde{\delta} = b^L/b$. Moreover, we write the annual steady-state total government debt-to-GDP ratio (in quarterly terms) as $b_y^{tot} = \left(b + b^L\right)/(4y)$, where the denominator captures annualized output. In order to find an expression for short-term government debt, we rewrite the last equation as $b = 4\, b_y^{tot}\left[(1-q)/(1-q+\delta)\right] y$, or $b = 4\, b_y^{tot}\left[1/\left(1+\tilde{\delta}\right)\right] y$. Market clearing then gives $b^H = b$.

Regarding the central bank, bond holdings are $b^{CB,L} = q\, b^L$. This pins down net asset purchases $\Omega = \left(1 - r^L\right) b^{CB,L}$ and households' total demand for long-term bonds $b^{H,L} = b^L - b^{CB,L}$. A borrower's bond holdings are then determined through the (binding) borrowing constraint, with $b^B = -\bar{D}/(1+\delta)$ and $b^{B,L} = -\bar{D} - b^B$. A saver's bond holdings are pinned down by market clearing, with $b^S = \left(b^H - \lambda b^B\right)/(1-\lambda)$ and $b^{S,L} = \left(b^{H,L} - \lambda b^{B,L}\right)/(1-\lambda)$. Finally, lump-sum taxes are given by $t = g + \Omega - b(1-r) - b^L(1-r^L)$ and the steady-state transfer by $tr = \lambda[c^B + (1-r)b^B + (1-r^L)b^{B,L} - wN^B - \tau^D d/\lambda + t]$.

A.4 Model summary

Table A.1 lists all equations of the TANK-BS model.

Table A.1: Model overview of the TANK-BS model with asset market operations

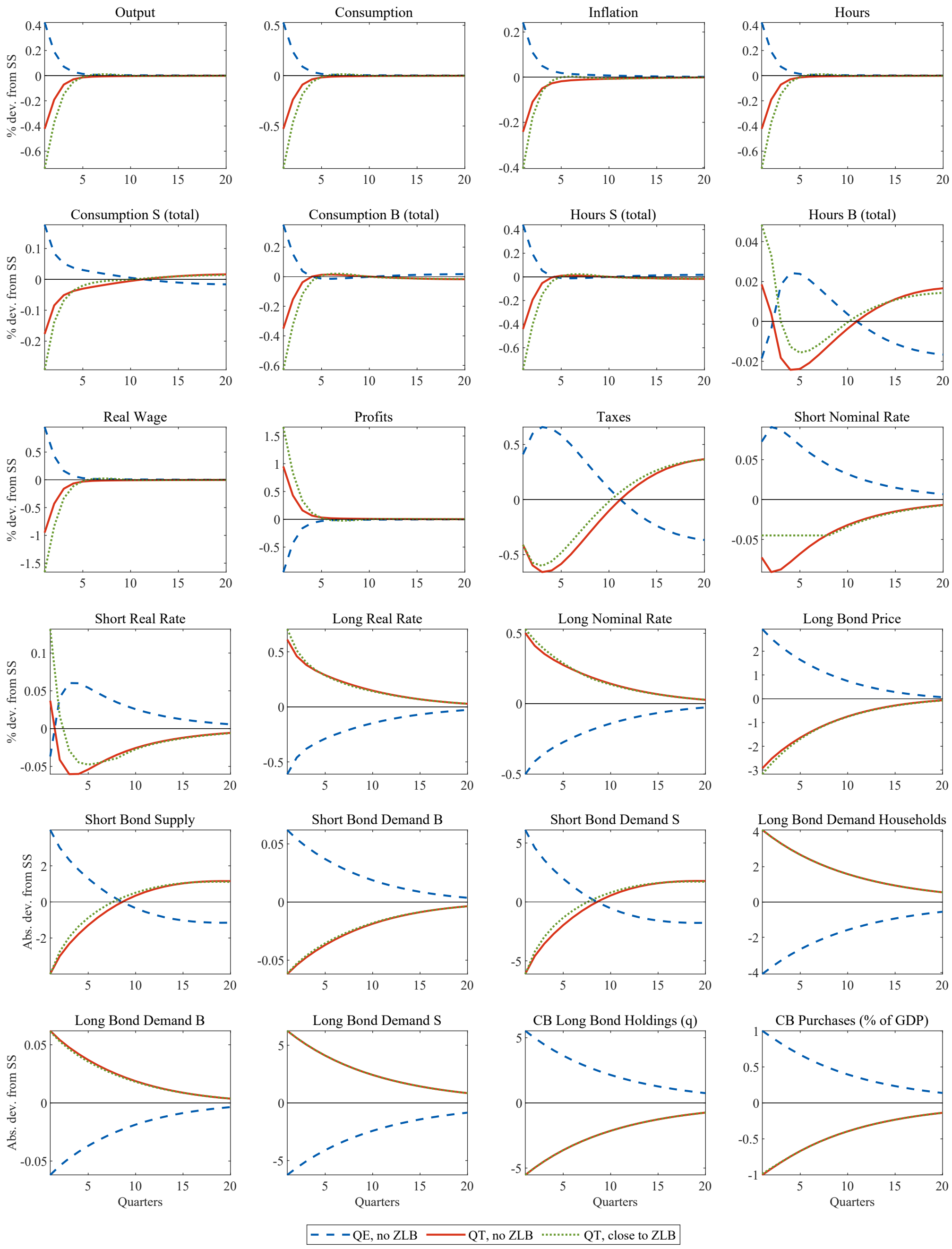
Labor supply	$w_t = \zeta^j (N_t^j)^{\varphi} (c_t^j)^{1/\sigma}, \;\; j = \{B, S\}$
Euler short-term bonds, S	$1 = \beta^S \mathbb{E}_t \left[\frac{\theta_{t+1}}{\theta_t} \left(\frac{c_{t+1}^S}{c_t^S} \right)^{-1/\sigma} \frac{R_t}{\Pi_{t+1}} \right] - \frac{\nu \, \delta^S}{b_t^{S,L}} \left(\delta^S \frac{b_t^S}{b_t^{S,L}} - 1 \right)$
Euler long-term bonds, S	$1 = \beta^S \mathbb{E}_t \left[\frac{\theta_{t+1}}{\theta_t} \left(\frac{c_{t+1}^S}{c_t^S} \right)^{-1/\sigma} \frac{R_{t+1}^L}{\Pi_{t+1}} \right] + \frac{\nu \, \delta^S b_t^S}{\left(b_t^{S,L}\right)^2} \left(\delta^S \frac{b_t^S}{b_t^{S,L}} - 1 \right)$
Budget constraint, S	$c_t^S + b_t^S + b_t^{S,L} = r_{t-1} b_{t-1}^S + r_t^L b_{t-1}^{S,L} + w_t N_t^S + \frac{1-\tau^D}{1-\lambda} d_t - t_t - \Psi_t^S - \frac{tr}{1-\lambda}$
Euler short-term bonds, B	$1 = \beta^B \mathbb{E}_t \left[\frac{\theta_{t+1}}{\theta_t} \left(\frac{c_{t+1}^B}{c_t^B} \right)^{-1/\sigma} \frac{R_t}{\Pi_{t+1}} \right] - \frac{\nu \, \delta^B}{b_t^{B,L}} \left(\delta^B \frac{b_t^B}{b_t^{B,L}} - 1 \right) + \frac{\psi_t^B}{\theta_t \left(c_t^B\right)^{-1/\sigma}}$
Euler long-term bonds, B	$1 = \beta^B \mathbb{E}_t \left[\frac{\theta_{t+1}}{\theta_t} \left(\frac{c_{t+1}^B}{c_t^B} \right)^{-1/\sigma} \frac{R_{t+1}^L}{\Pi_{t+1}} \right] + \frac{\nu \, \delta^B b_t^B}{\left(b_t^{B,L}\right)^2} \left(\delta^B \frac{b_t^B}{b_t^{B,L}} - 1 \right) + \frac{\psi_t^B}{\theta_t \left(c_t^B\right)^{-1/\sigma}}$
Budget constraint, B	$c_t^B + b_t^B + b_t^{B,L} = r_{t-1} b_{t-1}^B + r_t^L b_{t-1}^{B,L} + w_t N_t^B + \frac{\tau^D}{\lambda} d_t - t_t - \Psi_t^B + \frac{tr}{\lambda}$
Borrowing constraint	$-b_t^B - b_t^{B,L} \leq \bar{D}$
Portfolio adjustment cost	$\Psi_t^j = \frac{\nu}{2} \left(\delta^j \frac{b_t^j}{b_t^{j,L}} - 1 \right)^2, \;\; j = \{B, S\}$
Labor demand	$w_t = mc_t \frac{y_t}{N_t}$
Production function	$y_t = z_t N_t$
Profits, aggregate	$d_t = \left[1 - mc_t - \frac{\phi_p}{2} (\Pi_t - 1)^2 \right] y_t$
Phillips curve	$\phi_p (\Pi_t - 1) \Pi_t = \varepsilon \, mc_t + \left(1 + \tau^S\right)(1 - \varepsilon) + \beta^S \mathbb{E}_t \left[\frac{\theta_{t+1}}{\theta_t} \left(\frac{c_{t+1}^S}{c_t^S} \right)^{-\frac{1}{\sigma}} \phi_p (\Pi_{t+1} - 1) \Pi_{t+1} \frac{y_{t+1}}{y_t} \right]$
Government budget constraint	$b_t + b_t^L = r_{t-1} b_{t-1} + r_t^L b_{t-1}^L + \Omega_t + g_t - t_t$
Short-term real interest rate	$r_t = \frac{R_t}{\mathbb{E}_t \Pi_{t+1}}$
Nominal long-term bond return	$R_t^L = \frac{1 + \chi V_t}{V_{t-1}}$
Real long-term bond return	$r_t^L = \frac{R_t^L}{\Pi_t}$
Net bond purchases, CB	$\Omega_t = b_t^{CB,L} - r_t^L b_{t-1}^{CB,L}$
Value bond purchases, CB	$b_t^{CB,L} = q_t b_t^L$
Taylor rule	$\log\left(\frac{R_t}{R}\right) = \rho_r \log\left(\frac{R_{t-1}}{R}\right) + (1 - \rho_r) \left[\phi_\pi \log\left(\frac{\Pi_t}{\Pi}\right) \right] + \varepsilon_t^m$
QE shock rule	$\log\left(\frac{q_t}{q}\right) = \rho_q \log\left(\frac{q_{t-1}}{q}\right) + \varepsilon_t^q$
Fiscal rule	$\frac{t_t}{t} = \left(\frac{t_{t-1}}{t}\right)^{\rho^{\tau,t}} \left(\frac{b_t + b_t^L}{b + b^L}\right)^{\rho^{\tau,b}} \left(\frac{g_t}{g}\right)^{\rho^{\tau,g}}$
Aggregate consumption	$c_t = \lambda c_t^B + (1 - \lambda) c_t^S$
Aggregate labor	$N_t = \lambda N_t^B + (1 - \lambda) N_t^S$
Short-term bonds market clearing	$b_t = \lambda b_t^B + (1 - \lambda) b_t^S$
Long-term bonds market clearing	$b_t^L = \left(\lambda b_t^{B,L} + (1 - \lambda) b_t^{S,L} \right) + b_t^{CB,L}$
Resource constraint	$y_t = c_t + g_t + \frac{\phi_p}{2} (\Pi_t - 1)^2 y_t$
Other shock rules	$\log\left(\frac{x_t}{x}\right) = \rho_x \log\left(\frac{x_{t-1}}{x}\right) + \varepsilon_t^x, \;\; x = \{g, bL, z, \theta\}$

B Full sets of impulse responses

This appendix contains all impulse responses for the various QE or QT shocks studied in Section 3.

B.1 QE/QT and QT near the ZLB

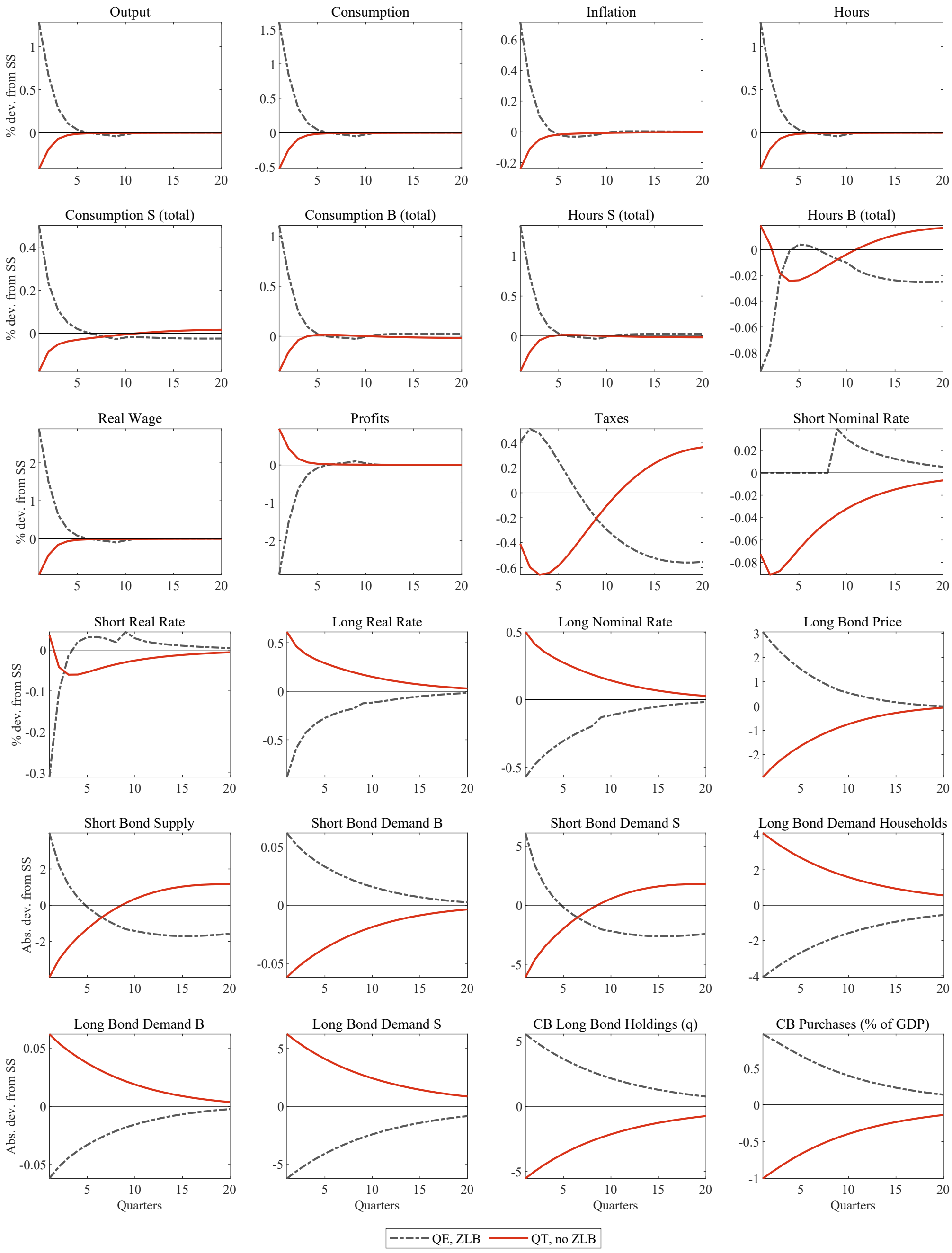
Figure B.1: Impulse responses to a QE/QT shock and a QT shock near the ZLB



Notes: This figure depicts the impulse responses to a QE (dashed blue line) and a QT (solid red line) shock occurring far enough above the ZLB, and a QT shock happening close to the ZLB (dotted green line). The shock for each simulation is an asset purchase/sale of size 1% of annualized GDP. Responses for individual consumption levels and hours are weighted by population shares of savers (S) and borrowers (B), respectively.

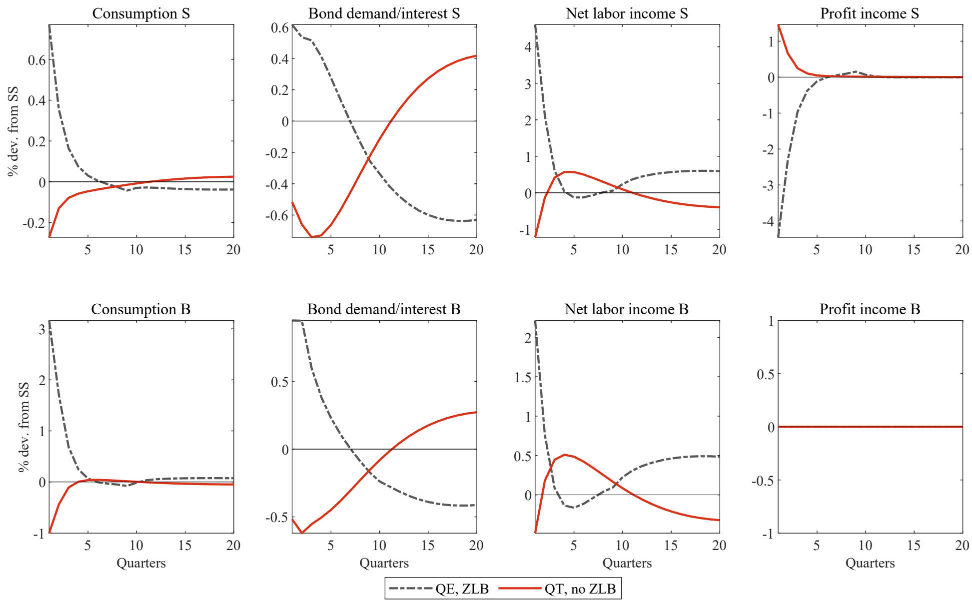
B.2 QE at the ZLB and QT off the ZLB

Figure B.2: Impulse responses to a QE shock at the ZLB and a QT shock off the ZLB



Notes: This figure depicts the impulse responses to a QE shock when the ZLB on the policy rate is binding (dash-dotted gray line, showing the impact of QE net of a preference shock), and a QT shock occurring far enough above the ZLB (solid red line). The shock for each simulation is an asset purchase/sale of size 1% of annualized GDP. Responses for individual consumption levels and hours are weighted by population shares of savers (S) and borrowers (B), respectively.

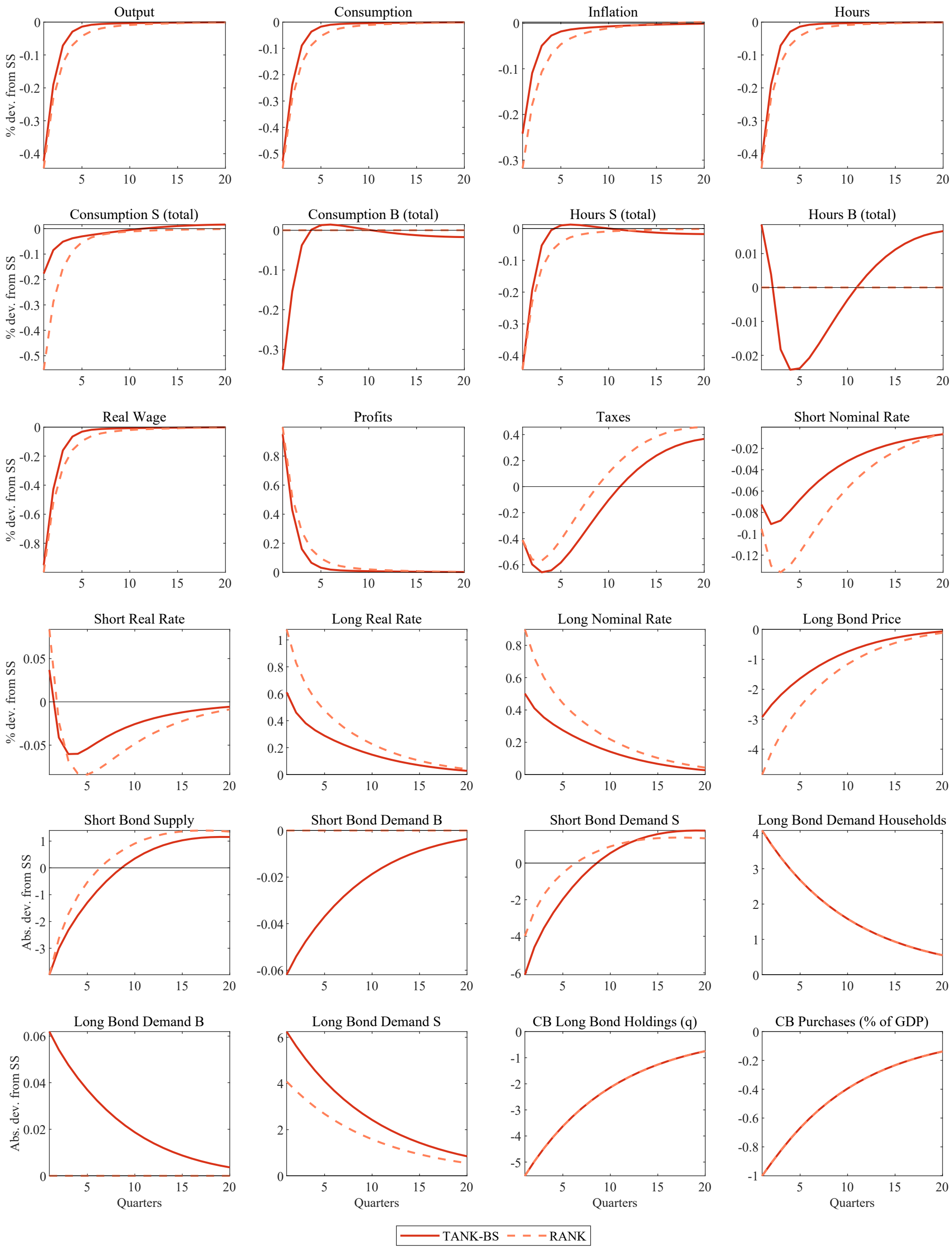
Figure B.3: Household budget components after a QE shock at the ZLB and a QT shock off the ZLB



Notes: This figure shows grouped components of the budget constraints of savers (top) and borrowers (bottom) in response to a QE shock when the ZLB on the policy rate is binding (dash-dotted gray line, showing the impact of QE net of a negative preference shock), and a QT shock occurring far enough above the ZLB (solid red line). The shock for each simulation is an asset purchase/sale of size 1% of annualized GDP. Each panel consists of four columns, containing the responses of individual consumption, bond-related variables (bond demand, interest payments/income, net of adjustment cost), labor income net of taxes, and income from profits. All responses are shown in per-capita terms.

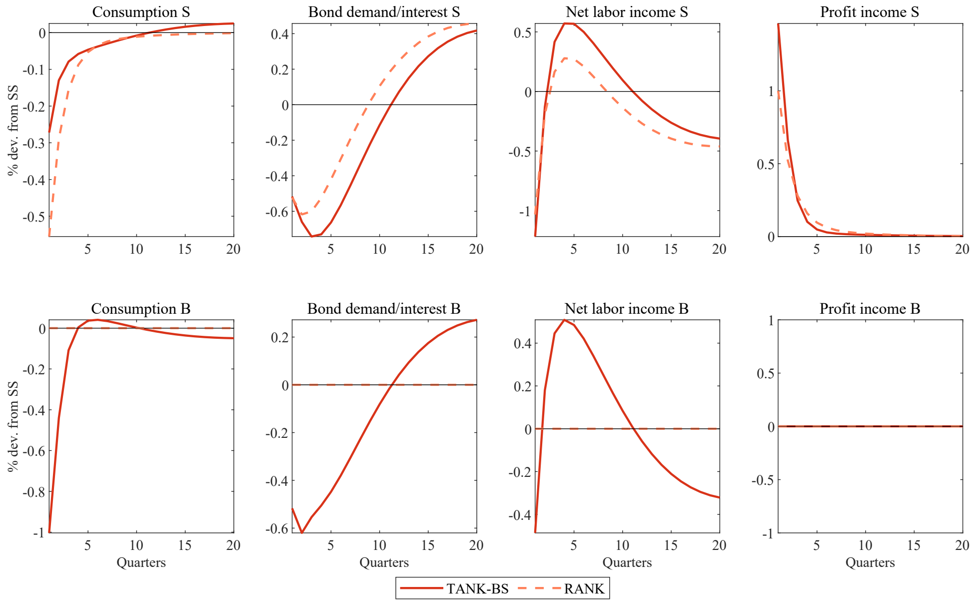
B.3 QT off the ZLB: RANK vs. TANK-BS

Figure B.4: Impulse responses to a QT shock off the ZLB: RANK vs. TANK-BS



Notes: This figure depicts the impulse responses to a QT shock occurring far enough above the ZLB, for the borrower-saver model (TANK-BS, solid red line) and its representative-agent counterpart with $\lambda = 0$ (RANK, dashed light red line). The shock for each simulation is an asset sale of size 1% of annualized GDP. Responses for individual consumption levels and hours are weighted by population shares of savers (S) and borrowers (B), respectively.

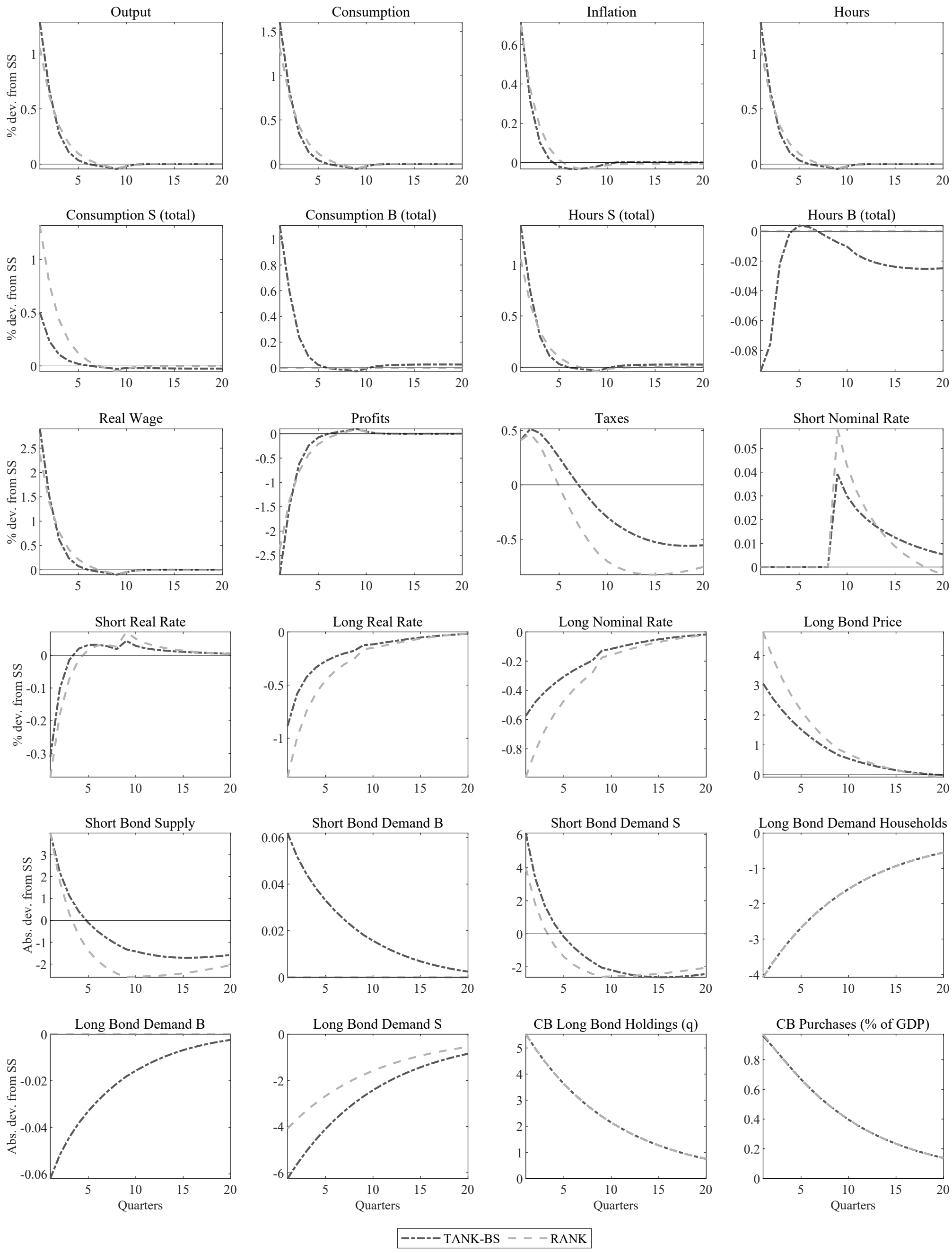
Figure B.5: Household budget components after a QT shock off the ZLB: RANK vs. TANK-BS



Notes: This figure shows grouped components of the budget constraints of savers (top) and borrowers (bottom) in response to a QT shock occurring far enough above the ZLB, for the borrower-saver model (TANK-BS, solid red line) and its representative-agent counterpart with $\lambda = 0$ (RANK, dashed light red line). The shock for each simulation is an asset sale of size 1% of annualized GDP. Each panel consists of four columns, containing the responses of individual consumption, bond-related variables (bond demand, interest payments/income, net of adjustment cost), labor income net of taxes, and income from profits. All responses are shown in per-capita terms.

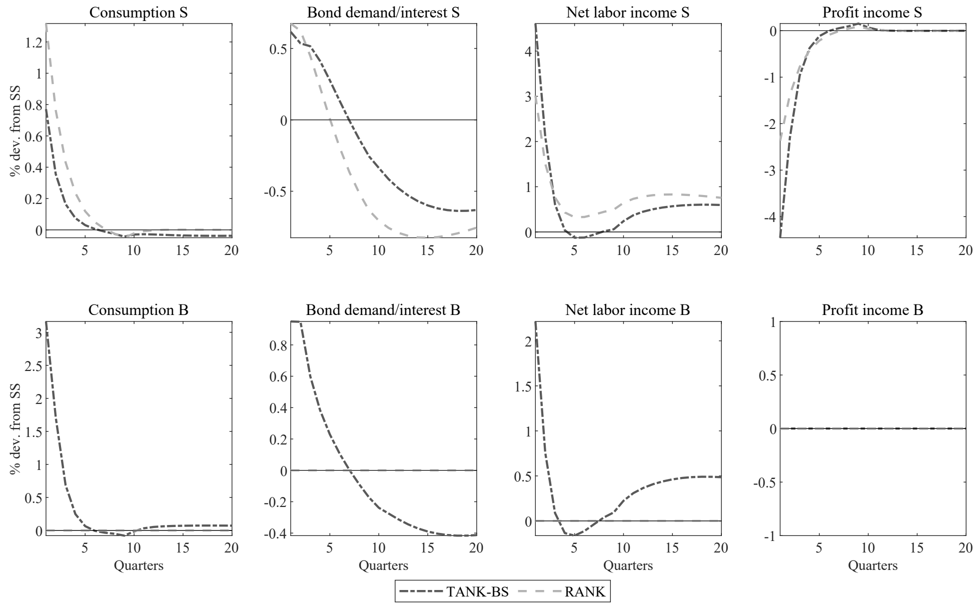
B.4 QE at the ZLB: RANK vs. TANK-BS

Figure B.6: Impulse responses to a QE shock at the ZLB: RANK vs. TANK-BS



Notes: This figure depicts the impulse responses to a QE shock net of a negative preference shock when the ZLB on the policy rate is binding, for the borrower-saver model (TANK-BS, dash-dotted gray line) and its representative-agent counterpart with $\lambda = 0$ (RANK, dashed light gray line). The shock for each simulation is an asset purchase of size 1% of annualized GDP. Responses for individual consumption levels and hours are weighted by population shares of savers (S) and borrowers (B), respectively.

Figure B.7: Household budget components after a QE shock at the ZLB: RANK vs. TANK-BS



Notes: This figure shows grouped components of the budget constraints of savers (top) and borrowers (bottom) in response to a QE shock net of a negative preference shock when the ZLB on the policy rate is binding, for the borrower-saver model (TANK-BS, dash-dotted gray line) and its representative-agent counterpart with $\lambda = 0$ (RANK, dashed light gray line). The shock for each simulation is an asset purchase of size 1% of annualized GDP. Each panel consists of four columns, containing the responses of individual consumption, bond-related variables (bond demand, interest payments/income, net of adjustment cost), labor income net of taxes, and income from profits. All responses are shown in per-capita terms.

C Robustness checks

This appendix addresses the robustness of our baseline results. It provides the *impact multipliers* (Appendix C.1) and the *impulse responses* (Appendix C.2) both for alternative parameterization choices in the baseline model and for a number of different fiscal and monetary policy rules. Moreover, it contains sensitivity checks on the model's *stability and determinacy* properties under these specifications (Appendix C.3).

Below are the different robustness checks we considered, along with references to the corresponding impulse responses. The baseline calibration values are highlighted in bold. Tables C.1 and C.2 provide the impact multipliers for each specification.

- Alternative parameter values for the tax on profits, namely $\tau^D = \{\mathbf{0}, 0.2, 0.35\}$ (see Figures C.1 to C.4). Taxing dividends at rate $\tau^D = \lambda = 0.35$ corresponds to the case of full profit redistribution.

- Alternative parameter values for the portfolio adjustment cost, namely $\nu = \{0.04, \mathbf{0.05}, 0.06\}$ (see Figures C.5 to C.8).

- A fiscal rule as implemented in the baseline model, where taxes respond to past tax revenues, total debt, and government spending:

$$\frac{t_t}{t} = \left(\frac{t_{t-1}}{t}\right)^{\rho^{\tau,t}} \left(\frac{b_t + b_t^L}{b + b^L}\right)^{\rho^{\tau,b}} \left(\frac{g_t}{g}\right)^{\rho^{\tau,g}} .$$

  We run separate robustness checks for the tax smoothing parameter $\rho^{\tau,t} = \{0, 0.4, \mathbf{0.7}\}$ (see Figures C.9 to C.12)[1] and for the tax response to total debt $\rho^{\tau,b} = \{0.1, \mathbf{0.33}, 0.9\}$ (see Figures C.13 to C.16).[2]

- A different fiscal setup where government spending reacts to total debt and real output, while taxes only react to total debt:

$$\frac{g_t}{g} = \left(\frac{b_t + b_t^L}{b + b^L}\right)^{\rho^{g,b}} \left(\frac{y_t}{y}\right)^{\rho^{g,y}} \quad \text{and} \quad \frac{t_t}{t} = \left(\frac{b_t + b_t^L}{b + b^L}\right)^{\rho^{\tau,b}} .$$

  This setup mirrors the exercise in Cui (2016). Figures C.17 to C.20 present the sensitivity checks for each pair $\left(\rho^{g,b}, \rho^{g,y}\right) = \{(\mathbf{0,0}), (-0.3, -0.2), (-0.9, -0.5)\}$. The selected values are either close to the optimal policy exercise parameters in Cui (2016) or chosen such that there is a larger spread between them.

- A different rule governing long-term debt based on its past value, taxes, and real output:

$$\frac{b_t^L}{b^L} = \left(\frac{b_{t-1}^L}{b^L}\right)^{\rho^{bL,b}} \left(\frac{t_t}{t}\right)^{\rho^{bL,t}} \left(\frac{y_t}{y}\right)^{\rho^{bL,y}} .$$

[1] The computational algorithm from the dynareOBC toolkit, used to implement the ZLB, was unable to find a solution for values of $\rho^{\tau,t}$ close to one for all simulations, which is why 0.7 is set as the upper bound for tax persistence.

[2] Since government spending follows an AR(1) process, we refrained from testing robustness regarding $\rho^{\tau,g}$.

This specification relaxes the constant-debt assumption for the long-term asset while short-term debt supply remains non-constant. Figures C.21 to C.24 show the robustness checks for each pair $\left(\rho^{bL,t}, \rho^{bL,y}\right) = \{(\mathbf{0,0}), (-0.2, -0.3), (-0.5, -0.9)\}$, whereby $\rho^{bL,b} = 0.9$. The selected values are mirror those of the previous specification, with an extreme parameterization included. Motivated by empirical evidence in Anzoategui (2022), we assign a larger weight to output.

- An extended Taylor rule where the nominal short-term interest rate not only reacts to inflation but also to output:

$$\log\left(\frac{R_t}{R}\right) = \rho_r \log\left(\frac{R_{t-1}}{R}\right) + (1-\rho_r)\left[\phi_\pi \log\left(\frac{\Pi_t}{\Pi}\right) + \phi_y \log\left(\frac{y_t}{y}\right)\right] + \varepsilon_t^m \,.$$

  Figures C.25 to C.28 depict the sensitivity checks for $\phi_y = \{\mathbf{0}, 0.4, 0.8\}$.

C.1 Multipliers on impact of a QE or QT shock: Sensitivity analysis

The following tables present the impact multipliers of the TANK-BS and RANK models for different robustness checks. Starting from the baseline calibration with $\tau^D = 0$, $\nu = 0.05$, $\rho^{\tau,t} = 0.7$, and $\rho^{\tau,b} = 0.33$, each row of Table C.1 changes one parameter value from the baseline model at a time. Table C.2 presents the impact multipliers under the various policy rules considered, where the baseline values are $\rho^{g,b} = \rho^{g,y} = \rho^{bL,t} = \rho^{bL,y} = \phi_y = 0$.

Table C.1: Impact multipliers (in %): Sensitivity in baseline TANK-BS model

	Output		**Inflation**		**Consumption**	
	QE	QT	QE	QT	QE	QT
TANK-BS						
Baseline	1.29	-0.42	0.71	-0.24	1.61	-0.53
(i) Tax on profits						
$\tau^D = 0.2$	0.81	-0.31	0.52	-0.20	1.02	-0.38
$\tau^D = 0.35$	0.63	-0.26	0.43	-0.18	0.79	-0.32
(ii) Portfolio adjustment cost						
$\nu = 0.04$	1.05	-0.34	0.58	-0.19	1.31	-0.43
$\nu = 0.06$	1.51	-0.50	0.84	-0.29	1.89	-0.63
(iii) Tax smoothing						
$\rho^{\tau,t} = 0$	1.32	-0.41	0.75	-0.26	1.65	-0.52
$\rho^{\tau,t} = 0.4$	1.32	-0.42	0.74	-0.25	1.64	-0.52
(iv) Tax response to debt						
$\rho^{\tau,b} = 0.1$	1.34	-0.44	0.75	-0.26	1.67	-0.55
$\rho^{\tau,b} = 0.9$	1.26	-0.39	0.70	-0.20	1.58	-0.48
RANK						
Baseline	1.05	-0.44	0.70	-0.32	1.32	-0.56
(i) Tax on profits						
$\tau^D = 0.2$	0.88	-0.39	0.62	-0.29	1.10	-0.49
$\tau^D = 0.35$	0.78	-0.36	0.57	-0.28	0.98	-0.45
(ii) Portfolio adjustment cost						
$\nu = 0.04$	0.90	-0.36	0.60	-0.26	1.12	-0.45
$\nu = 0.06$	1.20	-0.53	0.79	-0.37	1.50	-0.66
(iii) Tax smoothing						
$\rho^{\tau,t} = 0$	0.98	-0.45	0.64	-0.32	1.23	-0.56
$\rho^{\tau,t} = 0.4$	1.00	-0.45	0.66	-0.32	1.26	-0.56
(iv) Tax response to debt						
$\rho^{\tau,b} = 0.1$	0.98	-0.45	0.64	-0.32	1.22	-0.56
$\rho^{\tau,b} = 0.9$	1.18	-0.44	0.81	-0.31	1.48	-0.55

Notes: This table summarizes the aggregate effects for alternative parameter values in the baseline borrower-saver model (TANK-BS) and its representative-agent counterpart with $\lambda = 0$ (RANK), on impact of a QE shock when the ZLB on the policy rate is binding and on impact of a QT shock occurring far enough above the ZLB. The shock for each simulation is an asset purchase/sale of size 1% of annualized GDP.

Table C.2: Impact multipliers (in %): Sensitivity for alternative policy rules

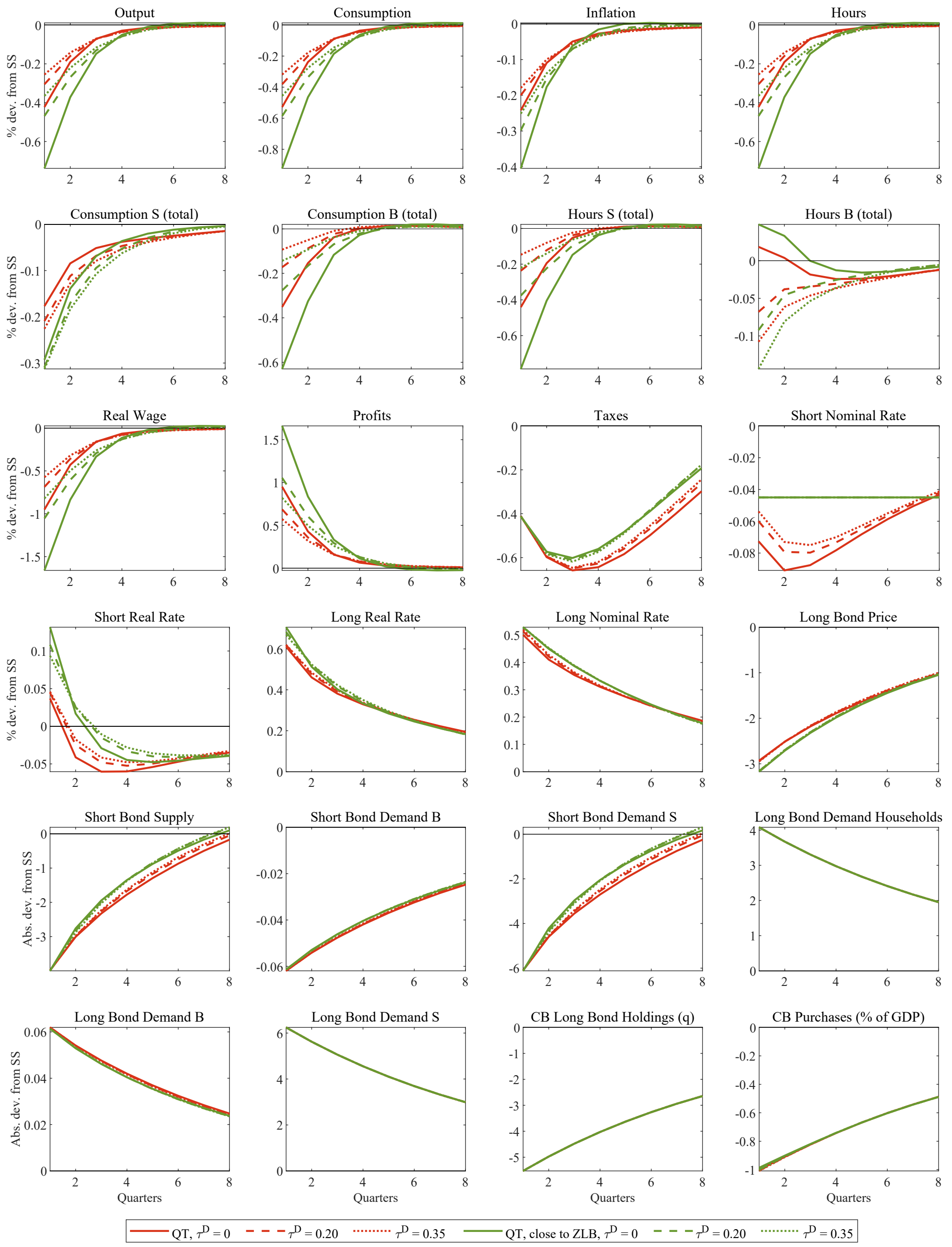
	Output		**Inflation**		**Consumption**	
	QE	QT	QE	QT	QE	QT
TANK-BS						
Baseline	1.29	-0.42	0.71	-0.24	1.61	-0.53
(v) Government spending response to debt and output						
$\rho^{g,b}=-0.3$, $\rho^{g,y}=-0.2$	1.06	-0.30	0.66	-0.22	1.47	-0.48
$\rho^{g,b}=-0.9$, $\rho^{g,y}=-0.5$	0.73	-0.10	0.56	-0.16	1.27	-0.41
(vi) Long-term debt response to taxes and output						
$\rho^{bL,t}=-0.2$, $\rho^{bL,y}=-0.3$	1.42	-0.46	0.79	-0.27	1.78	-0.57
$\rho^{bL,t}=-0.5$, $\rho^{bL,y}=-0.9$	1.49	-0.52	0.82	-0.32	1.87	-0.65
(vii) Taylor rule output coefficient						
$\phi_y=0.4$	1.06	-0.31	0.57	-0.17	1.32	-0.38
$\phi_y=0.8$	0.92	-0.24	0.48	-0.13	1.16	-0.31
RANK						
Baseline	1.05	-0.44	0.70	-0.32	1.32	-0.56
(v) Government spending response to debt and output						
$\rho^{g,b}=-0.3$, $\rho^{g,y}=-0.2$	0.88	-0.37	0.63	-0.30	1.23	-0.57
$\rho^{g,b}=-0.9$, $\rho^{g,y}=-0.5$	0.74	-0.23	0.63	-0.27	1.28	-0.58
(vi) Long-term debt response to taxes and output						
$\rho^{bL,t}=-0.2$, $\rho^{bL,y}=-0.3$	0.97	-0.48	0.62	-0.34	1.22	-0.60
$\rho^{bL,t}=-0.5$, $\rho^{bL,y}=-0.9$	0.85	-0.53	0.50	-0.38	1.06	-0.67
(vii) Taylor rule output coefficient						
$\phi_y=0.4$	0.98	-0.35	0.64	-0.25	1.23	-0.44
$\phi_y=0.8$	0.92	-0.29	0.59	-0.20	1.15	-0.36

Notes: This table summarizes the aggregate effects for different parameter values in the borrower-saver model under alternative policy rules (TANK-BS) and its representative-agent counterpart with $\lambda=0$ (RANK), on impact of a QE shock when the ZLB on the policy rate is binding and on impact of a QT shock occurring far enough above the ZLB. The shock for each simulation is an asset purchase/sale of size 1% of annualized GDP.

C.2 Impulse responses: Sensitivity analysis

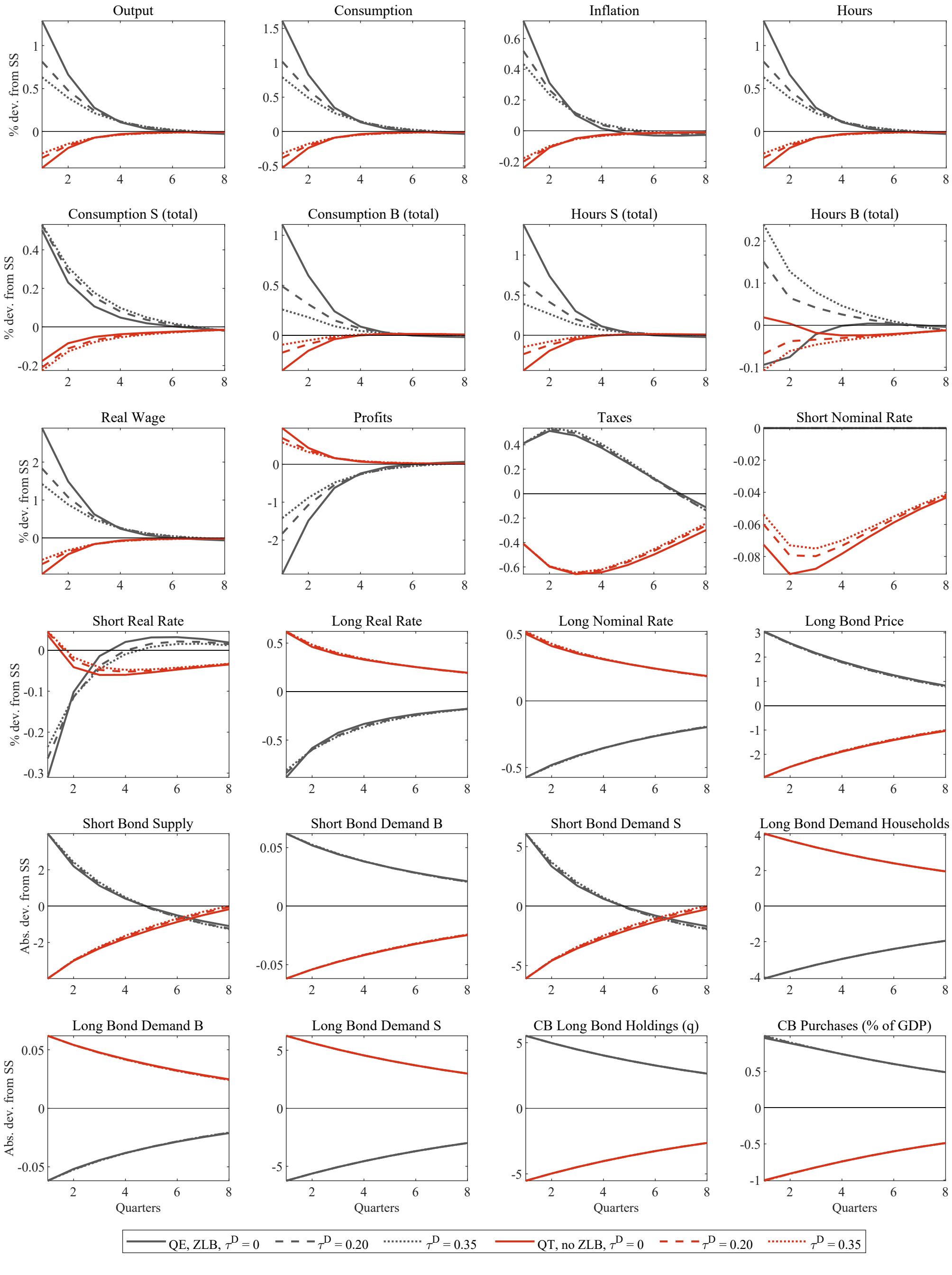
C.2.1 Tax on profits τ^D

Figure C.1: Impulse responses to a QT shock and a QT shock near the ZLB: Robustness for tax on profits τ^D



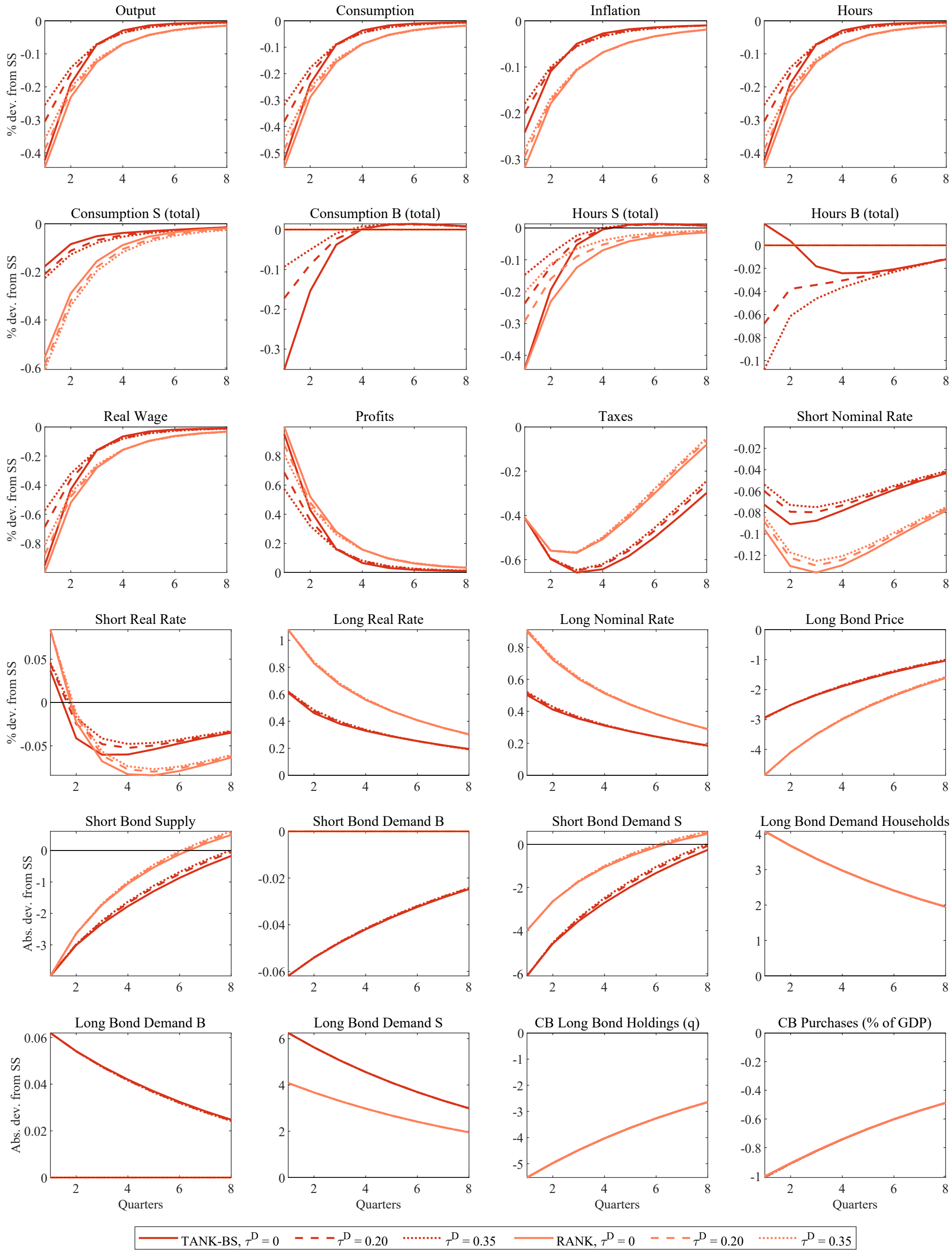
Notes: This figure depicts the impulse responses to a QT shock occurring far enough above the ZLB (red lines) and a QT shock happening close to the ZLB (green lines). The shock for each simulation is an asset purchase/sale of size 1% of annualized GDP. Responses for individual consumption levels and hours are weighted by population shares of savers (S) and borrowers (B), respectively.

Figure C.2: Impulse responses to a QE shock at the ZLB and a QT shock off the ZLB: Robustness for tax on profits τ^D



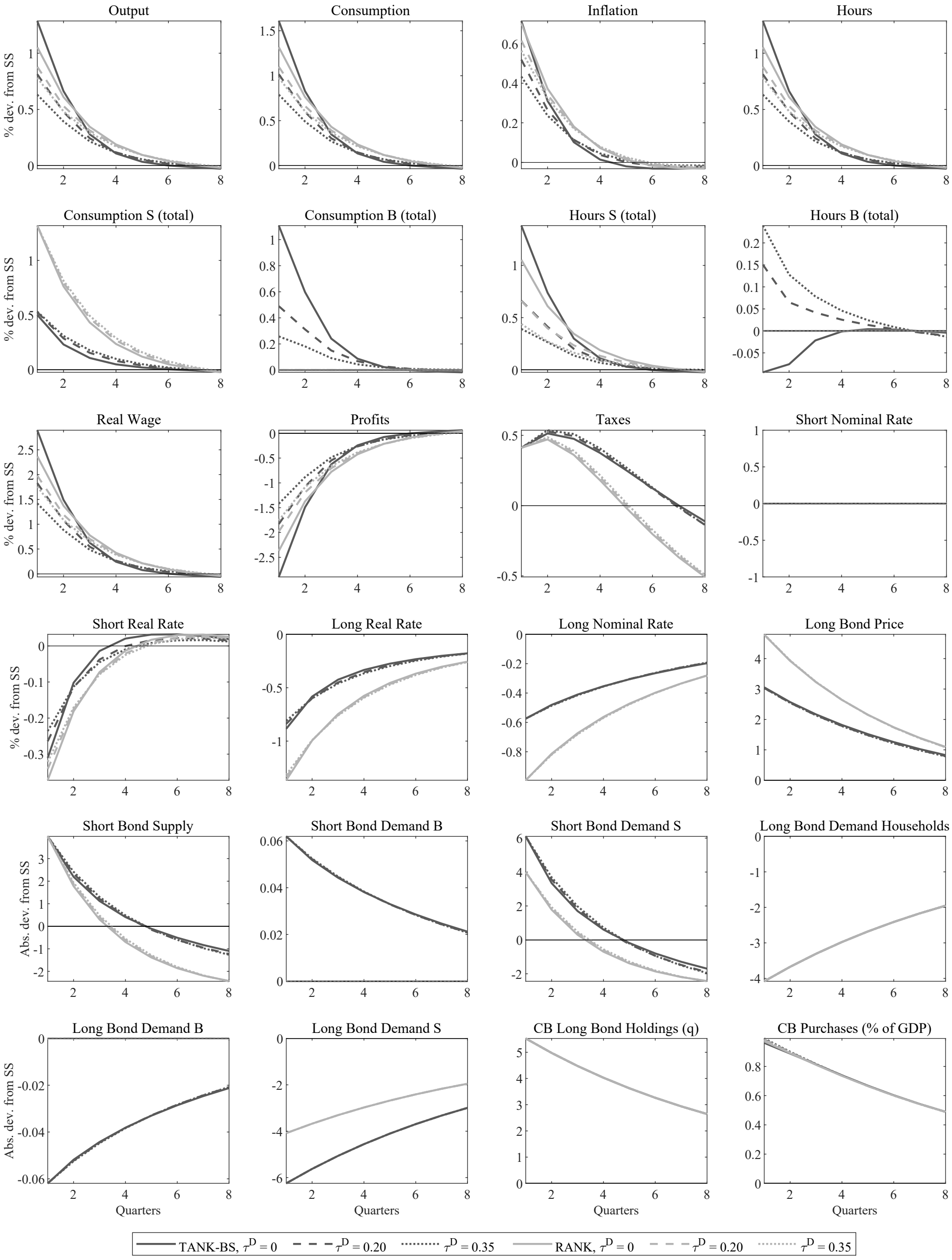
Notes: This figure depicts the impulse responses to a QE shock when the ZLB on the policy rate is binding (gray lines, showing the impact of QE net of a preference shock), and a QT shock occurring far enough above the ZLB (red lines). The shock for each simulation is an asset purchase/sale of size 1% of annualized GDP. Responses for individual consumption levels and hours are weighted by population shares of savers (S) and borrowers (B), respectively.

Figure C.3: Impulse responses to a QT shock off the ZLB: RANK vs. TANK-BS: Robustness for tax on profits τ^D



Notes: This figure depicts the impulse responses to a QT shock occurring far enough above the ZLB, for the borrower-saver model (TANK-BS, red lines) and its representative-agent counterpart with $\lambda = 0$ (RANK, light red lines). The shock for each simulation is an asset sale of size 1% of annualized GDP. Responses for individual consumption levels and hours are weighted by population shares of savers (S) and borrowers (B), respectively.

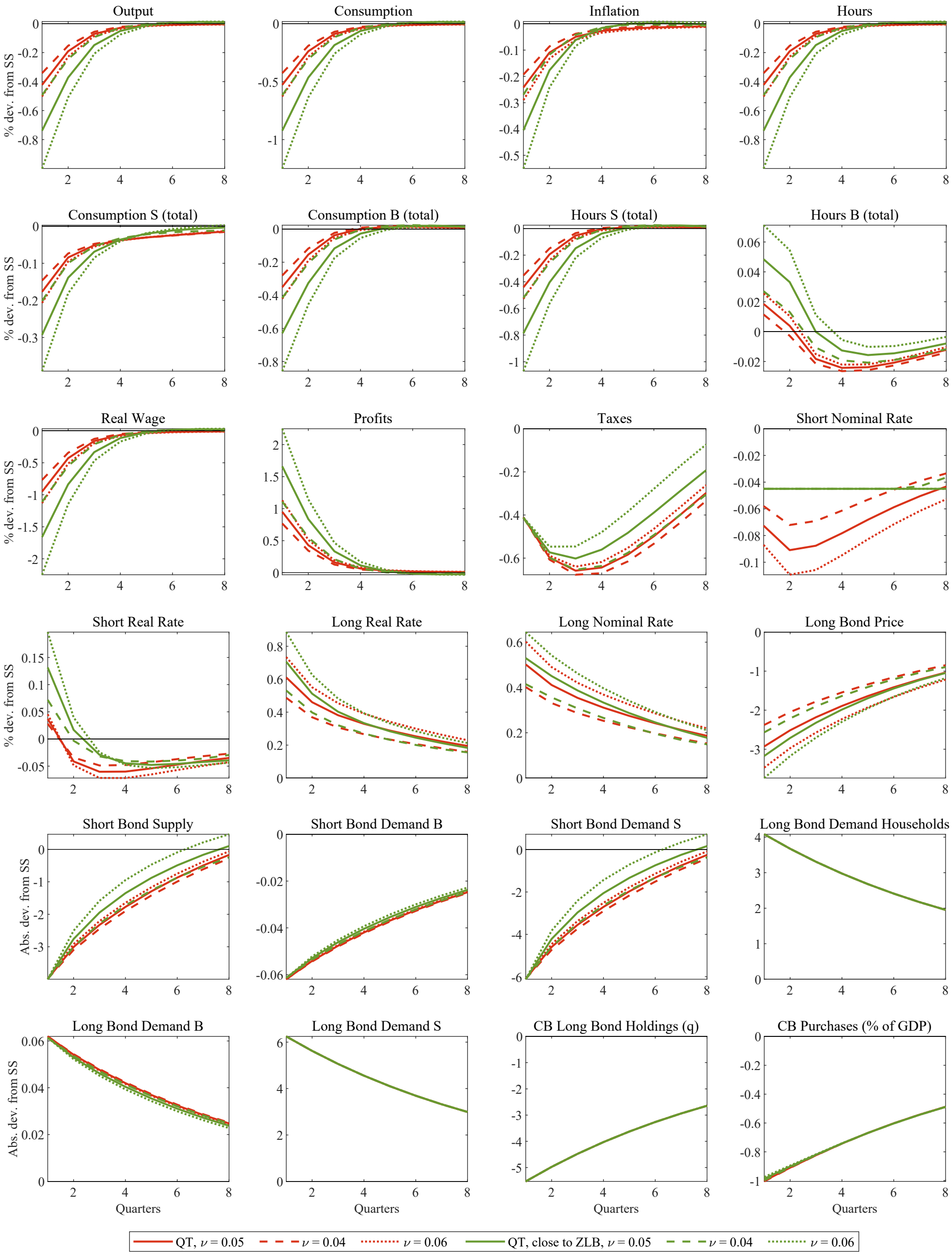
Figure C.4: Impulse responses to a QE shock at the ZLB: RANK vs. TANK-BS: Robustness for tax on profits τ^D



Notes: This figure depicts the impulse responses to a QE shock net of a negative preference shock when the ZLB on the policy rate is binding, for the borrower-saver model (TANK-BS, gray lines) and its representative-agent counterpart with $\lambda = 0$ (RANK, light gray lines). The shock for each simulation is an asset purchase of size 1% of annualized GDP. Responses for individual consumption levels and hours are weighted by population shares of savers (S) and borrowers (B), respectively.

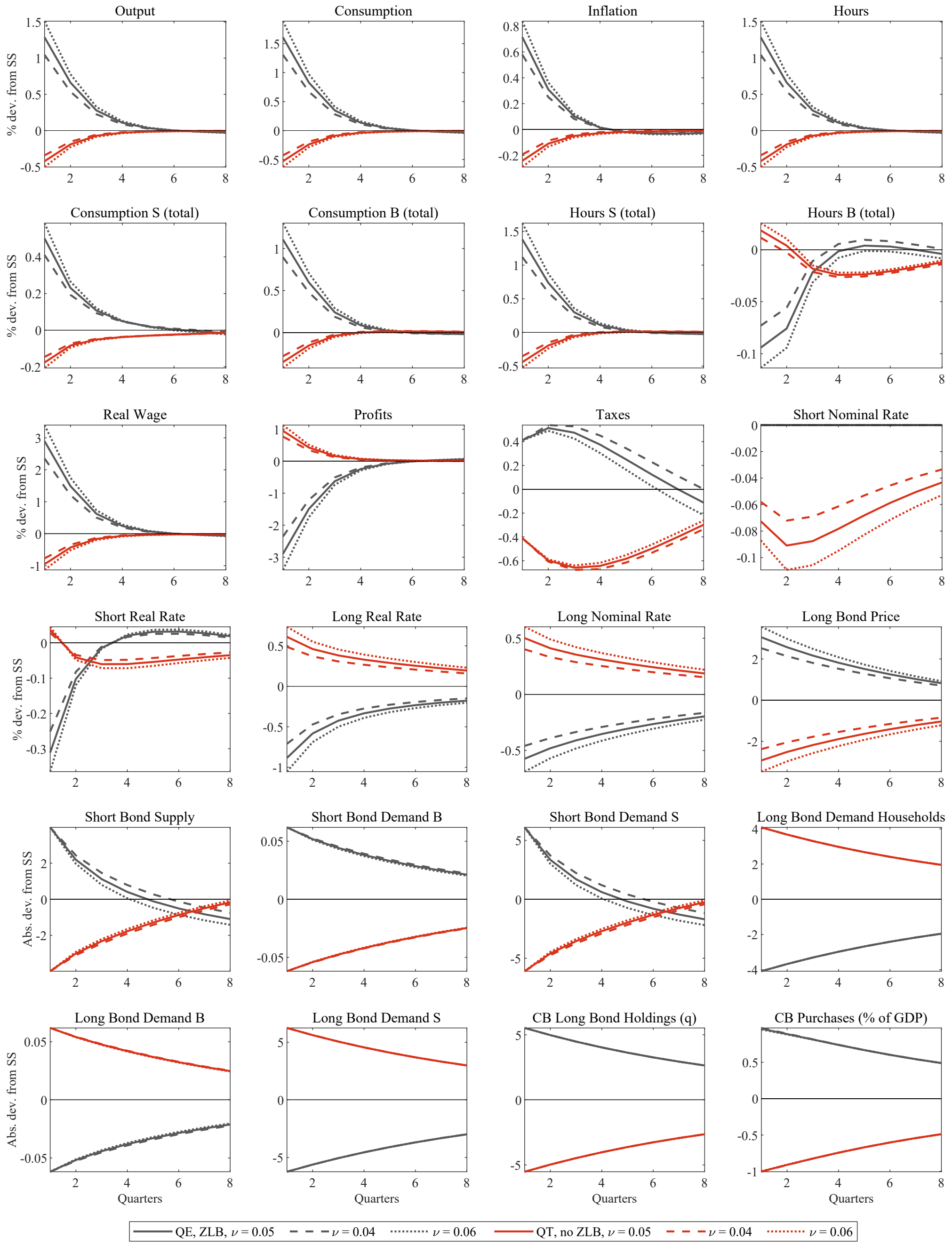
C.2.2 Portfolio adjustment cost ν

Figure C.5: Impulse responses to a QT shock and a QT shock near the ZLB: Robustness for portfolio adjustment cost ν



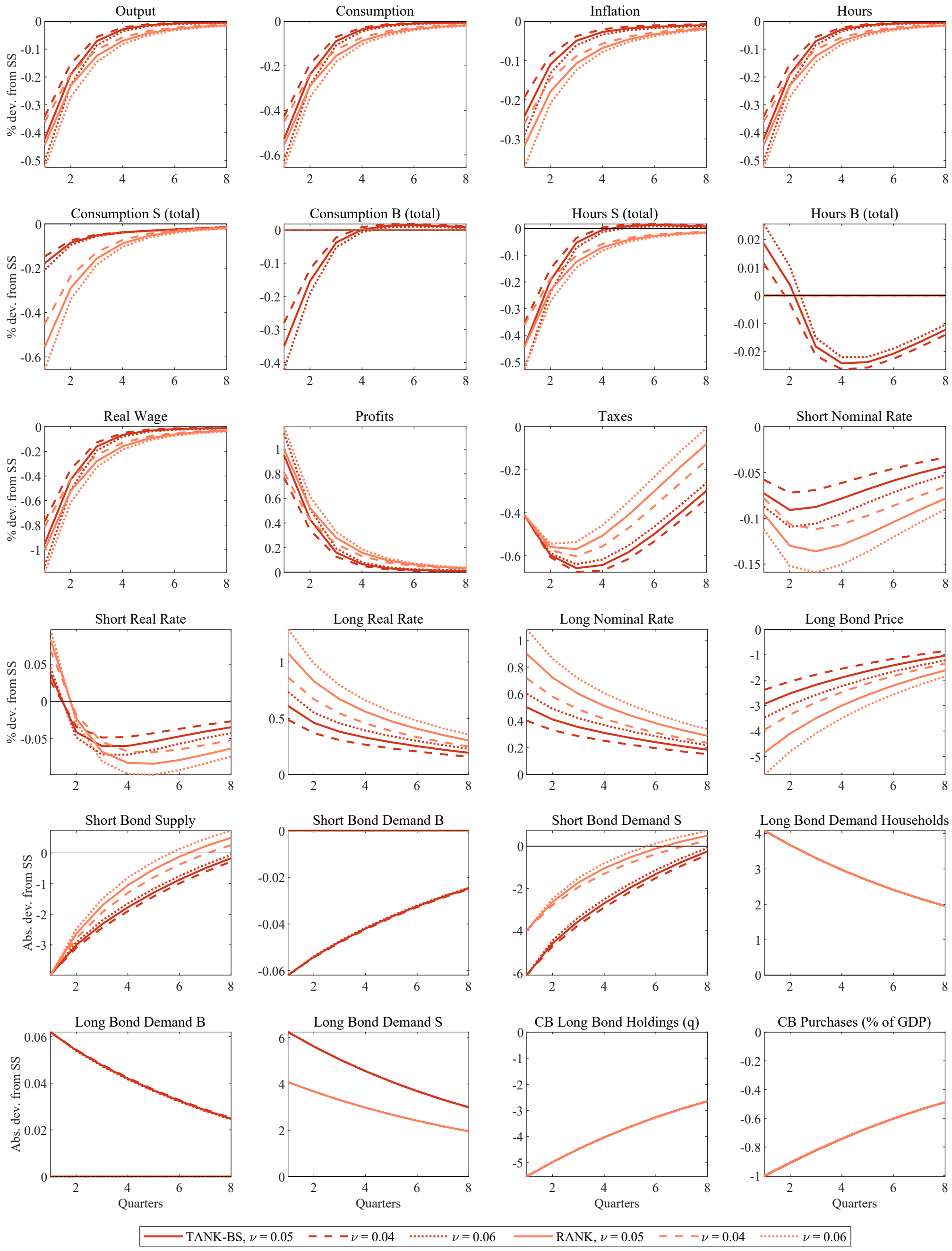
Notes: This figure depicts the impulse responses to a QT shock occurring far enough above the ZLB (red lines) and a QT shock happening close to the ZLB (green lines). The shock for each simulation is an asset purchase/sale of size 1% of annualized GDP. Responses for individual consumption levels and hours are weighted by population shares of savers (S) and borrowers (B), respectively.

Figure C.6: Impulse responses to a QE shock at the ZLB and a QT shock off the ZLB: Robustness for portfolio adjustment cost ν



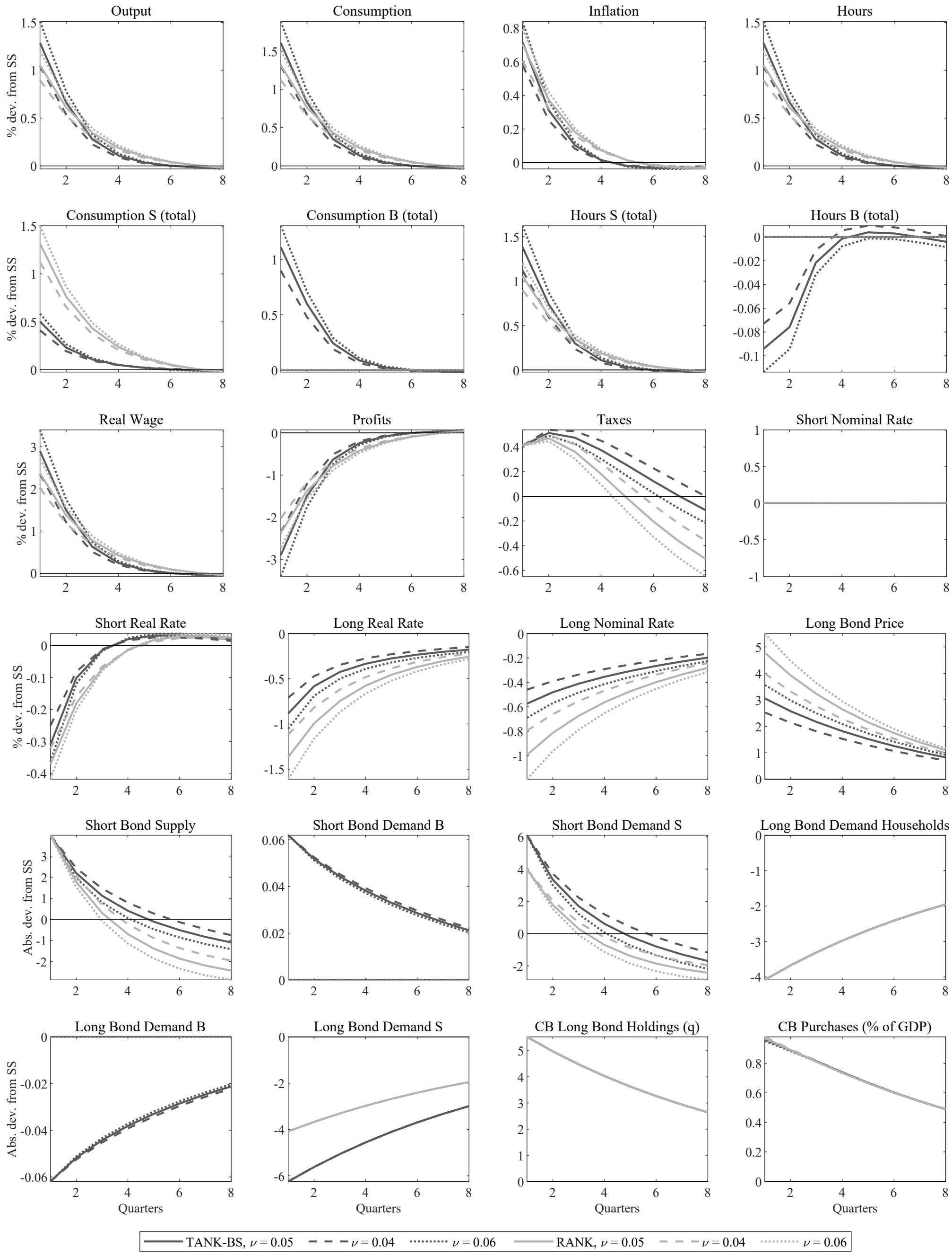
Notes: This figure depicts the impulse responses to a QE shock when the ZLB on the policy rate is binding (gray lines, showing the impact of QE net of a preference shock), and a QT shock occurring far enough above the ZLB (red lines). The shock for each simulation is an asset purchase/sale of size 1% of annualized GDP. Responses for individual consumption levels and hours are weighted by population shares of savers (S) and borrowers (B), respectively.

Figure C.7: Impulse responses to a QT shock off the ZLB: RANK vs. TANK-BS: Robustness for portfolio adjustment cost ν



Notes: This figure depicts the impulse responses to a QT shock occurring far enough above the ZLB, for the borrower-saver model (TANK-BS, red lines) and its representative-agent counterpart with $\lambda = 0$ (RANK, light red lines). The shock for each simulation is an asset sale of size 1% of annualized GDP. Responses for individual consumption levels and hours are weighted by population shares of savers (S) and borrowers (B), respectively.

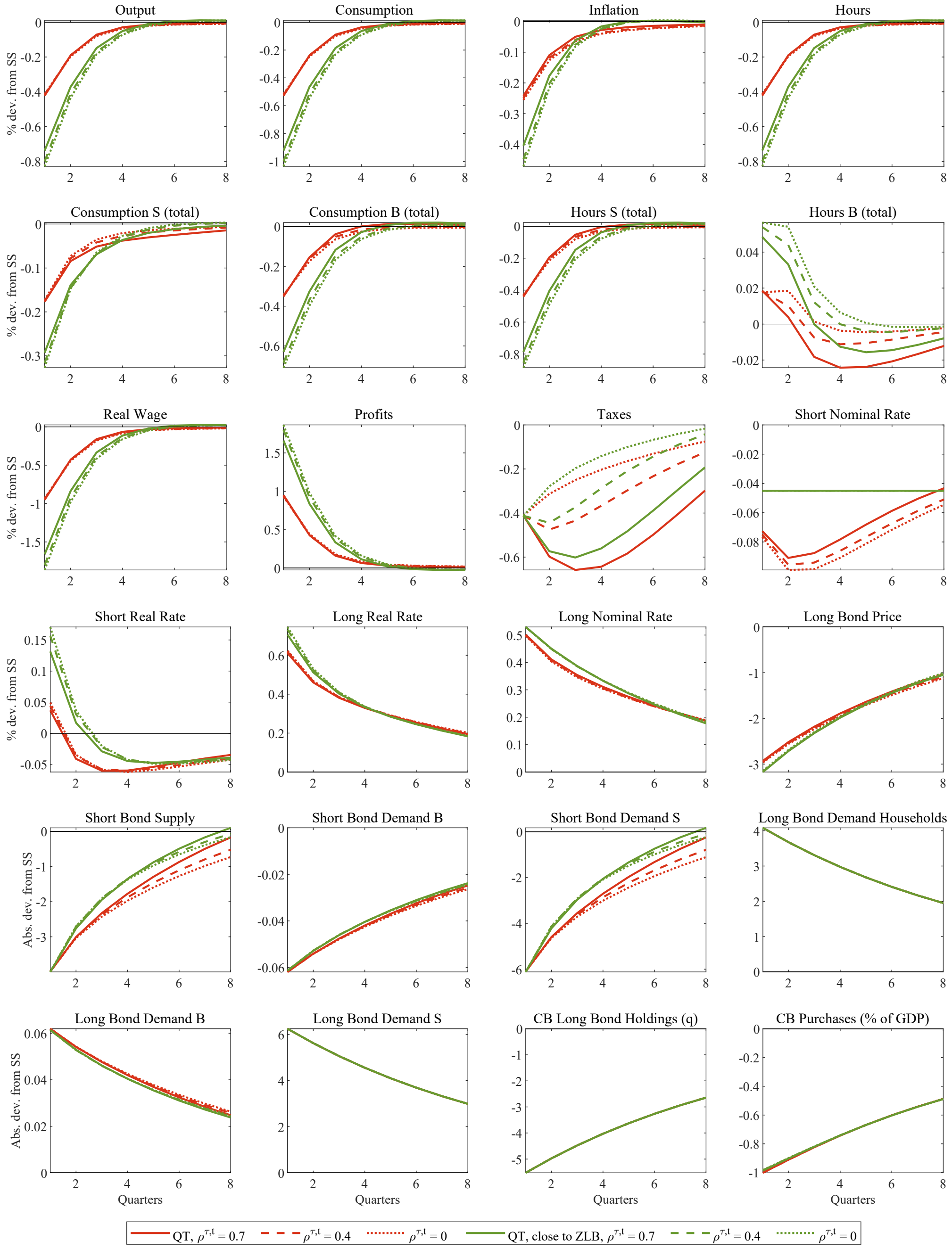
Figure C.8: Impulse responses to a QE shock at the ZLB: RANK vs. TANK-BS: Robustness for portfolio adjustment cost ν



Notes: This figure depicts the impulse responses to a QE shock net of a negative preference shock when the ZLB on the policy rate is binding, for the borrower-saver model (TANK-BS, gray lines) and its representative-agent counterpart with $\lambda = 0$ (RANK, light gray lines). The shock for each simulation is an asset purchase of size 1% of annualized GDP. Responses for individual consumption levels and hours are weighted by population shares of savers (S) and borrowers (B), respectively.

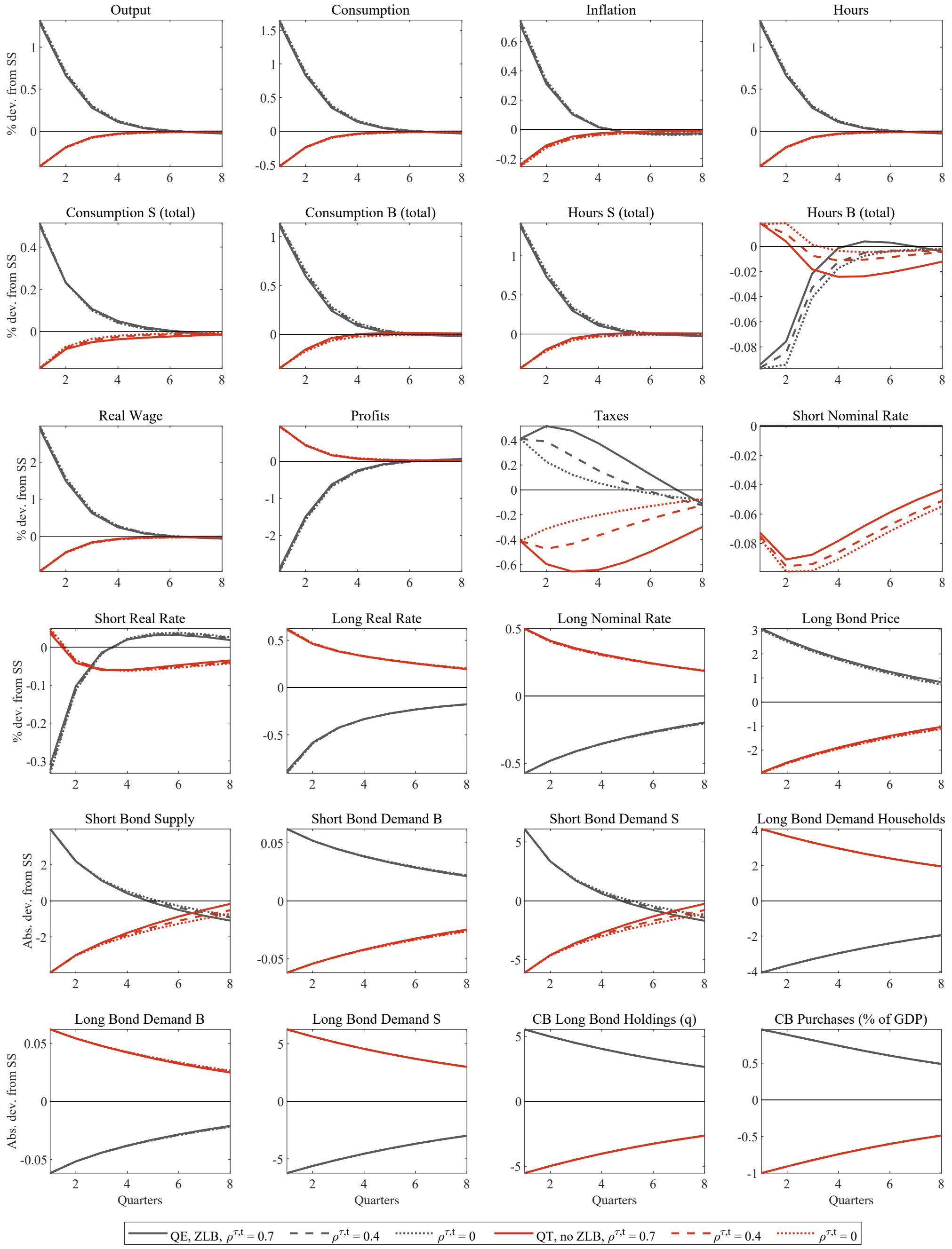
C.2.3 Tax smoothing in fiscal rule $\rho^{\tau,t}$

Figure C.9: Impulse responses to a QT shock off and a QT shock near the ZLB: Robustness for tax smoothing parameter $\rho^{\tau,t}$



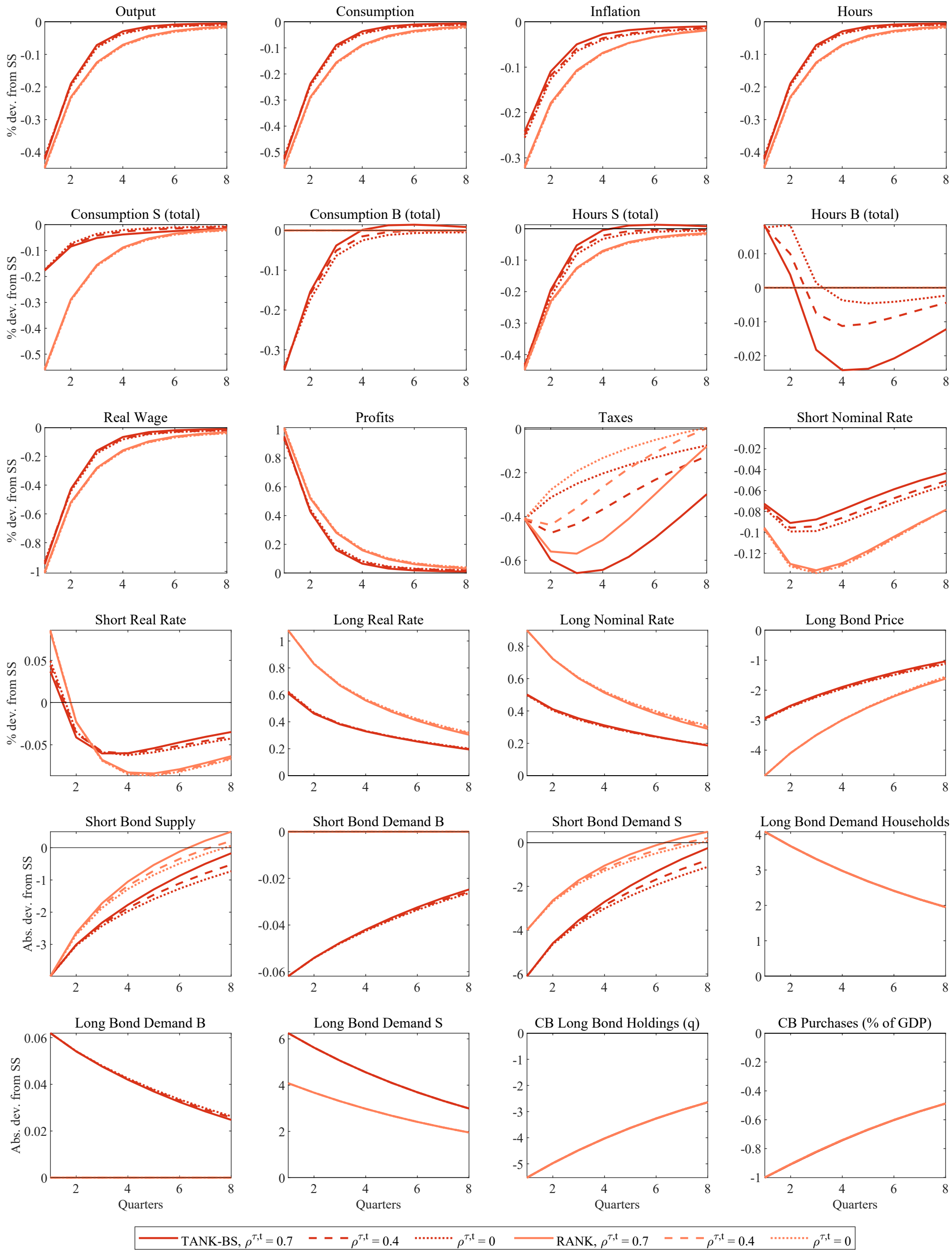
Notes: This figure depicts the impulse responses for the baseline borrower-saver model to a QT shock occurring far enough above the ZLB (red lines) and a QT shock happening close to the ZLB (green lines). The shock for each simulation is an asset purchase/sale of size 1% of annualized GDP. Responses for individual consumption levels and hours are weighted by population shares of savers (S) and borrowers (B), respectively.

Figure C.10: Impulse responses to a QE shock at the ZLB and a QT shock off the ZLB: Robustness for tax smoothing parameter $\rho^{\tau,t}$



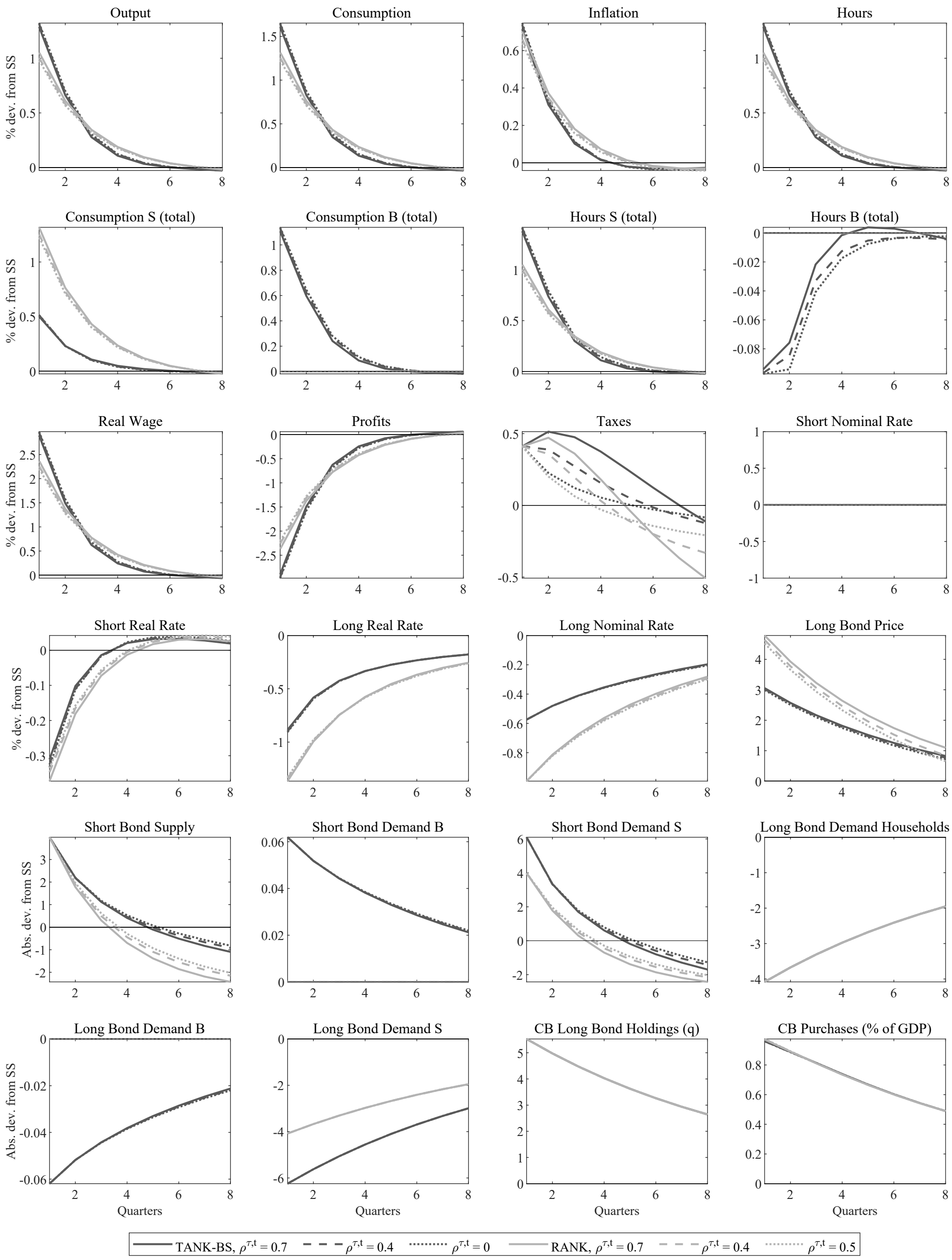
Notes: This figure depicts the impulse responses for the baseline borrower-saver model to a QE shock when the ZLB on the policy rate is binding (gray lines, showing the impact of QE net of a preference shock), and a QT shock occurring far enough above the ZLB (red lines). The shock for each simulation is an asset purchase/sale of size 1% of annualized GDP. Responses for individual consumption levels and hours are weighted by population shares of savers (S) and borrowers (B), respectively.

Figure C.11: Impulse responses to a QT shock off the ZLB: Robustness for tax smoothing parameter $\rho^{\tau,t}$ in RANK vs. TANK-BS



Notes: This figure depicts the impulse responses to a QT shock occurring far enough above the ZLB, for the basline borrower-saver model (TANK-BS, red lines) and its representative-agent counterpart with $\lambda = 0$ (RANK, light red lines). The shock for each simulation is an asset sale of size 1% of annualized GDP. Responses for individual consumption levels and hours are weighted by population shares of savers (S) and borrowers (B), respectively.

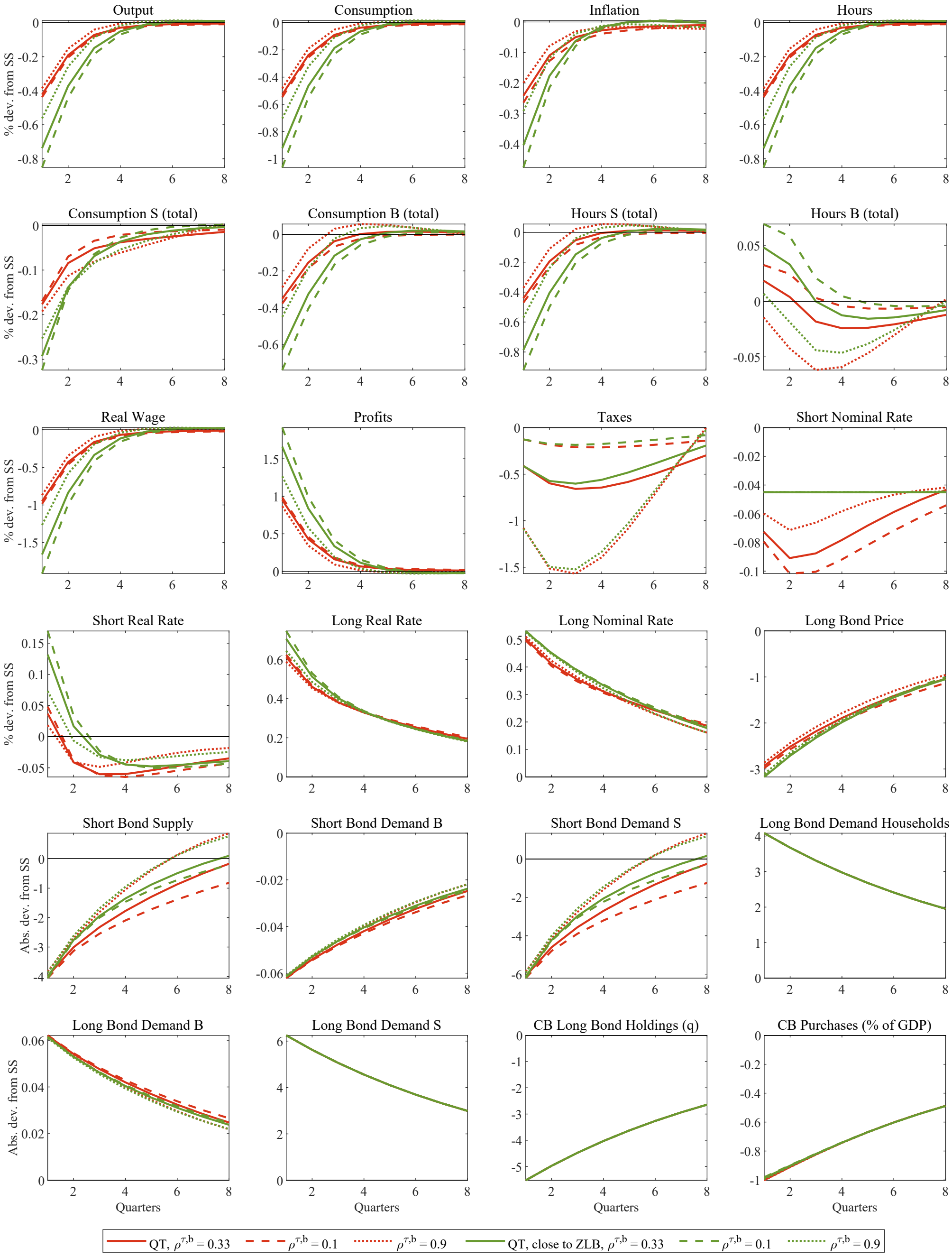
Figure C.12: Impulse responses to a QE shock at the ZLB: Robustness for tax smoothing parameter $\rho^{\tau,t}$ in RANK vs. TANK-BS



Notes: This figure depicts the impulse responses to a QE shock net of a negative preference shock when the ZLB on the policy rate is binding, for the baseline borrower-saver model (TANK-BS, gray lines) and its representative-agent counterpart with $\lambda = 0$ (RANK, light gray lines). The shock for each simulation is an asset purchase of size 1% of annualized GDP. Responses for individual consumption levels and hours are weighted by population shares of savers (S) and borrowers (B), respectively.

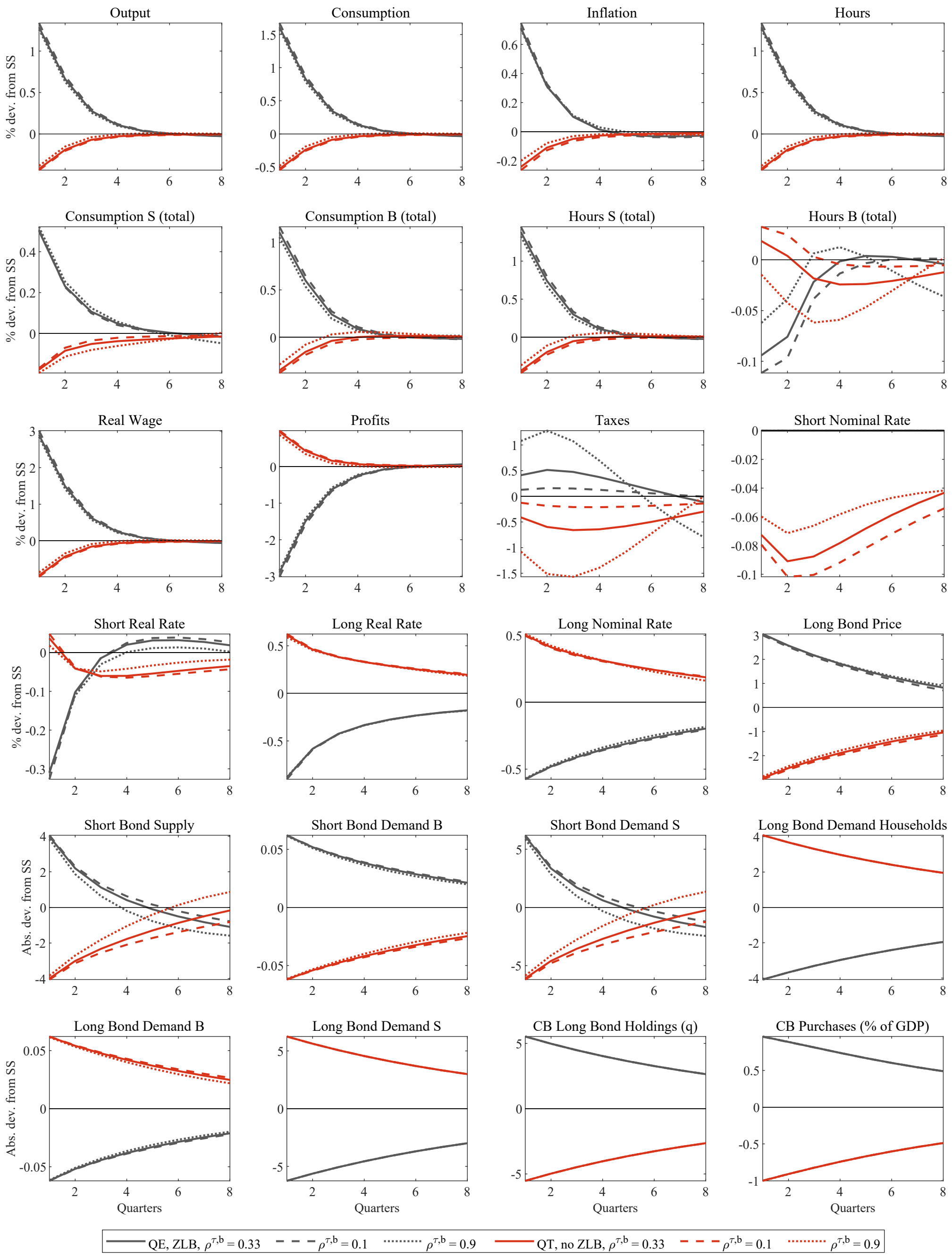
C.2.4 Tax response to total debt $\rho^{\tau,b}$

Figure C.13: Impulse responses to a QT shock off and a QT shock near the ZLB: Robustness for tax response to debt $\rho^{\tau,b}$



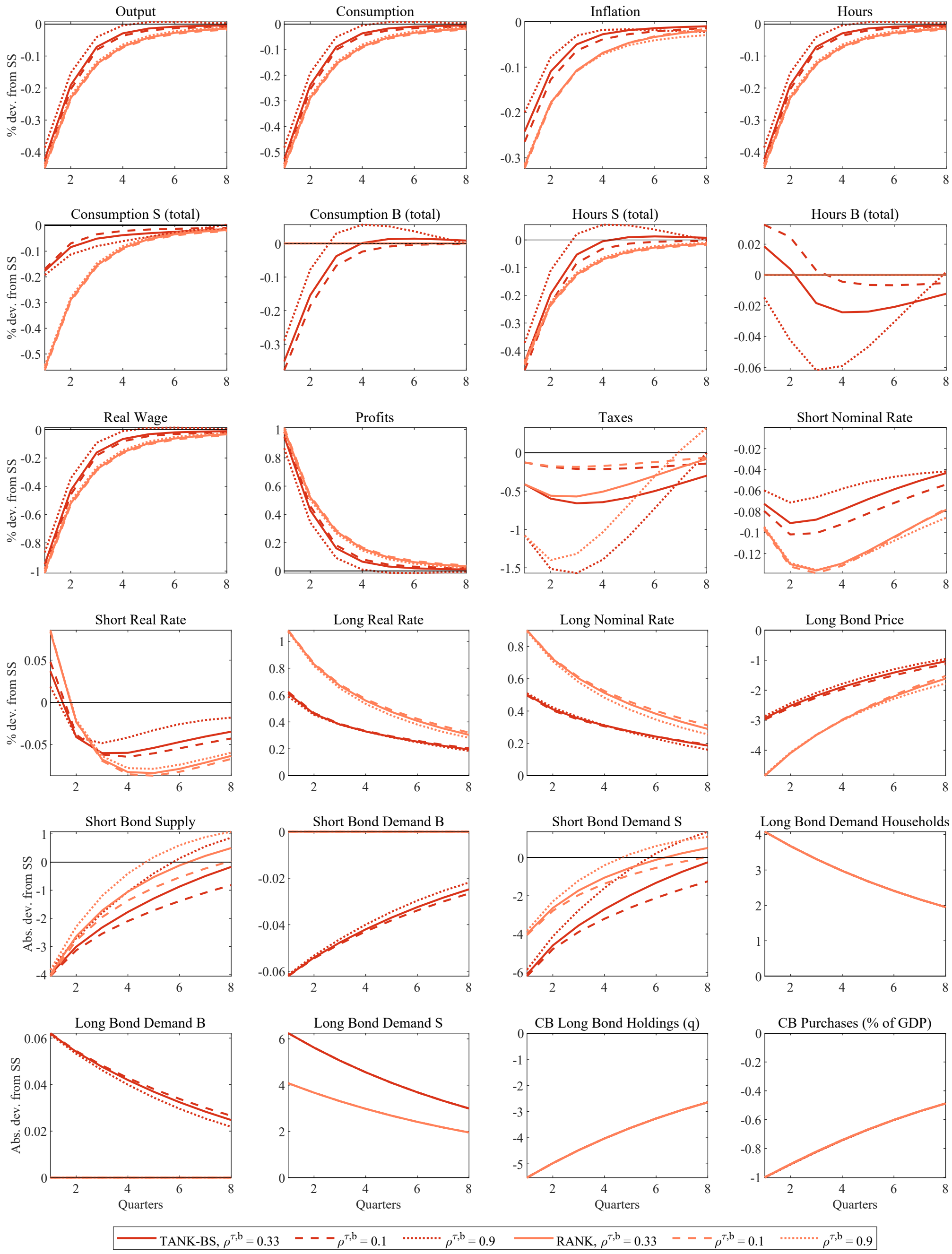
Notes: This figure depicts the impulse responses for the baseline borrower-saver model to a QT shock occurring far enough above the ZLB (red lines) and a QT shock happening close to the ZLB (green lines). The shock for each simulation is an asset purchase/sale of size 1% of annualized GDP. Responses for individual consumption levels and hours are weighted by population shares of savers (S) and borrowers (B), respectively.

Figure C.14: Impulse responses to a QE shock at the ZLB and a QT shock off the ZLB: Robustness for tax response to debt $\rho^{\tau,b}$



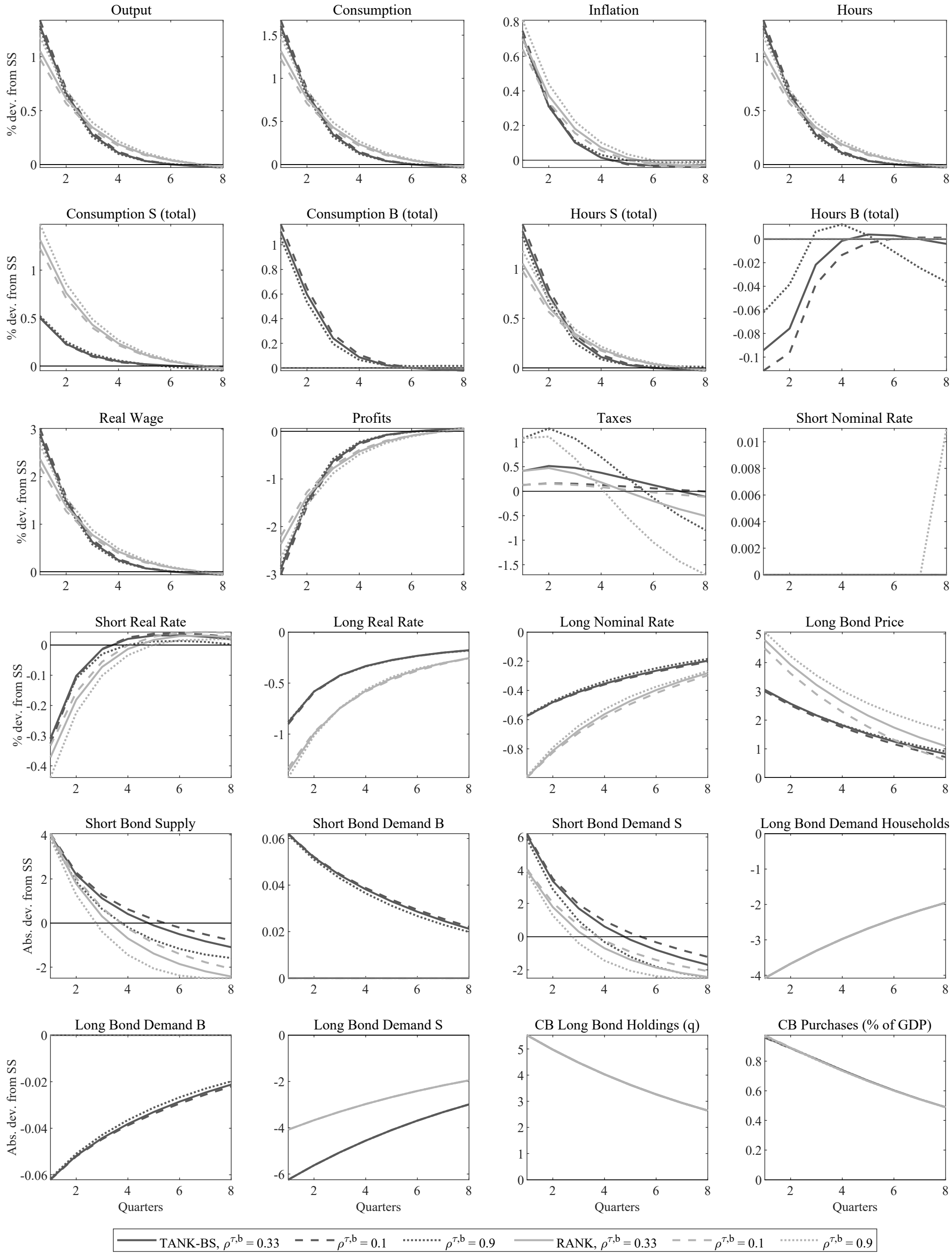
Notes: This figure depicts the impulse responses for the baseline borrower-saver model to a QE shock when the ZLB on the policy rate is binding (gray lines, showing the impact of QE net of a preference shock), and a QT shock occurring far enough above the ZLB (red lines). The shock for each simulation is an asset purchase/sale of size 1% of annualized GDP. Responses for individual consumption levels and hours are weighted by population shares of savers (S) and borrowers (B), respectively.

Figure C.15: Impulse responses to a QT shock off the ZLB: Robustness for tax response to debt $\rho^{\tau,b}$ in RANK vs. TANK-BS



Notes: This figure depicts the impulse responses to a QT shock occurring far enough above the ZLB, for the baseline borrower-saver model (TANK-BS, red lines) and its representative-agent counterpart with $\lambda = 0$ (RANK, light red lines). The shock for each simulation is an asset sale of size 1% of annualized GDP. Responses for individual consumption levels and hours are weighted by population shares of savers (S) and borrowers (B), respectively.

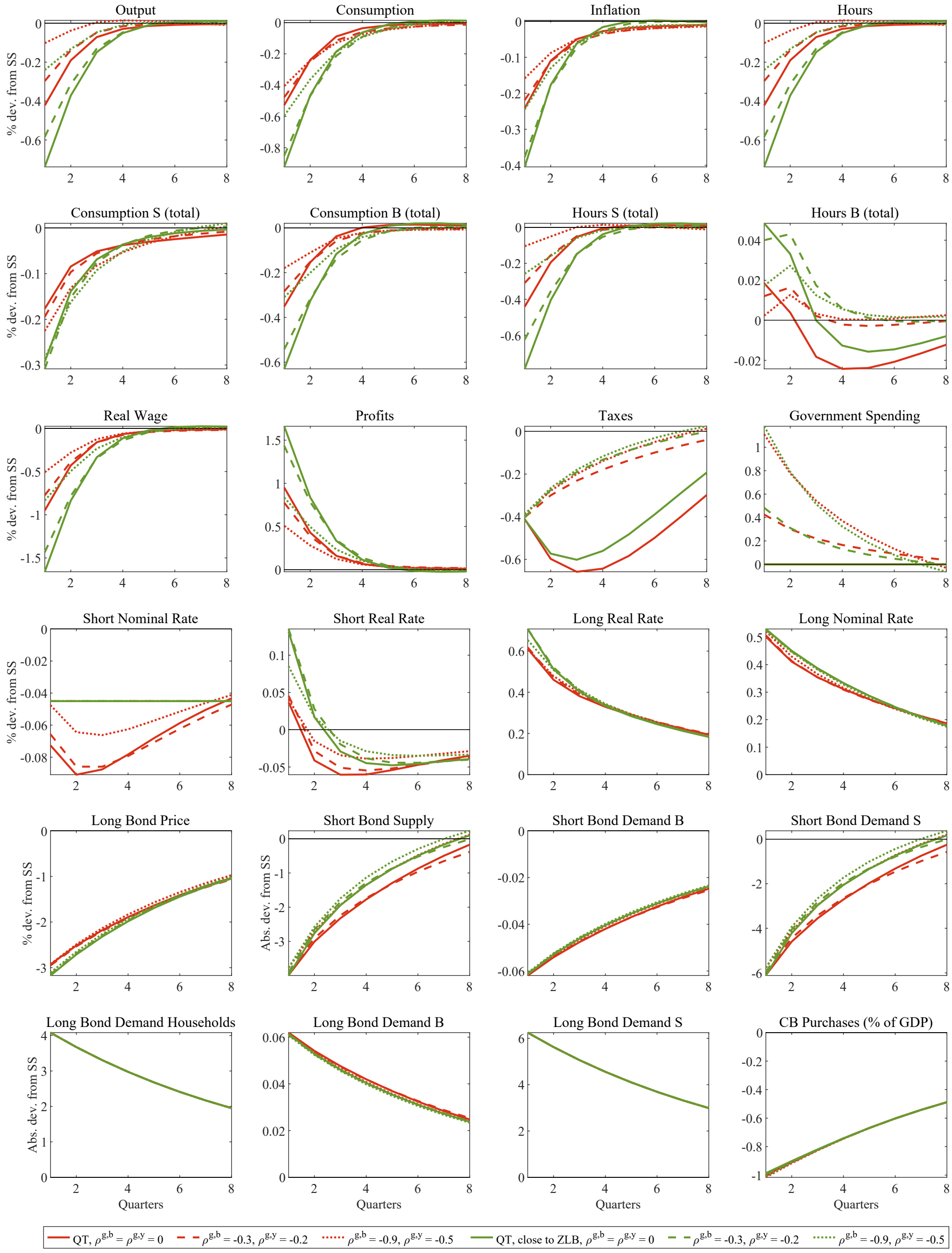
Figure C.16: Impulse responses to a QE shock at the ZLB: Robustness for tax response to debt $\rho^{\tau,b}$ in RANK vs. TANK-BS



Notes: This figure depicts the impulse responses to a QE shock net of a negative preference shock when the ZLB on the policy rate is binding, for the baseline borrower-saver model (TANK-BS, gray lines) and its representative-agent counterpart with $\lambda = 0$ (RANK, light gray lines). The shock for each simulation is an asset purchase of size 1% of annualized GDP. Responses for individual consumption levels and hours are weighted by population shares of savers (S) and borrowers (B), respectively.

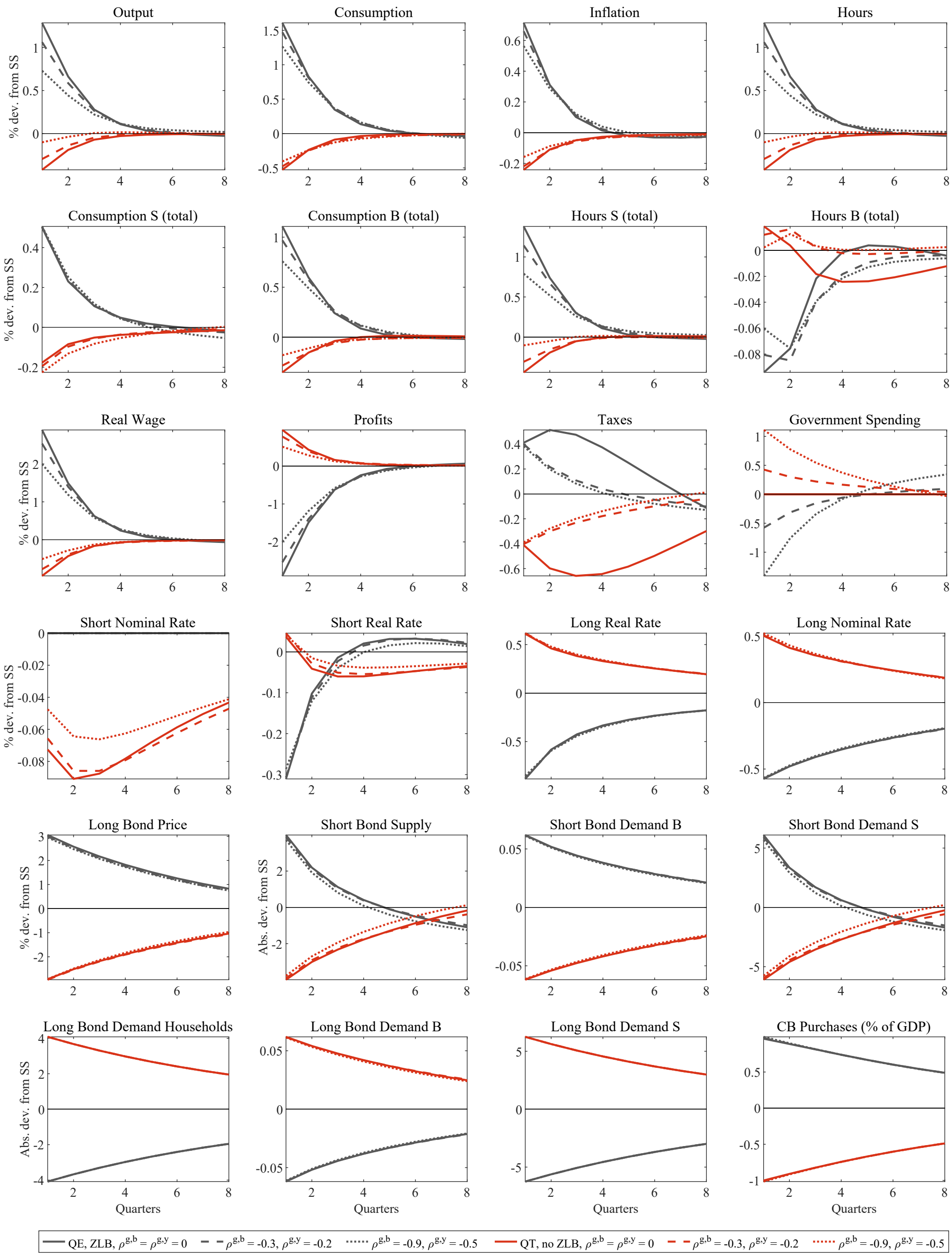
C.2.5 Fiscal rule for government spending: Response to total debt $\rho^{g,b}$ and output $\rho^{g,y}$

Figure C.17: Impulse responses to a QT shock off and a QT shock near the ZLB: Robustness for government spending rule coefficients $\rho^{g,b}$ and $\rho^{g,y}$



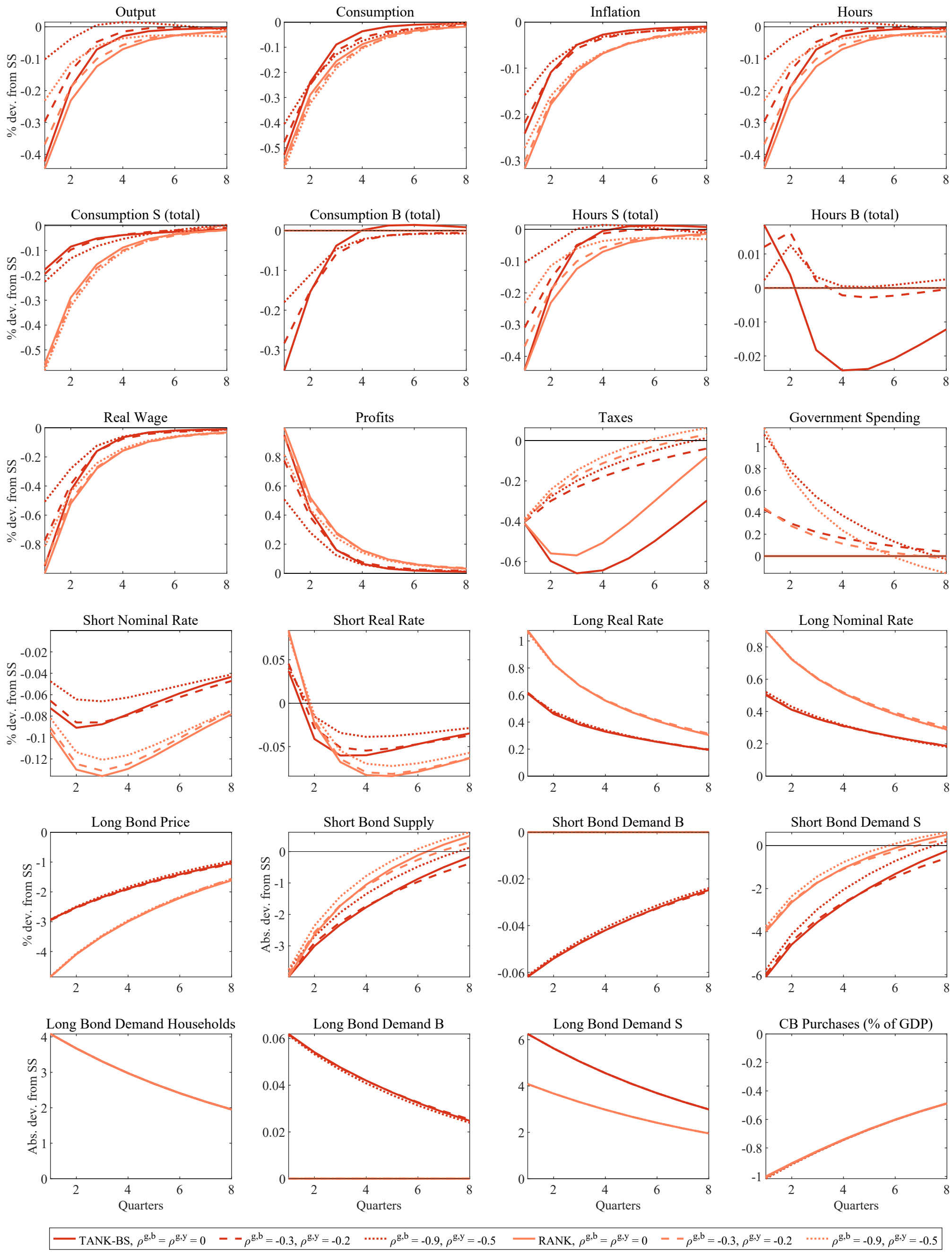
Notes: This figure depicts the impulse responses to a QT shock occurring far enough above the ZLB (red lines) and a QT shock happening close to the ZLB (green lines), for the borrower-saver model with a government spending rule. The shock for each simulation is an asset purchase/sale of size 1% of annualized GDP. Responses for individual consumption levels and hours are weighted by population shares of savers (S) and borrowers (B), respectively.

Figure C.18: Impulse responses to a QE shock at the ZLB and a QT shock off the ZLB: Robustness for government spending rule coefficients $\rho^{g,b}$ and $\rho^{g,y}$



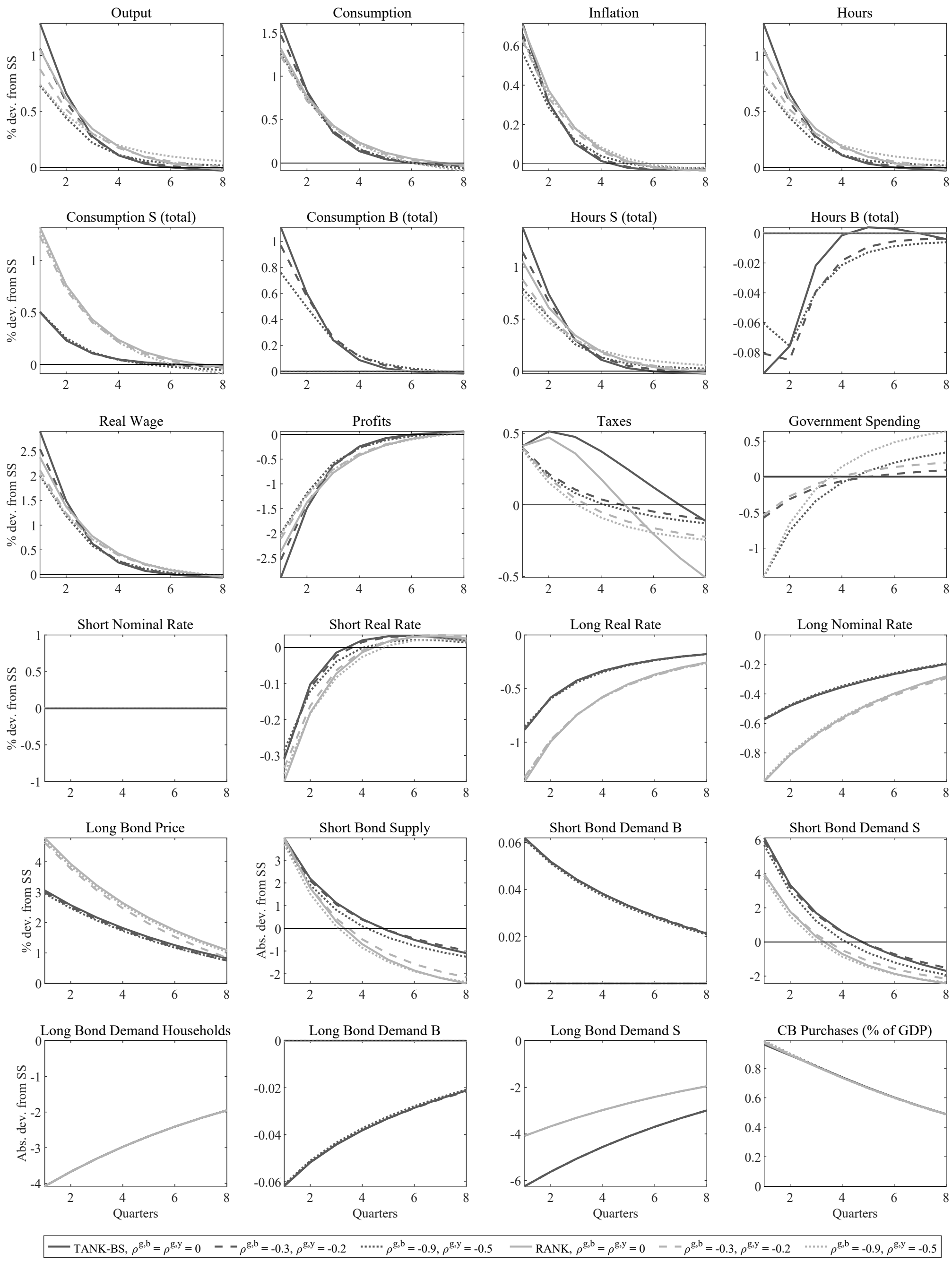
Notes: This figure depicts the impulse responses to a QE shock when the ZLB on the policy rate is binding (gray lines, showing the impact of QE net of a preference shock), and a QT shock occurring far enough above the ZLB (red lines), for the borrower-saver model with a government spending rule. The shock for each simulation is an asset purchase/sale of size 1% of annualized GDP. Responses for individual consumption levels and hours are weighted by population shares of savers (S) and borrowers (B), respectively.

Figure C.19: Impulse responses to a QT shock off the ZLB: Robustness for government spending rule coefficients $\rho^{g,b}$ and $\rho^{g,y}$ in RANK vs. TANK-BS



Notes: This figure depicts the impulse responses to a QT shock occurring far enough above the ZLB, for the borrower-saver model with a government spending rule (TANK-BS, red lines) and its representative-agent counterpart with $\lambda = 0$ (RANK, light red lines). The shock for each simulation is an asset sale of size 1% of annualized GDP. Responses for individual consumption levels and hours are weighted by population shares of savers (S) and borrowers (B), respectively.

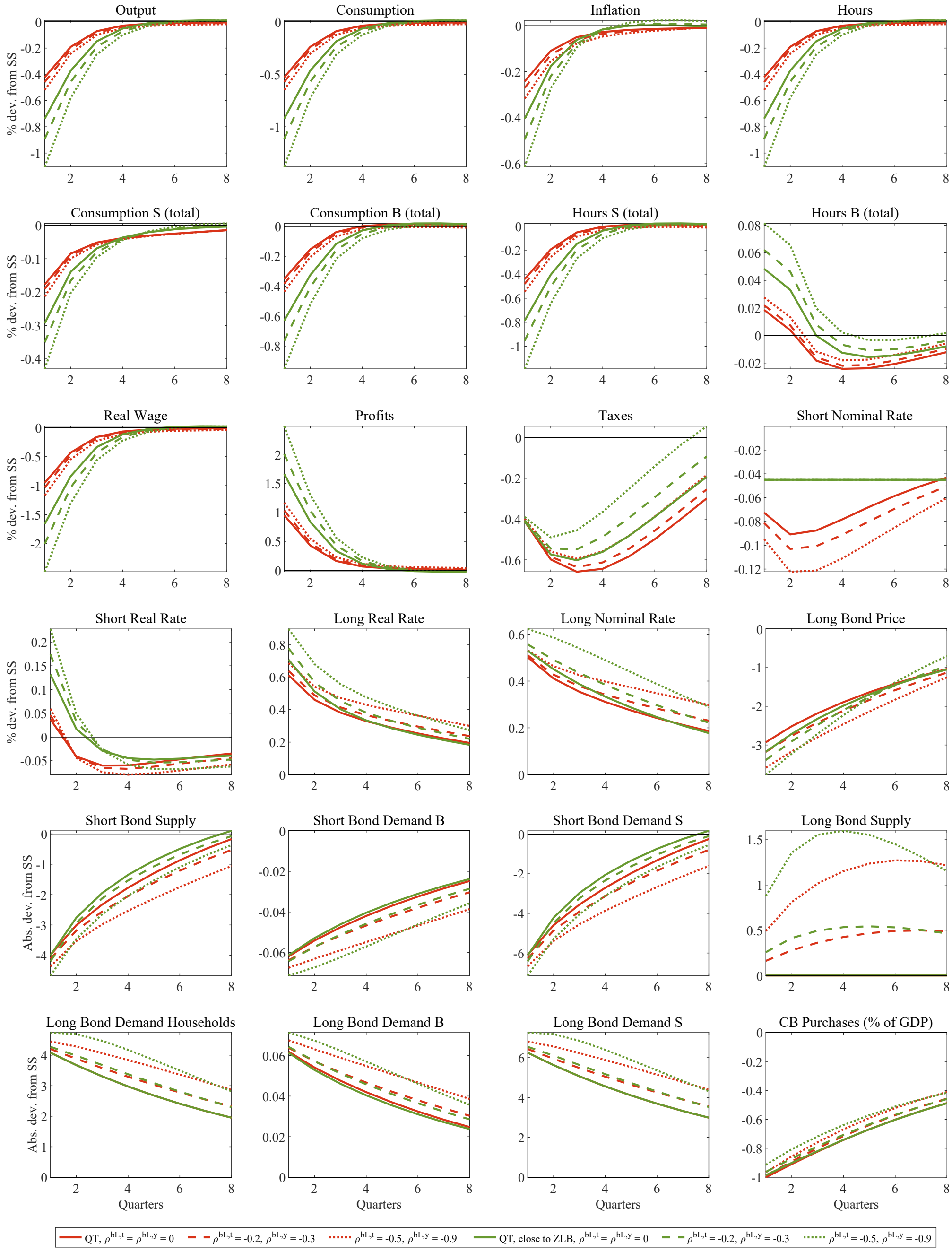
Figure C.20: Impulse responses to a QE shock at the ZLB: Robustness for government spending rule coefficients $\rho^{g,b}$ and $\rho^{g,y}$ in RANK vs. TANK-BS



Notes: This figure depicts the impulse responses to a QE shock net of a negative preference shock when the ZLB on the policy rate is binding, for the borrower-saver model with a government spending rule (TANK-BS, gray lines) and its representative-agent counterpart with $\lambda = 0$ (RANK, light gray lines). The shock for each simulation is an asset purchase of size 1% of annualized GDP. Responses for individual consumption levels and hours are weighted by population shares of savers (S) and borrowers (B), respectively.

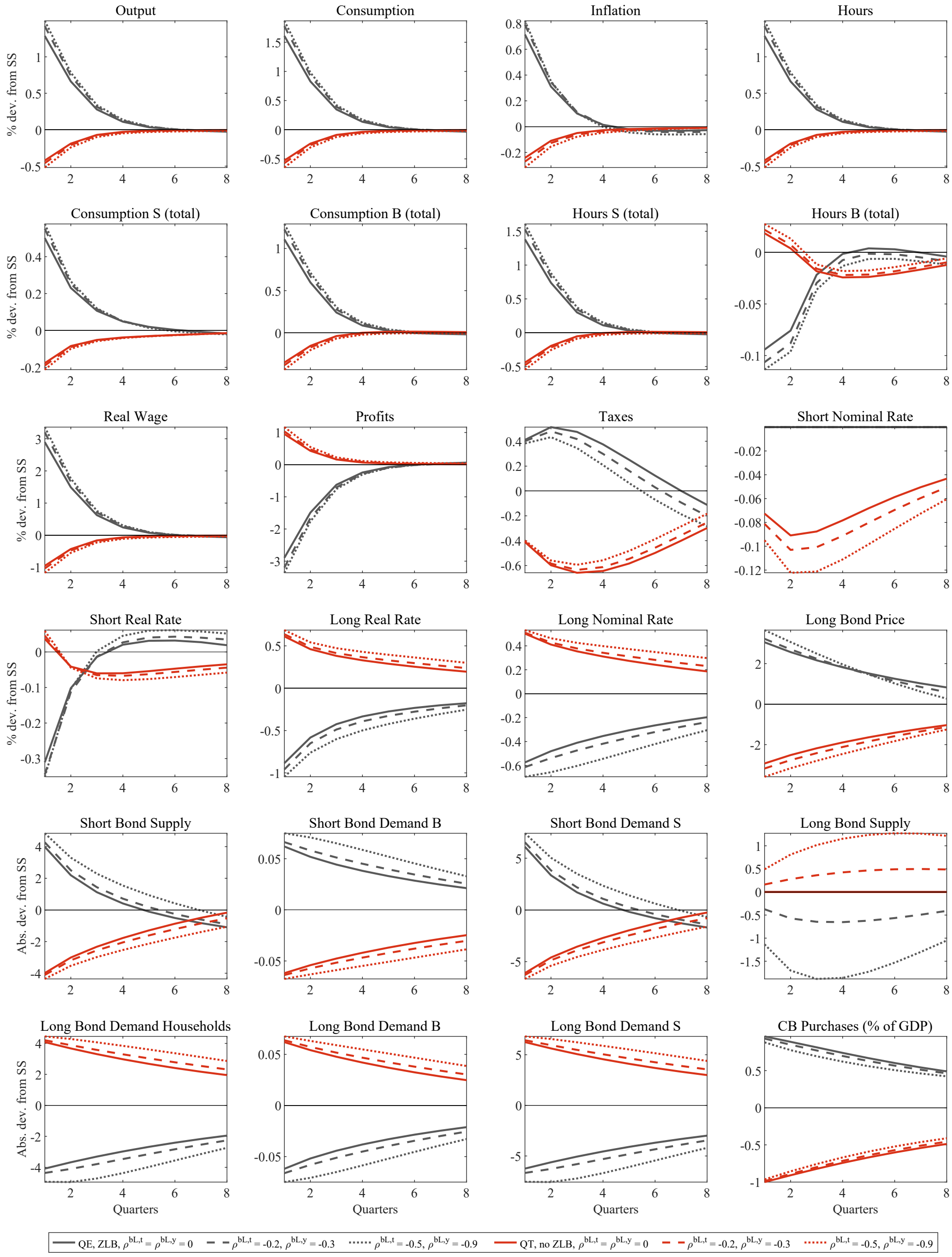
C.2.6 Fiscal rule for long-term debt: Response to taxes $\rho^{bL,t}$ and output $\rho^{bL,y}$

Figure C.21: Impulse responses to a QT shock off and a QT shock near the ZLB: Robustness for long-term debt rule coefficients $\rho^{bL,t}$ and $\rho^{bL,y}$



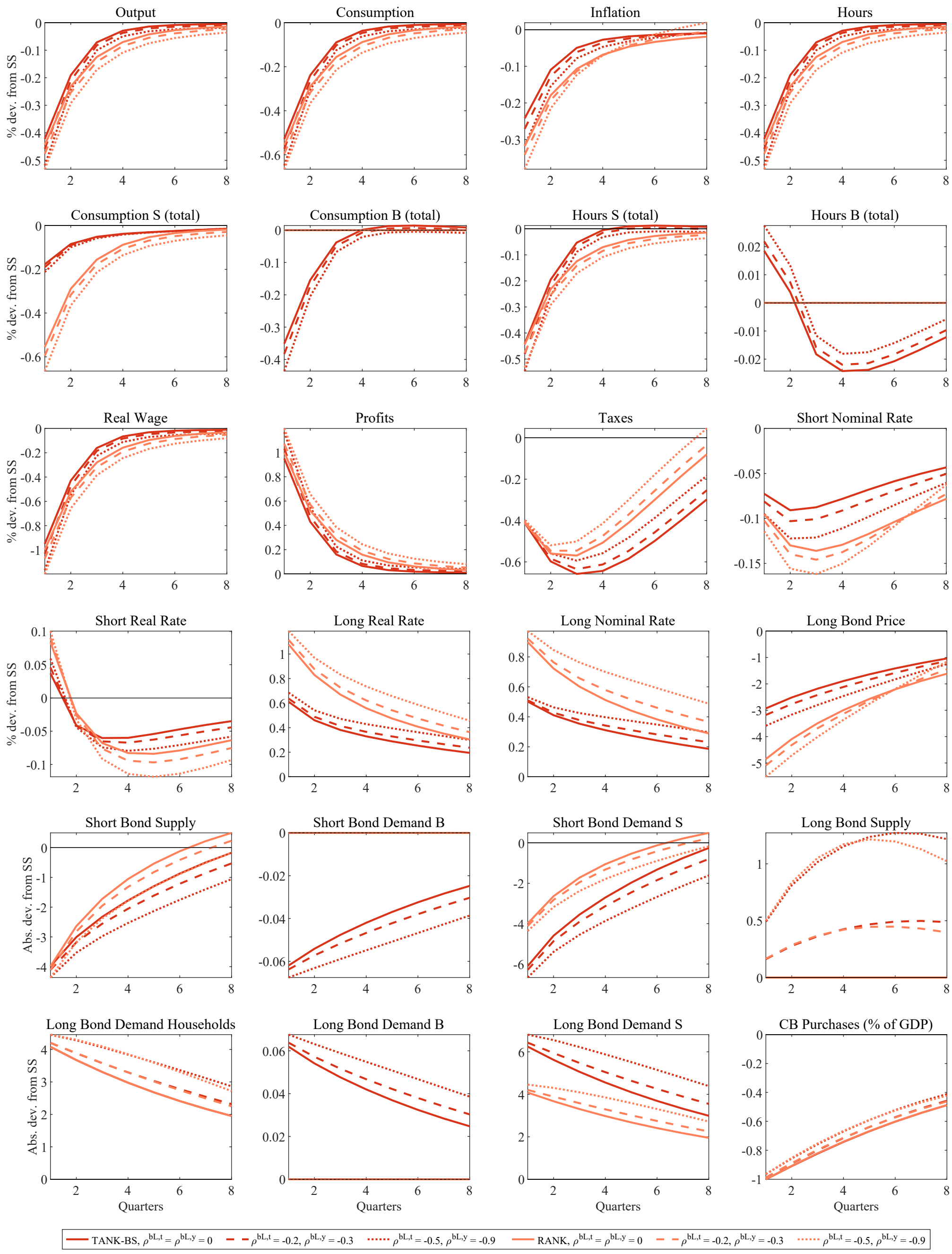
Notes: This figure depicts the impulse responses to a QT shock occurring far enough above the ZLB (red lines) and a QT shock happening close to the ZLB (green lines), for the borrower-saver model with a long-term debt rule. The shock for each simulation is an asset purchase/sale of size 1% of annualized GDP. Responses for individual consumption levels and hours are weighted by population shares of savers (S) and borrowers (B), respectively.

Figure C.22: Impulse responses to a QE shock at the ZLB and a QT shock off the ZLB: Robustness for long-term debt rule coefficients $\rho^{bL,t}$ and $\rho^{bL,y}$



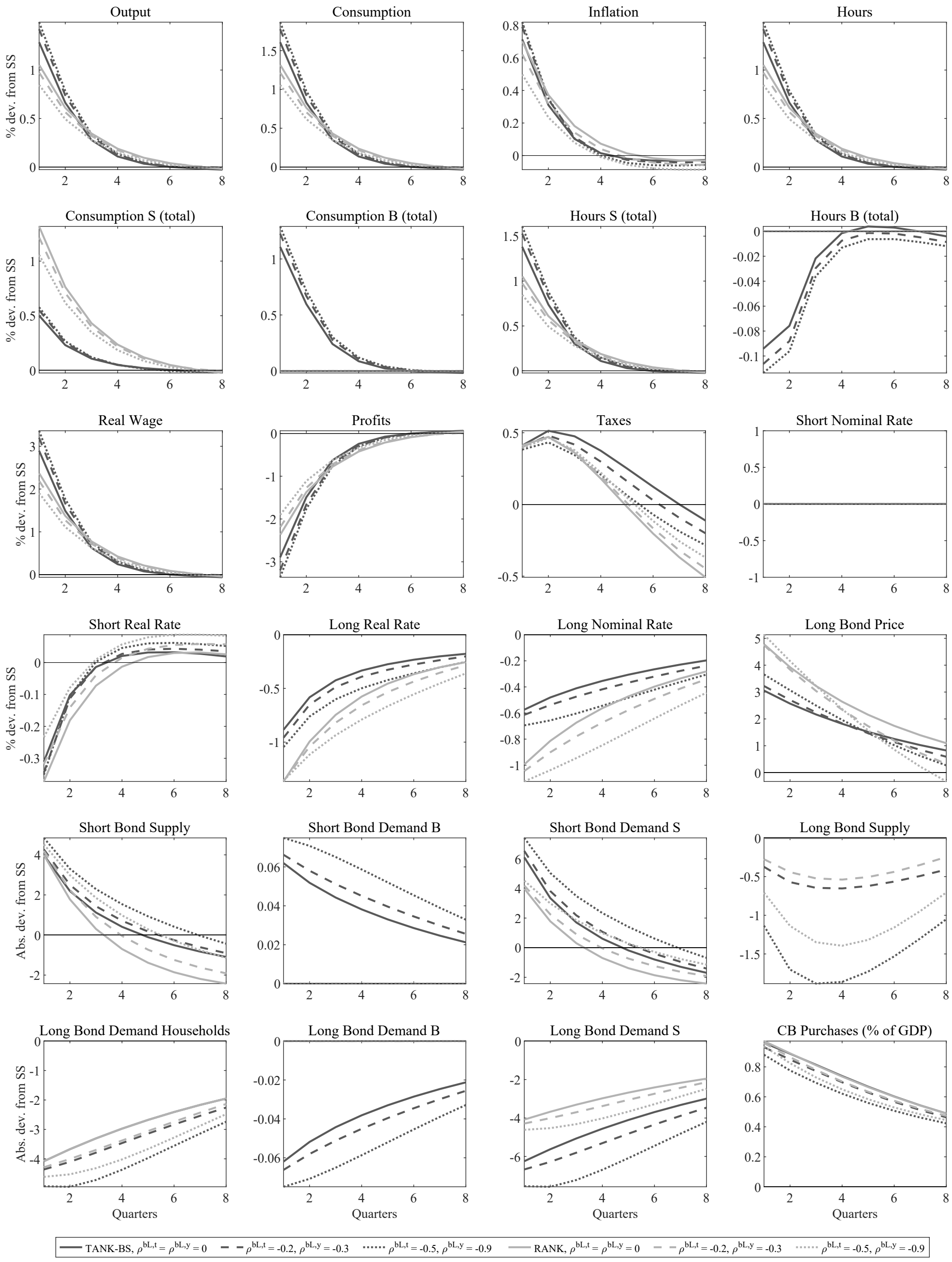
Notes: This figure depicts the impulse responses to a QE shock when the ZLB on the policy rate is binding (gray lines, showing the impact of QE net of a preference shock), and a QT shock occurring far enough above the ZLB (red lines), for the borrower-saver model with a long-term debt rule. The shock for each simulation is an asset purchase/sale of size 1% of annualized GDP. Responses for individual consumption levels and hours are weighted by population shares of savers (S) and borrowers (B), respectively.

Figure C.23: Impulse responses to a QT shock off the ZLB: Robustness for long-term debt rule coefficients $\rho^{bL,t}$ and $\rho^{bL,y}$ in RANK vs. TANK-BS



Notes: This figure depicts the impulse responses to a QT shock occurring far enough above the ZLB, for the borrower-saver model with a long-term debt rule (TANK-BS, red lines) and its representative-agent counterpart with $\lambda = 0$ (RANK, light red lines). The shock for each simulation is an asset sale of size 1% of annualized GDP. Responses for individual consumption levels and hours are weighted by population shares of savers (S) and borrowers (B), respectively.

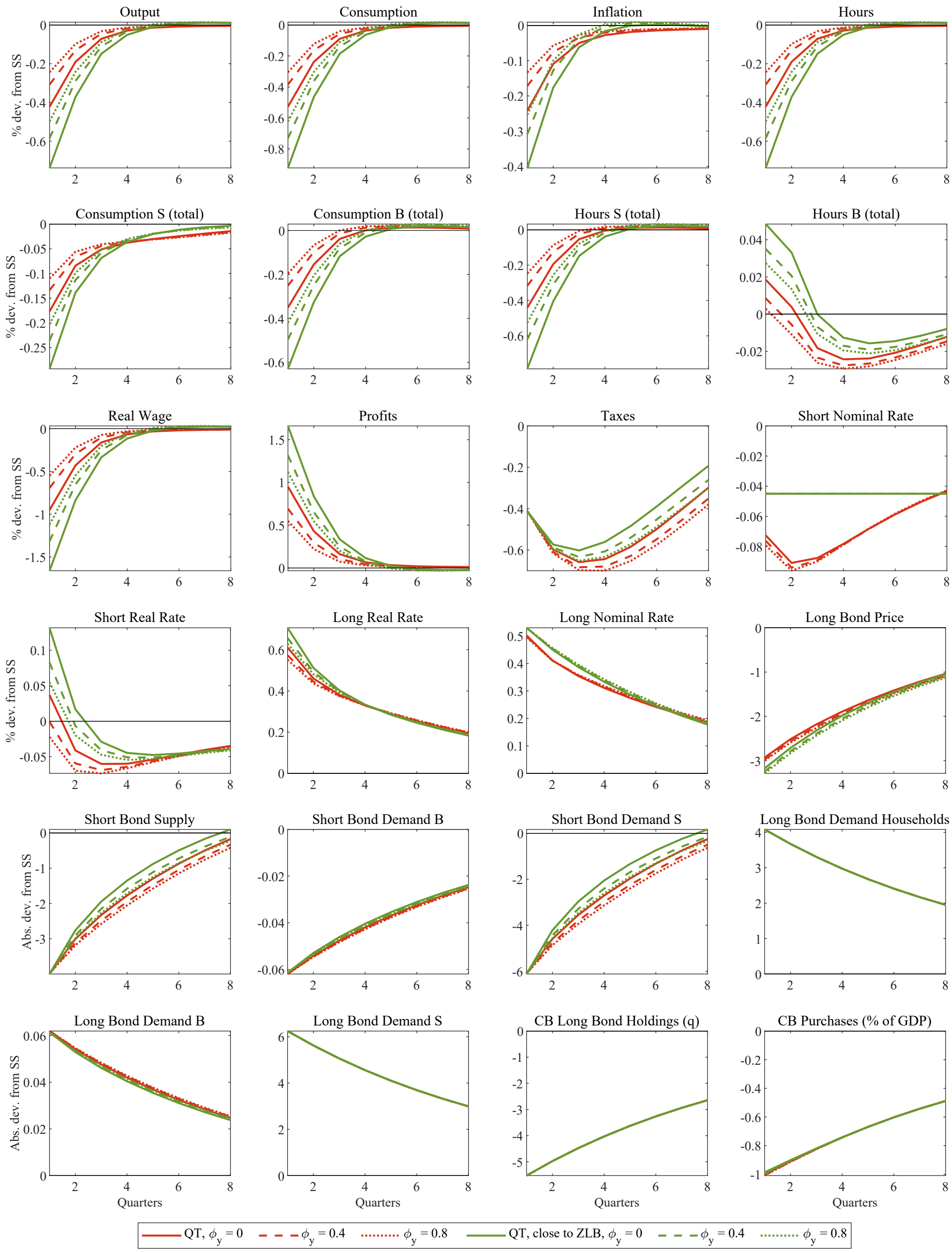
Figure C.24: Impulse responses to a QE shock at the ZLB: Robustness for long-term debt rule coefficients $\rho^{bL,t}$ and $\rho^{bL,y}$ in RANK vs. TANK-BS



Notes: This figure depicts the impulse responses to a QE shock net of a negative preference shock when the ZLB on the policy rate is binding, for the borrower-saver model with a long-term debt rule (TANK-BS, gray lines) and its representative-agent counterpart with $\lambda = 0$ (RANK, light gray lines). The shock for each simulation is an asset purchase of size 1% of annualized GDP. Responses for individual consumption levels and hours are weighted by population shares of savers (S) and borrowers (B), respectively.

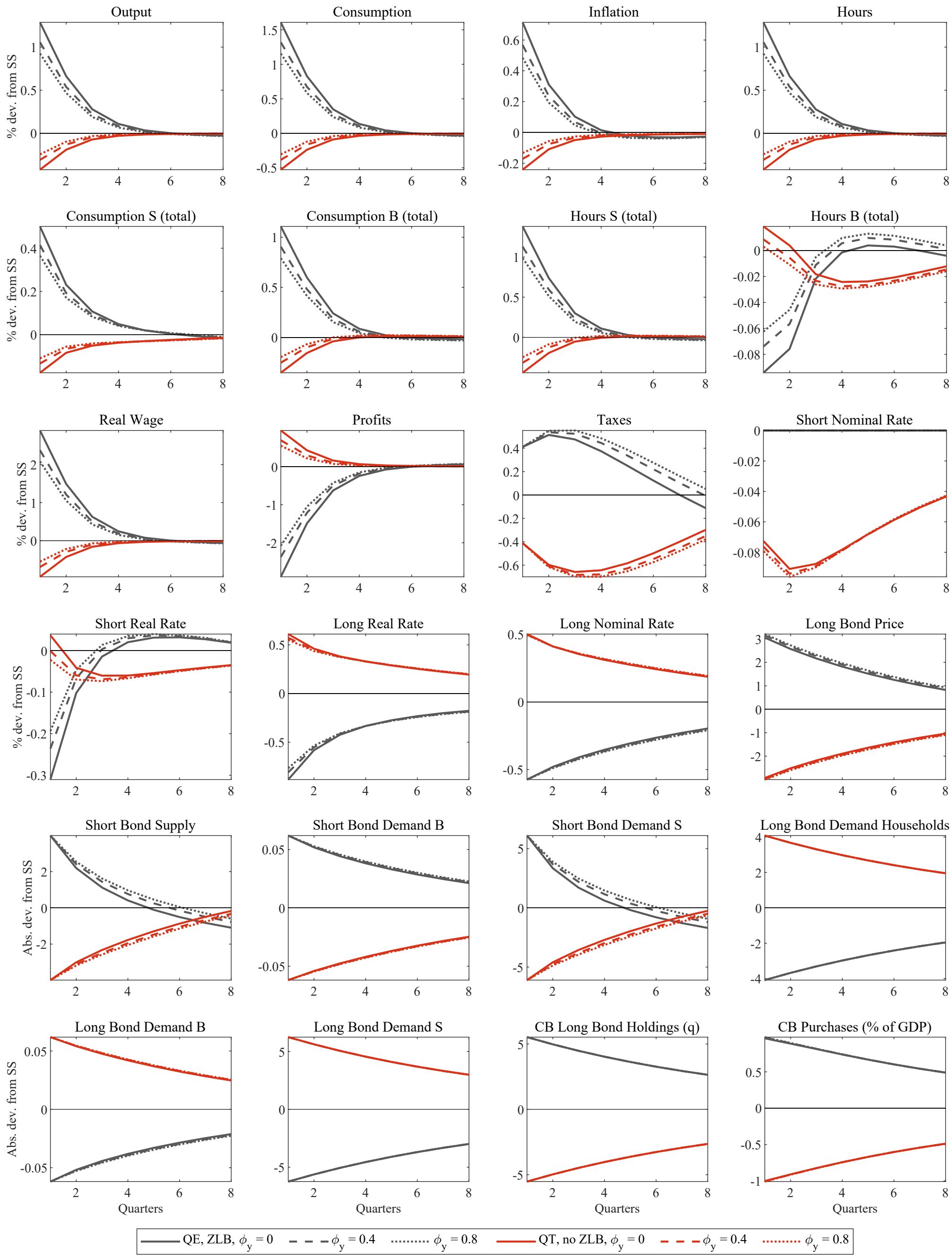
C.2.7 Taylor rule coefficient on output ϕ_y

Figure C.25: Impulse responses to a QT shock off and a QT shock near the ZLB: Robustness for Taylor rule output coefficient ϕ_y



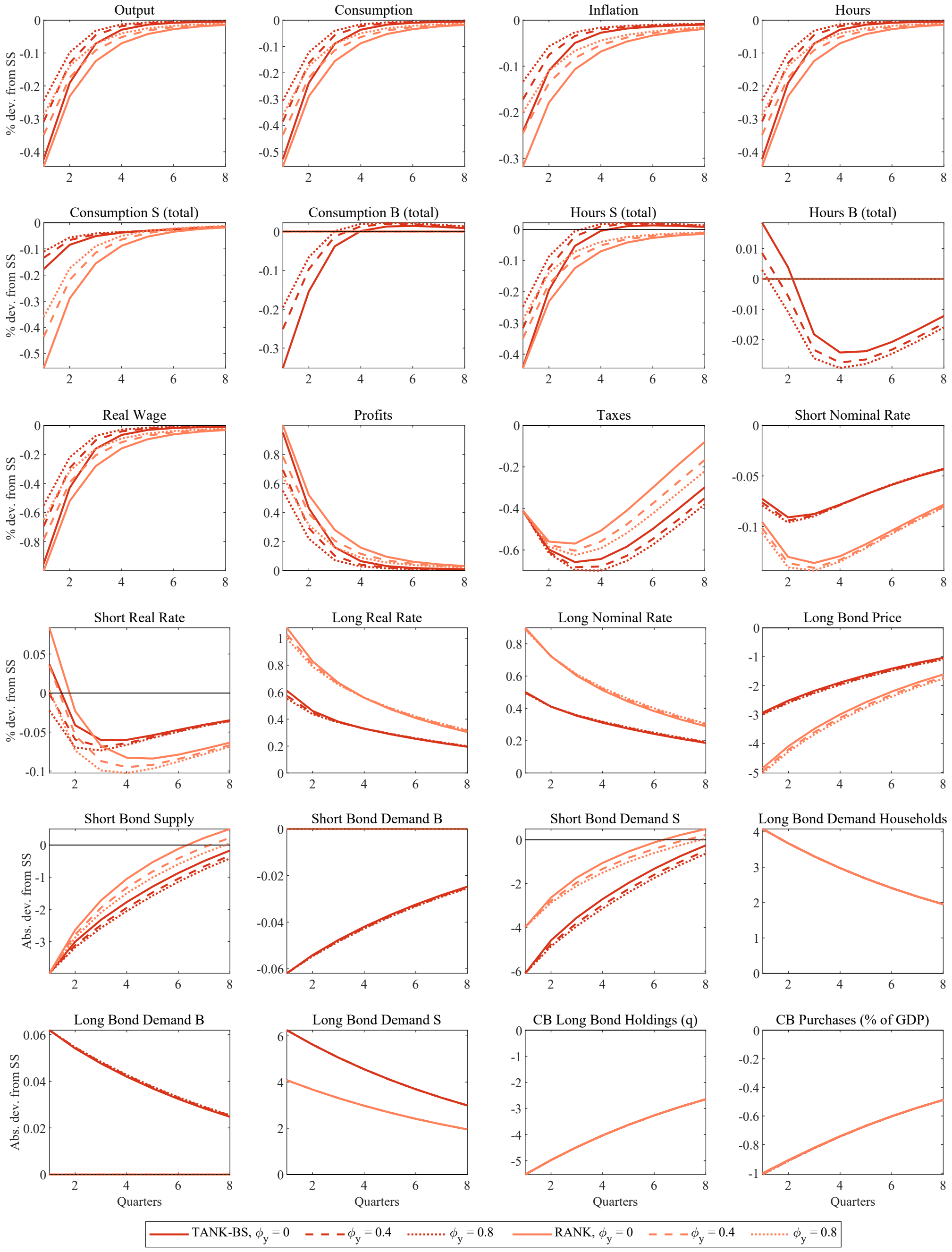
Notes: This figure depicts the impulse responses to a QT shock occurring far enough above the ZLB (red lines) and a QT shock happening close to the ZLB (green lines), for the borrower-saver model with a Taylor rule responding to both inflation and output. The shock for each simulation is an asset purchase/sale of size 1% of annualized GDP. Responses for individual consumption levels and hours are weighted by population shares of savers (S) and borrowers (B), respectively.

Figure C.26: Impulse responses to a QE shock at the ZLB and a QT shock off the ZLB: Robustness for Taylor rule output coefficient ϕ_y



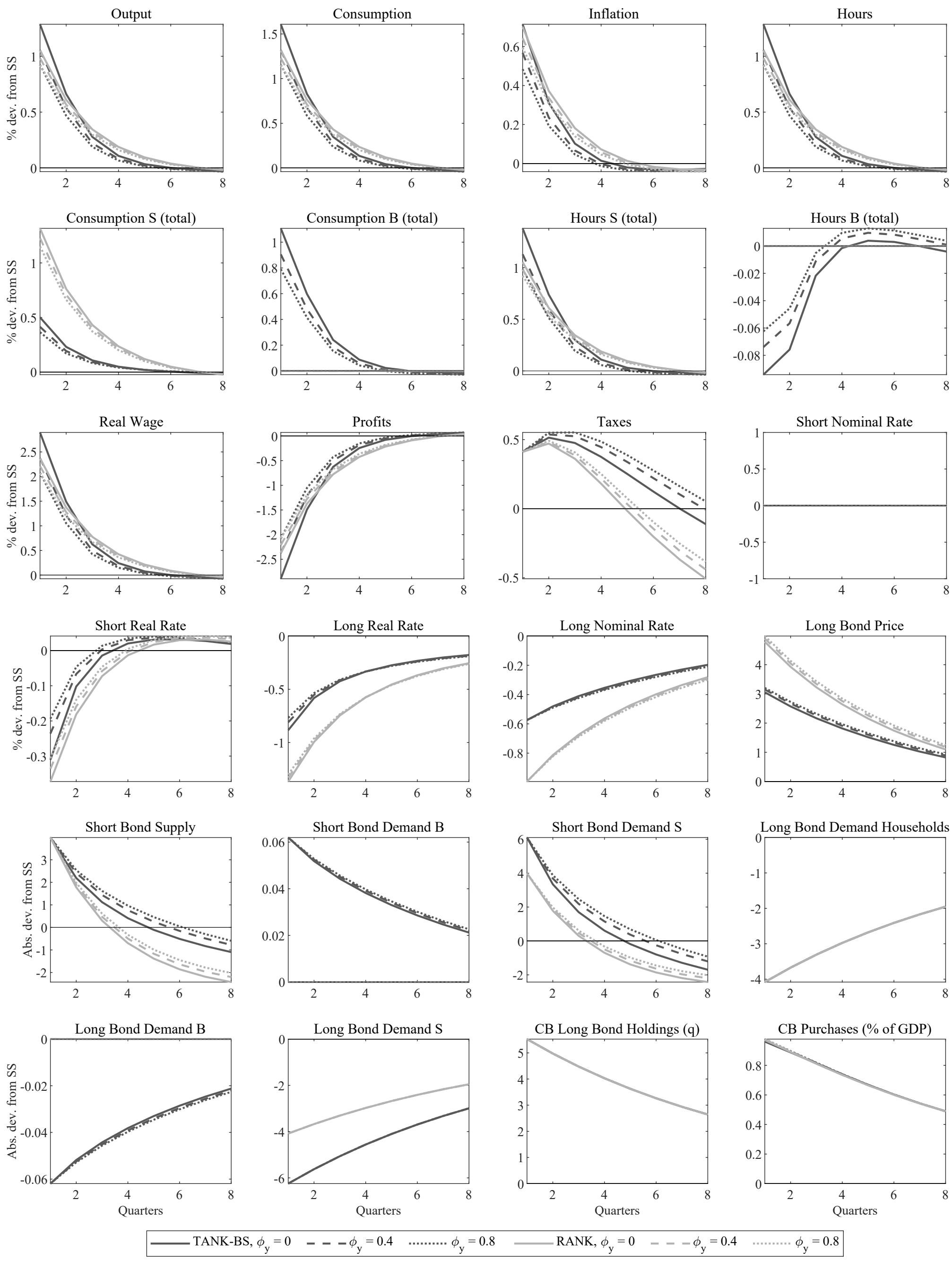
Notes: This figure depicts the impulse responses to a QE shock when the ZLB on the policy rate is binding (gray lines, showing the impact of QE net of a preference shock), and a QT shock occurring far enough above the ZLB (red lines), for the borrower-saver model with a Taylor rule responding to both inflation and output. The shock for each simulation is an asset purchase/sale of size 1% of annualized GDP. Responses for individual consumption levels and hours are weighted by population shares of savers (S) and borrowers (B), respectively.

Figure C.27: Impulse responses to a QT shock off the ZLB: Robustness for Taylor rule output coefficient ϕ_y in RANK vs. TANK-BS



Notes: This figure depicts the impulse responses to a QT shock occurring far enough above the ZLB, for the borrower-saver model with a Taylor rule responding to both inflation and output (TANK-BS, red lines) and its representative-agent counterpart with $\lambda = 0$ (RANK, light red lines). The shock for each simulation is an asset sale of size 1% of annualized GDP. Responses for individual consumption levels and hours are weighted by population shares of savers (S) and borrowers (B), respectively.

Figure C.28: Impulse responses to a QE shock at the ZLB: Robustness for Taylor rule output coefficient ϕ_y in RANK vs. TANK-BS

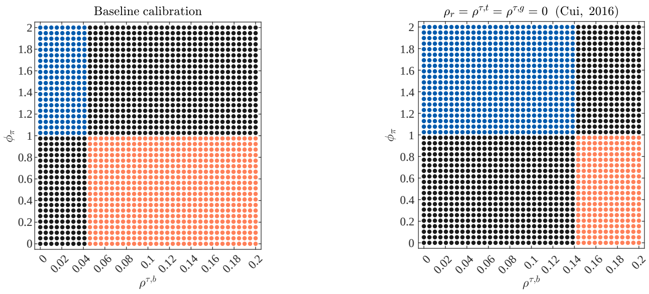


Notes: This figure depicts the impulse responses to a QE shock net of a negative preference shock when the ZLB on the policy rate is binding, for the borrower-saver model with a Taylor rule responding to both inflation and output (TANK-BS, gray lines) and its representative-agent counterpart with $\lambda = 0$ (RANK, light gray lines). The shock for each simulation is an asset purchase of size 1% of annualized GDP. Responses for individual consumption levels and hours are weighted by population shares of savers (S) and borrowers (B), respectively.

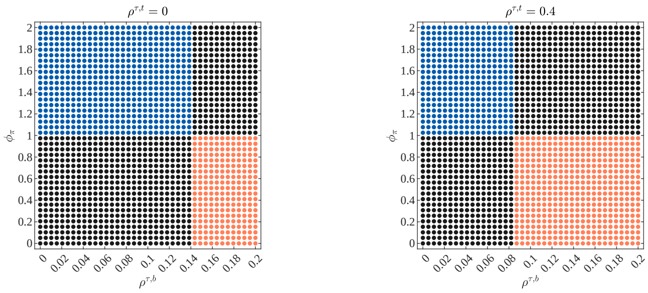
C.3 Equilibrium dynamics: Sensitivity analysis

Figure C.29: Stability regions for the baseline TANK-BS and alternative policy rules

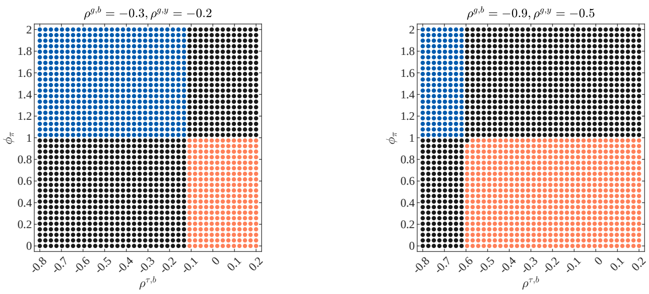
(a) Baselines



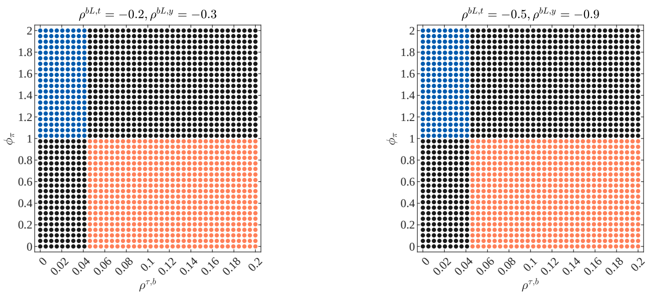
(b) Tax smoothing in baseline fiscal rule



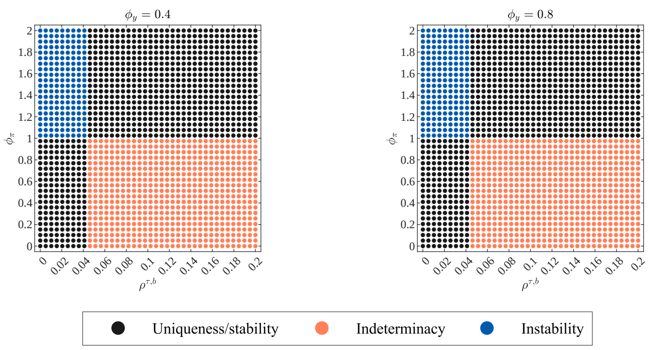
(c) Government spending response to debt and output



(d) Long-term debt response to taxes and output



(e) Taylor rule output coefficient



Notes: These figures show stability and determinacy regions in the parameter space spanned by the Taylor rule coefficient on inflation ϕ_π and the tax response to debt $\rho^{\tau,b}$, for the baseline borrower-saver model and with alternative policy rules. The equilibrium of the model is either unique and stable (black), indeterminate (orange), or unstable (blue) in a neighborhood of the steady state.

References

Anzoategui, D. (2022). Sovereign Spreads and the Effects of Fiscal Austerity. *Journal of International Economics*, *139*, 103658.

Cui, W. (2016). Monetary–Fiscal Interactions with Endogenous Liquidity Frictions. *European Economic Review*, *87*, 1–25.