Fiscal and monetary policy actions under wage rigidity

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Motivation

- Policymakers use policy instruments to stabilize the economy. See e.g. the Taylor rule.
- Question asked here: What is the optimal (fiscal and monetary) policy reaction to the business cycle under labor market frictions? In particular, does optimal (fiscal and monetary) policy depend on whether the labor market is flexible or sclerotic?
- Blanchard and Gali (2010) and many others have studied monetary policy.
- What about fiscal policy, and the optimal mix between fiscal and monetary policy, under labor market frictions?

- Recall that the use of fiscal policy for stabilization has always been more controversial (Leeper, 2010).
- Before the 2008-9 world financial and economic crisis, there was a widespread consensus in academia that fiscal policy should not be used actively for output stabilization.
- In particular, the so-called "consensus assignment" was that monetary policy should focus on controlling inflation by managing demand, while fiscal policy should focus on reacting to public debt (see e.g. Kirsanova et al., 2009). In other words, at least in academia, it was widely believed that "counter-cyclical fiscal policy is counter-productive" (see e.g. Gordon and Leeper, 2003, Taylor, 2009, and Feldstein, 2009).

- This changed during the 2008-2009 crisis.
- Most governments used active fiscal policy to counter the economic downturn.
- Also several academics argued that the consensus assignment needs to be modified in the sense that, if the economy is hit by an adverse shock, fiscal reaction to the output gap is productive (see e.g. Wren-Lewis, 2010).
- Which view is right? In this paper, we revisit this policy question using a New Keynesian DSGE model with labor market frictions calibrated to data from the euro area.

A clarification

- Since it might be optimal to respond to more than one indicators at the same time, the central issue is what is the dominant response. It is this that will shape the net change in a particular policy instrument.

Description of the model

- Standard New Keynesian (imperfect competition and Calvo-type price fixities).
- Wage rigidity as in Blanchard and Gali (2005) and many others. Thus, wages respond sluggishly to labor market conditions as a result of some (unmodeled) friction.
- See Blanchard and Gali (2010) and Gali (2011) for reviews of models with labor market frictions.
- Rich menu of state-contingent (monetary and fiscal) policy rules.
- Optimized policy rules working as in Schmitt-Grohé and Uribe (2004, 2007).

Model

Household's problem

There are $i = 1, 2, ..., .N$ households. Each i solves:

$$E_0 \sum_{t=0}^{\infty} \beta^t U\left(c_{i,t}, n_{i,t}, m_{i,t}, g_t\right) \tag{1}$$

$$u_{i,t}\left(c_{i,t}, n_{i,t}, m_{i,t}, g_t\right) = \frac{c_{i,t}^{1-\sigma}}{1-\sigma} - \chi_n \frac{n_{i,t}^{1+\eta}}{1+\eta} + \chi_m \frac{m_{i,t}^{1-\mu}}{1-\mu} + \chi_g \frac{g_t^{1-\zeta}}{1-\zeta} \tag{2}$$

$$\begin{aligned}\left(1+\tau_t^c\right) c_{i,t} + x_{i,t} + b_{i,t} + m_{i,t} = \left(1-\tau_t^k\right)\left(r_t^k k_{i,t-1} + d_{i,t}\right) + \\ + \left(1-\tau_t^n\right) w_t n_{i,t} + R_{t-1} \tfrac{P_{t-1}}{P_t} b_{i,t-1} + \tfrac{P_{t-1}}{P_t} m_{i,t-1} - \tau_{i,t}^l\end{aligned} \tag{3}$$

$$k_{i,t} = (1-\delta) k_{i,t-1} + x_{i,t} \tag{4}$$

Household i's consumption bundle at t, $c_{i,t}$, is a composite of $h = 1, 2, ..., N$ varieties of goods, $c_{i,t}(h)$, where each variety h is produced monopolistically by one firm h. Using a Dixit-Stiglitz aggregator, we define:

$$c_{i,t} = \left[\sum_{h=1}^{N} \lambda [c_{i,t}(h)]^{\frac{\phi-1}{\phi}} \right]^{\frac{\phi}{\phi-1}} \tag{5}$$

where $\phi > 0$ is the elasticity of substitution across goods produced and $\sum_{h=1}^{N} \lambda = 1$ are weights (to avoid scale effects, we assume $\lambda = 1/N$).

$$P_t c_{i,t} = \sum_{h=1}^{N} \lambda P_t(h) c_{i,t}(h) \tag{6}$$

Each household i acts competitively taking prices and policy as given.

$$\frac{c_{i,t}^{-\sigma}}{(1+\tau_t^c)} = \beta E_t \frac{c_{i,t+1}^{-\sigma}}{(1+\tau_{t+1}^c)} \left[\left(1-\tau_{t+1}^k\right) r_{t+1}^k + (1-\delta) \right] \tag{7}$$

$$\frac{c_{i.t}^{-\sigma}}{(1+\tau_t^c)} = \beta E_t \frac{c_{i,t+1}^{-\sigma}}{(1+\tau_{t+1}^c)} R_t \frac{P_t}{P_{t+1}} \tag{8}$$

$$\chi_m m_{i,t}^{-\mu} - \frac{c_{i,t}^{-\sigma}}{(1+\tau_t^c)} + \beta E_t \frac{c_{i,t+1}^{-\sigma}}{(1+\tau_{t+1}^c)} \frac{P_t}{P_{t+1}} = 0 \tag{9}$$

$$w_t = \frac{\chi_n (1+\tau_t^c) n_{i,t}^{\eta}}{(1-\tau_t^n) c_{i,t}^{-\sigma}} \equiv mrs_t \tag{10}$$

$$c_{i,t}(h) = \left[\frac{P_t(h)}{P_t} \right]^{-\phi} c_{i,t} \tag{11}$$

In nominal terms:

$$W_t \equiv (W_{t-1})^{\gamma} \left(P_t mrs_t\right)^{1-\gamma} \tag{12}$$

or in real terms:

$$w_t \equiv \left(w_{t-1}\frac{P_{t-1}}{P_t}\right)^{\gamma} \left(mrs_t\right)^{1-\gamma} \tag{13}$$

where $0 \leq \gamma \leq 1$ is the degree of wage sluggishness. If $\gamma = 0$, the labor market is Walrasian.

There are $h = 1, 2, ..., .N$ firms. Each firm h produces a differentiated good of variety h under monopolistic competition facing Calvo-type nominal fixities. Each firm h maximizes nominal profits, $D_t(h)$, defined as:

$$D_t(h) = P_t(h)y_t(h) - r_t^k P_t(h)k_{t-1}(h) - W_t n_t(h) \tag{14}$$

$$y_t(h) = A_t[k_{t-1}(h)]^\alpha [n_t(h)]^{1-\alpha} \tag{15}$$

$$y_t(h) = \left[\frac{P_t(h)}{P_t}\right]^{-\phi} y_t$$

In addition, following Calvo (1983), firms choose their prices facing a nominal fixity. In each period, firm h faces an exogenous probability θ of not being able to reset its price. A firm h, which is able to reset its price, chooses its price $P_t^{\#}(h)$ to maximize the sum of discounted expected nominal profits for the next k periods in which it may have to keep its price fixed.

Model

Firm's optimality condition

$$w_t = mc_t(1-a)A_t[k_{t-1}(h)]^{\alpha}[n_t(h)]^{-\alpha} \tag{16}$$

$$r_t^k = mc_t a A_t[k_{t-1}(h)]^{\alpha-1}[n_t(h)]^{1-\alpha} \tag{17}$$

$$\sum_{k=0}^{\infty}(\theta)^k E_t[\Xi_{t,t+k}\left[\frac{P_t^{\#}(h)}{P_{t+k}}\right]^{-\phi} y_{t+k}\left\{\frac{P_t^{\#}(h)}{P_t}-\frac{\phi}{\phi-1}mc_{t+k}\frac{P_{t+k}}{P_t}\right\}]=0 \tag{18}$$

The evolution of the aggregate price level is given by:

$$(P_t)^{1-\phi} = \theta\,(P_{t-1})^{1-\phi} + (1-\theta)\left(P_t^{\#}\right)^{1-\phi} \tag{19}$$

Model

Government Budget Constraint

$$b_t + m_t = R_{t-1}\frac{P_{t-1}}{P_t}b_{t-1} + \frac{P_{t-1}}{P_t}m_{t-1} + g_t - \\ -\tau_t^c c_t - \tau_t^k(r_t^k k_{t-1} + d_t) - \tau_t^n w_t n_t - \tau_t^l \tag{20}$$

Decentralized Equilibrium (for any feasible policy)

$$\frac{c_t^{-\sigma}}{(1+\tau_t^c)} = \beta E_t \frac{{c_{t+1}}^{-\sigma}}{(1+\tau_{t+1}^c)} \left[\left(1-\tau_{t+1}^k\right) r_{t+1}^k + (1-\delta) \right] \tag{21}$$

$$c_t^{-\sigma} \frac{1}{(1+\tau_t^c)} = \beta E_t R_t \frac{c_{t+1}^{-\sigma}}{(1+\tau_{t+1}^c)} \frac{P_t}{P_{t+1}} \tag{22}$$

$$\chi_m m_t^{-\mu} - \frac{c_t^{-\sigma}}{(1+\tau_t^c)} + \beta E_t \frac{c_{t+1}^{-\sigma}}{(1+\tau_{t+1}^c)} \frac{P_t}{P_{t+1}} = 0 \tag{23}$$

$$w_t = \left(w_{t-1} \frac{P_{t-1}}{P_t} \right)^{\gamma} \left(\frac{\chi_n (1+\tau_t^c) n_t^{\eta}}{(1-\tau_t^n) c_t^{-\sigma}} \right)^{1-\gamma} \tag{24}$$

Decentralized Equilibrium (for any feasible policy)

$$k_t = (1-\delta)\, k_{t-1} + x_t \tag{25}$$

$$\sum_{k=0}^{\infty} \theta^k E_t \left\{ \Xi_{t,t+k} \left[\frac{P_t^{\#}}{P_{t+k}} \right]^{-\varepsilon} y_{t+k} \left(\frac{P_t^{\#}}{P_t} - \frac{\varepsilon}{\varepsilon - 1} mc_{t+k} \frac{P_{t+k}}{P_t} \right) \right\} = 0 \tag{26}$$

$$w_t = mc_t (1-a) \frac{y_t}{n_t} \tag{27}$$

$$r_t^k = mc_t a \frac{y_t}{k_t} \tag{28}$$

Decentralized Equilibrium (for any feasible policy)

$$d_t = y_t - w_t n_t - r_t^k k_{t-1} \tag{29}$$

$$y_t = \frac{1}{\left(\frac{\widetilde{P}_t}{P_t}\right)^{-\phi}} A_t k_{t-1}^a n_t^{1-a} \tag{30}$$

$$\begin{gathered} b_t + m_t = R_{t-1} b_{t-1} \tfrac{P_{t-1}}{P_t} + m_{t-1} \tfrac{P_{t-1}}{P_t} + \\ + g_t - \tau_t^c c_t - \tau_t^n w_t n_t - \tau_t^k \left(r_t^k k_{t-1} + d_t \right) - \tau_t^l \end{gathered} \tag{31}$$

$$y_t = c_t + x_t + g_t \tag{32}$$

Decentralized Equilibrium (for any feasible policy)

$$(P_t)^{1-\phi} = \theta(P_{t-1})^{1-\phi} + (1-\theta)\left(P_t^{\#}\right)^{1-\phi} \tag{33}$$

$$(\widetilde{P}_t)^{-\phi} = \theta(\widetilde{P}_{t-1})^{-\phi} + (1-\theta)\left(P_t^{\#}\right)^{-\phi} \tag{34}$$

where $\widetilde{P}_t \equiv \left(\sum_{h=1}^{N}\left[P_t\left(h\right)\right]^{-\phi}\right)^{-\frac{1}{\phi}}$ and $\left(\frac{\widetilde{P}_t}{P_t}\right)^{-\phi}$ is a measure of price dispersion.

We thus have 14 equilibrium conditions for the DE.

Decentralized Equilibrium (for any feasible policy)

- To solve the model, we need to specify the policy regime and thus classify variables into endogenous and exogenous.
- Regarding monetary policy, we assume that the nominal interest rate, R_t, is used as a policy instrument.
- Regarding fiscal policy, we assume that τ_t^c, τ_t^k, τ_t^n, g_t, τ_t^l are used as policy instruments, while the end-of-period public debt, b_t, follows residually.
- Then, the 14 endogenous variables are $\{y_t, c_t, n_t, x_t, k_t, m_t, b_t, P_t, P_t^{\#}, \widetilde{P}_t, w_t, mc_t, d_t, r_t^k\}_{t=0}^{\infty}$. This is given the independently set policy instruments, $\{R_t, \tau_t^c, \tau_t^k, \tau_t^n, g_t, \tau_t^l\}_{t=0}^{\infty}$, technology, $\{A_t\}_{t=0}^{\infty}$, and initial conditions for the state variables.

Decentralized Equilibrium transformed (for any feasible policy)

Variables expressed in ratios

We use the gross inflation rate $\Pi_t \equiv \frac{P_t}{P_{t-1}}$, the auxiliary variable $\Theta_t \equiv \frac{P_t^{\#}}{P_t}$, and the price dispersion index $\Delta_t \equiv \left[\frac{\widetilde{P}_t}{P_t}\right]^{-\phi}$. We also use $s_t^g \equiv \frac{g_t}{y_t}$ and $s_t^l \equiv \frac{\tau_t^l}{y_t}$.

Thus, from now on, we use Π_t, Θ_t, Δ_t, s_t^g, s_t^l instead of P_t, $P_t^{\#}$, $\widetilde{P}_t$, g_t, τ_t^l respectively.

Decentralized Equilibrium transformed (for any feasible policy)

Equation (26) expressed in recursive form

We replace the recursive equation:

$$\sum_{k=0}^{\infty} (\theta)^k \, E_t \, \Xi_{t,t+k} \left[\frac{P_t^{\#}}{P_{t+k}} \right]^{-\phi} y_{t+k} \left\{ \frac{P_t^{\#}}{P_t} - \frac{\phi}{(\phi-1)} mc_{t+k} \frac{P_{t+k}}{P_t} \right\} = 0 \tag{35}$$

with:

$$z_t^1 = \frac{\phi}{(\phi-1)} z_t^2 \tag{36}$$

Decentralized Equilibrium transformed (for any feasible policy)

Equation (26) expressed in recursive form

where:

$$z_t^1 = \Theta_t^{-\phi-1} y_t + \beta\theta E_t \frac{c_{t+1}^{-\sigma}}{c_t^{-\sigma}} \frac{1+\tau_t^c}{1+\tau_{t+1}^c} \left(\frac{\Theta_t}{\Theta_{t+1}}\right)^{-\phi-1} \left(\frac{1}{\Pi_{t+1}}\right)^{-\phi} z_{t+1}^1 \tag{37}$$

$$z_t^2 = \Theta_t^{-\phi} y_t mc_t + \beta\theta E_t \frac{c_{t+1}^{-\sigma}}{c_t^{-\sigma}} \frac{1+\tau_t^c}{1+\tau_{t+1}^c} \left(\frac{\Theta_t}{\Theta_{t+1}}\right)^{-\phi} \left(\frac{1}{\Pi_{t+1}}\right)^{1-\phi} z_{t+1}^2 \tag{38}$$

Decentralized Equilibrium transformed (for any feasible policy)

Lifetime utility written as a first-order dynamic equation

$$V_t = \frac{c_t^{1-\sigma}}{1-\sigma} - \chi_n \frac{n_t^{1+\phi}}{1+\phi} + \chi_m \frac{m_t^{1-\mu}}{1-\mu} + \chi_g \frac{\left(s_t^g y_t\right)^{1-\zeta}}{1-\zeta} + \beta E_t V_{t+1} \qquad (39)$$

Thus, from now on, we add equation (39) to the equilibrium system.

Policy rules

$$\log\left(\frac{R_t}{R}\right) = \phi_\pi \log\left(\frac{\Pi_t}{\Pi}\right) + \phi_y \log\left(\frac{y_t}{y}\right) + \nu_t^R \tag{40}$$

$$s_t^g - s^g = -\gamma_l^g \left(l_{t-1} - l\right) - \gamma_y^g \left(y_t - y\right) + \nu_t^g \tag{41}$$

$$\tau_t^c - \tau^c = \gamma_l^c \left(l_{t-1} - l\right) + \gamma_y^c \left(y_t - y\right) + \nu_t^c \tag{42}$$

$$\tau_t^k - \tau^k = \gamma_l^k \left(l_{t-1} - l\right) + \gamma_y^k \left(y_t - y\right) + \nu_t^k \tag{43}$$

$$\tau_t^n - \tau^n = \gamma_l^n \left(l_{t-1} - l\right) + \gamma_y^n \left(y_t - y\right) + \nu_t^n \tag{44}$$

$$l_t \equiv \frac{R_t b_t}{y_t} \tag{45}$$

where $\nu_t^j \sim N\left(0,\ \sigma_j^2\right)$.

Exogenous stochastic variables

$$\log A_t = \left(1-\rho^A\right)\log\left(A\right)+\rho^A\log A_{t-1}+\varepsilon_t^A \tag{46}$$

$$\log \nu_t^R = \left(1-\rho^R\right)\log\left(\nu^R\right)+\rho^R\log \nu_{t-1}^R+\varepsilon_t^R \tag{47}$$

$$\log \nu_t^g = \left(1-\rho^g\right)\log\left(\nu^g\right)+\rho^g\log \nu_{t-1}^g+\varepsilon_t^g \tag{48}$$

$$\log \nu_t^c = \left(1-\rho^c\right)\log\left(\nu^c\right)+\rho^c\log \nu_{t-1}^c+\varepsilon_t^c \tag{49}$$

$$\log \nu_t^k = \left(1-\rho^k\right)\log\left(\nu^k\right)+\rho^k\log \nu_{t-1}^k+\varepsilon_t^k \tag{50}$$

$$\log \nu_t^n = \left(1-\rho^n\right)\log\left(\nu^n\right)+\rho^n\log \nu_{t-1}^n+\varepsilon_t^n \tag{51}$$

where $0 \leq \rho^i \leq 1$ and $\varepsilon_t^i \sim N\left(0,\ \sigma_i^2\right)$.

Final Equilibrium system

$$\frac{c_t{}^{-\sigma}}{(1+\tau_t^c)} = \beta E_t \frac{c_{t+1}{}^{-\sigma}}{(1+\tau_{t+1}^c)} \left[\left(1-\tau_{t+1}^k\right) r_{t+1}^k + (1-\delta) \right] \tag{52}$$

$$\frac{c_t{}^{-\sigma}}{R_t} \frac{1}{(1+\tau_t^c)} = \beta E_t \frac{c_{t+1}{}^{-\sigma}}{(1+\tau_{t+1}^c)} \frac{1}{\Pi_{t+1}} \tag{53}$$

$$\chi_m m_t^{-\mu} - \frac{c_t^{-\sigma}}{(1+\tau_t^c)} + \beta E_t \frac{c_{t+1}^{-\sigma}}{(1+\tau_{t+1}^c)} \frac{1}{\Pi_{t+1}} = 0 \tag{54}$$

$$w_t = \left(w_{t-1} \frac{1}{\Pi_t} \right)^{\gamma} \left(\frac{\chi_n (1+\tau_t^c) n_t^{\eta}}{(1-\tau_t^n) c_t^{-\sigma}} \right)^{1-\gamma} \tag{55}$$

Final Equilibrium system

$$k_t = (1-\delta)\, k_{t-1} + x_t \tag{56}$$

$$z_t^1 = \frac{\phi - 1}{\phi} z_t^2 \tag{57}$$

$$w_t = mc_t (1-a) \frac{y_t}{n_t} \tag{58}$$

$$r_t^k = mc_t a \frac{y_t}{k_{t-1}} \tag{59}$$

Final Equilibrium system

$$d_t = y_t - w_t n_t - r_t^k k_{t-1} \tag{60}$$

$$y_t = \frac{1}{\Delta_t} A_t k_{t-1}^a n_t^{1-a} \tag{61}$$

$$b_t + m_t = R_{t-1} b_{t-1} \frac{1}{\Pi_t} + m_{t-1} \frac{1}{\Pi_t} + s_t^g y_t - \tau_t^c c_t - \tau_t^n w_t n_t - \tau_t^k \left[r_t^k k_{t-1} + d_t \right. \tag{62}$$

$$y_t = c_t + x_t + s_t^g y_t \tag{63}$$

$$\Pi_t^{1-\phi} = \theta + (1-\theta) \left[\Theta_t \Pi_t \right]^{1-\phi} \tag{64}$$

$$\Delta_t = (1-\theta) \Theta_t^{-\phi} + \theta \Pi_t^{\phi} \Delta_{t-1} \tag{65}$$

Final Equilibrium system

$$z_t^1 = y_t mc_t \Theta_t^{-\phi-1} + \beta\theta E_t \frac{c_{t+1}^{-\sigma}}{c_t^{-\sigma}} \frac{1+\tau_t^c}{1+\tau_{t+1}^c} \left(\frac{\Theta_t}{\Theta_{t+1}}\right)^{-\phi-1} \Pi_{t+1}^{\phi} z_{t+1}^1 \quad (66)$$

$$z_t^2 = \Theta_t^{-\phi} y_t + \beta\theta E_t \frac{c_{t+1}^{-\sigma}}{c_t^{-\sigma}} \frac{1+\tau_t^c}{1+\tau_{t+1}^c} \left(\frac{\Theta_t}{\Theta_{t+1}}\right)^{-\phi} \Pi_{t+1}^{\phi-1} z_{t+1}^2 \quad (67)$$

$$V_t = \frac{c_t^{1-\sigma}}{1-\sigma} + \chi_m \frac{m_t^{1-\mu}}{1-\mu} - \chi_n \frac{n_t^{1+\phi}}{1+\phi} + \chi_g \frac{\left(s_t^g y_t\right)^{1-\zeta}}{1-\zeta} + \beta E_t V_{t+1} \quad (68)$$

Final Equilibrium system

$$\log\left(\frac{R_t}{R}\right) = \phi_\pi \log\left(\frac{\Pi_t}{\Pi}\right) + \phi_y \log\left(\frac{y_t}{y}\right) + \nu_t^R \tag{69}$$

$$s_t^g - s^g = -\gamma_l^g \left(l_{t-1} - l\right) - \gamma_y^g \left(y_t - y\right) + \nu_t^g \tag{70}$$

$$\tau_t^c - \tau^c = \gamma_l^c \left(l_{t-1} - l\right) + \gamma_y^c \left(y_t - y\right) + \nu_t^c \tag{71}$$

$$\tau_t^k - \tau^k = \gamma_l^k \left(l_{t-1} - l\right) + \gamma_y^k \left(y_t - y\right) + \nu_t^k \tag{72}$$

$$\tau_t^n - \tau^n = \gamma_l^n \left(l_{t-1} - l\right) + \gamma_y^n \left(y_t - y\right) + \nu_t^n \tag{73}$$

$$l_t \equiv \frac{R_t b_t}{y_t} \tag{74}$$

Final Equilibrium system

There are therefore 23 equations in 23 endogenous variables, $\{y_t,\ c_t,\ n_t,\ x_t,\ k_t,\ m_t,\ b_t,\ \Pi_t,\ \Theta_t,\ \Delta_t,\ w_t,\ mc_t,\ d_t,\ r_t^k,\ z_t^1,\ z_t^2,\ V_t,\ R_t,\ s_t^g,\ \tau_t^c,\ \tau_t^k,\ \tau_t^n,\ l_t\}_{t=0}^{\infty}$.
Among them, there are 16 non-predetermined or jump variables, $\{y_t,\ c_t,\ n_t,\ x_t,\ \Pi_t,\ \Theta_t,\ mc_t,\ d_t,\ r_t^k,\ z_t^1,\ z_t^2,\ V_t,\ s_t^g,\ \tau_t^c,\ \tau_t^k,\ \tau_t^n\}_{t=0}^{\infty}$, and 7 predetermined or state variables, $\{w_t,\ R_t,\ k_t,\ b_t,\ m_t,\ \Delta_t,\ l_t\}_{t=0}^{\infty}$.
This is given technology and policy shocks, $\{A_t, \nu_t^R, \nu_t^g, \nu_t^c, \nu_t^k, \nu_t^n\}_{t=0}^{\infty}$, and initial conditions for the state variables.
To solve this first-order non-linear difference equation system, we will take a second-order approximation around its long-run solution.

Data, calibration and long-run solution

Table 1: Parameter values

Parameter	Value	Description
a	0.33	share of capital
β	0.9926	discount factor
μ	3.42	real money balances elasticity
δ	0.021	capital depreciation rate (quarterly)
ϕ	6	price elasticity of demand
η	1	Frisch labour supply elasticity
σ	1	elasticity of intertemporal substitution
ζ	1	elasticity of public consumption in utility
θ	2/3	share of firms which cannot reset their prices
γ	0.95	wage rigidity parameter
χ_m	0.05	preference parameter for real money balances
χ_n	6	preference parameter for hours worked
χ_g	0.1	preference parameter for public good

Data, calibration and long-run solution

Table 1(continued)

ρ^A	0.8	serial correlation of TFP shock
ρ^R	0.85	serial correlation of monetary shock
ρ^g	0.87	serial correlation of spending shock
ρ^c	0.96	serial correlation of consumption tax shock
ρ^k	0.97	serial correlation of capital tax shock
ρ^n	0.94	serial correlation of labour tax shock
σ_A	0.0062	standard deviation of innovation to TFP shock
σ_R	0.005	standard deviation of innovation to monetary shock
σ_g	0.016	standard deviation of innovation to spending shock
σ_c	0.001	standard deviation of innovation to consumption tax shock
σ_k	0.003	standard deviation of innovation to capital tax shock
σ_n	0.0005	standard deviation of innovation to labour tax shock

Data, calibration and long-run solution

Table 2: Long-run values of policy instruments

R	τ^c	τ^k	τ^n	s^g	$s^l \equiv \frac{\tau^l}{y^H}$
1.0075	0.19	0.28	0.38	0.23	-0.20

Status quo long-run solution

Table 3: Long-run solution and some data

Variables	Long-run solution	Variables	Long-run solution	Data
y	0.74	mc	0.83	-
c	0.46	d	0.12	-
n	0.28	r^k	0.04	-
x	0.11	z^1	1.82	-
k	5.19	z^2	2.18	-
m	1.46	V	-161.62	-
b	2.52	I	3.43	-
Π	1	$\frac{c}{y}$	0.62	0.57
Θ	1	$\frac{b}{y}$	3.4	3.4
Δ	1	$\frac{x}{y}$	0.15	0.18
w	1.47	$\frac{m}{y}$	1.97	-
		$\frac{k}{y}$	7	-

How we work

- We take a second-order approximation of expected discounted lifetime utility, V_0, subject to a second-order approximation of the equilibrium conditions. See Schmitt-Grohé and Uribe (2004). This is given policy and in particular feedback policy coefficients.
- We compute the feedback policy coefficients that maximize the above. See Schmitt-Grohé and Uribe (2005, 2007). This is the so-called optimized policy rules.
- Welfare comparison: Say that there is a flat consumption subsidy, ξ, that makes the agent indifferent between two regimes, s and r. Then,

$$\xi \simeq \left(V_0^s - V_0^r\right)(1-\beta) \tag{75}$$

so that if $\xi > 0$ (resp. $\xi < 0$), the agent is better off under s (resp. under r).

The stabilization regime with the highest ξ is the most preferred one. See e.g. Lucas (1990).

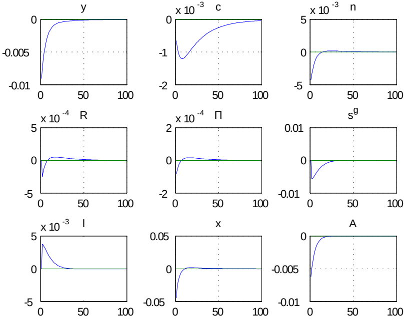
Table 4: Optimal monetary reaction to inflation and output and optimal fiscal reaction to debt and output

Policy instruments	Optimal interest-rate reaction to inflation and output	Optimal fiscal reaction to debt and output	ξ
R_t s_t^g	$\phi_\pi = 3$ $\phi_y = 0$	$\gamma_l^g = 0.1$ $\gamma_y^g = 0$	0.022
R_t τ_t^c	$\phi_\pi = 3$ $\phi_y = 0.096$	$\gamma_l^c = 0.1$ $\gamma_y^c = 0.3428$	0.0206
R_t τ_t^k	$\phi_\pi = 3$ $\phi_y = 0.39$	$\gamma_l^k = 3$ $\gamma_y^k = 0.051$	0.02
R_t τ_t^n	$\phi_\pi = 3$ $\phi_y = 0.044$	$\gamma_l^n = 0.1$ $\gamma_y^n = 3$	0.0195

Results without wage rigidity

Impulse Responce Functions

Figure 1: Impulse responce functions to a negative TFP shock under the best possible policy mix



Results without wage rigidity

Impulse Responce Functions

Figure 2: Impulse responce functions to a negative TFP shock when the fiscal instrument is the consumption tax rate

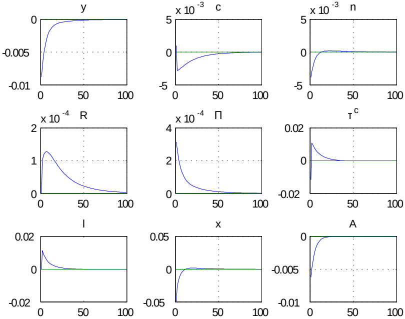


Figure 3: Impulse responce functions to a negative TFP shock when the fiscal instrument is the capital tax rate

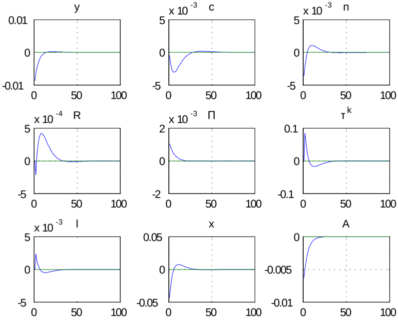


Figure 4: Impulse responce functions to a negative TFP shock when the fiscal instrument is the labour tax rate

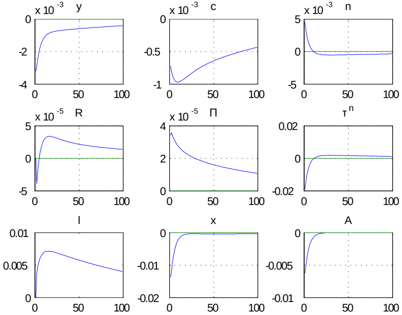
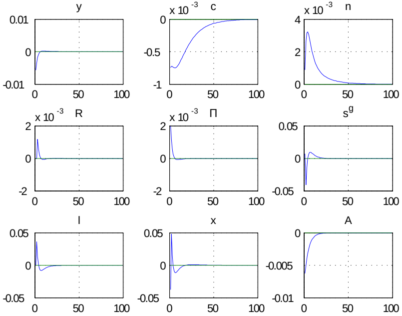


Table 5: Optimal monetary reaction to inflation and output and optimal fiscal reaction to debt and output

Policy instruments	Optimal interest-rate reaction to inflation and output	Optimal fiscal reaction to debt and output	ξ
R_t s_t^g	$\phi_\pi = 3$ $\phi_y = 0.84$	$\gamma_l^g = 0.1$ $\gamma_y^g = 0.4$	0.0312
R_t τ_t^c	$\phi_\pi = 3$ $\phi_y = 0.66$	$\gamma_l^c = 0.1$ $\gamma_y^c = 0.4$	0.0298
R_t τ_t^k	$\phi_\pi = 3$ $\phi_y = 0.84$	$\gamma_l^k = 3$ $\gamma_y^k = 3$	0.0299
R_t τ_t^n	$\phi_\pi = 3$ $\phi_y = 1.99$	$\gamma_l^n = 0.1$ $\gamma_y^n = 3$	0.0297

Figure 5: Impulse responce functions to a negative TFP shock under the best possible policy mix



Results with wage rigidity

Impulse responce functions

Figure 6: Impulse responce functions to a negative TFP shock when the fiscal instrument is the consumption tax rate

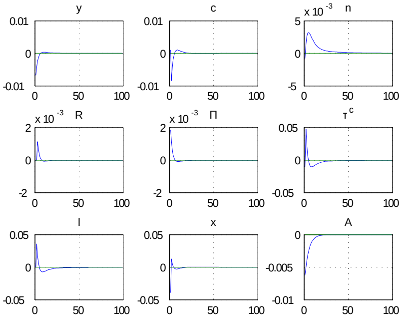


Figure 7: Impulse responce functions to a negative TFP shock when the fiscal instrument is the capital tax rate

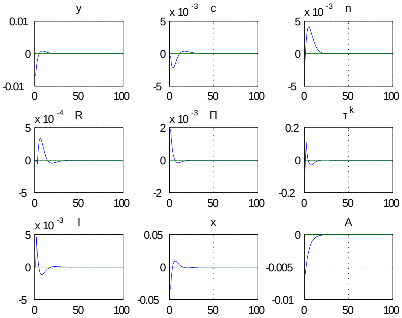
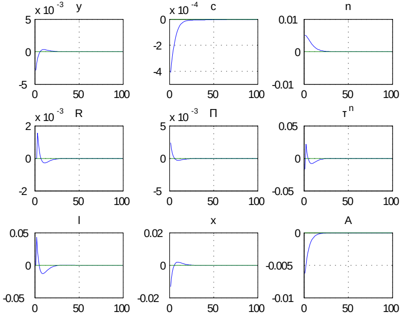


Figure 8: Impulse responce functions to a negative TFP shock when the fiscal instrument is the labour tax rate



Results

- Among fiscal instruments, public spending is the best, or the least distorting, instrument to use in all cases.
- It is optimal to use the nominal interest rate to react aggresively to inflation and a fiscal policy instrument (as said, preferably, public spending) to react to the debt cycle in all cases.
- Policy (both monetary and fiscal) reaction to the output gap is always recommended under wage rigidity.
- Actually, under wage rigidity, fiscal reaction to the output gap should not be weaker than reaction to public debt, $\gamma_y^q \geq \gamma_l^q > 0$. Thus, the net changes in fiscal policy instruments should be dominated by developments in real activity. To put it differently, counter-cyclical (fiscal) policy, or fiscal activism, are productive under wage rigidity.

Results (continued)

- Under wage rigidity, if the economy is hit by an adverse supply shock, which causes a fall in output and a rise in the debt burden as share of output, public spending should rise, and all tax rates should fall, at impact. Only in turn the fiscal authorities should use their tax-spending instruments to address debt imbalances.
- Under wage flexibility, there is partial support to the consensus assignment. In particular, over the short and medium term, fiscal reaction to debt should outweigh reaction to output if we use public spending and capital taxes, while, the opposite should happen if we use consumption and especially labor taxes.
- The welfare benefits from active policy are larger under wage rigidity (compare the values of ξ).

Extensions

- Other labor market frictions
- Open economy (semi-small open economy or 2-country model)
- Heterogeneity across agents (e.g. workers versus capitalists) and distributional implications of stabilization policy