Macroeconomic Effects of Taxes on Banking

ONLINE APPENDIX

A The Complete Model

We now introduce the main components of the model. Although we use an index j to distinguish households, firms, banks, etc., we focus on a symmetric equilibrium where this index will not affect the description of the equilibrium. The model differs from that in Boscá et al. (2020) in two key ways: (1) given the nature of our analysis, we employ a deterministic version of the model, omitting any reference to stochastic shocks, and (2) we introduce banking taxes, which affect several equations in the model. For each agent in the economy, we primarily present the optimization problem, specifying both the objective function and the budget constraint.

A.1 Patient households

There is a continuum of patient households in the economy indexed by j, with mass γ_p, whose utility depends on consumption, $c^p_{j,t}$; housing services, $h^p_{j,t}$; and hours worked, $\ell^p_{j,t}$ and has the following form:

$$E_0 \sum_{t=0}^{+\infty} \beta_p^t \left[(1-a_{cp}) log(c^p_{j,t} - a_{cp} c^p_{t-1}) + a_{hp} log(h^p_{j,t}) - \frac{a_{\ell p} {\ell^p_{j,t}}^{1+\phi}}{1+\phi} \right], \tag{1}$$

where c^p_t denotes the average patient household's consumption, $c^p_t = \gamma_p^{-1} \left(\int_0^{\gamma_p} c^p_{j,t} dj \right)$, and a_{cp} is a habit parameter.

The jth patient household is subject to the following budget constraint (expressed in terms of final goods):

$$(1+\tau_t^c)c_{j,t}^p + (1+\tau_t^h)q_t^h(h_{j,t}^p - (1-\delta_h)h_{j,t-1}^p) + d_{j,t}^p + \frac{\alpha_{RW}(1-\alpha_{B_g})Bg_t}{\gamma_p} =$$

$$(1-\tau_t^w)w_{j,t}^p\ell_{j,t}^p + \frac{1+r_{t-1}^d}{\pi_t}d_{j,t-1}^p + \frac{(1-\omega_b)(1-\tau_t^{Jb})}{\gamma_p}J_{t-1}^b - \frac{T_t^{up}}{\gamma_p} + \frac{T_t^g}{\gamma_p+\gamma_i+\gamma_e+\gamma_m} +$$

$$\frac{\alpha_{RW}(1-\alpha_{B_g})(1+r_t^d)Bg_{t-1}}{\gamma_p},$$

Taxes on banks' profits, τ_t^{Jb}, affect the patient households' budget constrained by reducing the amount of net profits that banks distribute, $\frac{(1-\omega_b)(1-\tau_t^{Jb})J_{t-1}^b}{\gamma_p}$ (where ω_b is the share of benefits that the banking sector does not distribute as dividends).

The rest of the variables are the following: $\pi_t = \frac{P_t}{P_{t-1}}$ is the gross inflation of the consumption good, with P_t denoting the price of the consumption good, and τ_t^w, τ_t^c, τ_t^h denoting taxes on labor income, consumption, and accumulation of housing services, respectively; q_t^h is the price of housing services in terms of the consumption good; δ_h is the depreciation rate of housing; $w_{j,t}^p$ is the real wage in terms of the consumption good; and r_{t-1}^d is the nominal interest rate on deposits.

The flow of expenses, expressed in terms of the consumption good, is consumption (plus consumption taxes), $(1+\tau_t^c)c_{j,t}^p$; investment in housing services (plus taxes on housing services), $(1+\tau_t^h)q_t^h(h_{j,t}^p-(1-\delta_h)h_{j,t-1}^p)$; current deposits, $d_{j,t}^p$; and government bonds $\frac{\alpha_{RW}(1-\alpha_{B_g})Bg_t}{\gamma_p}$.

The sources of income, also expressed in terms of the consumption good, are after-tax labor income, $(1-\tau_t^w)w_{j,t}^p\ell_{j,t}^p$; deposits gross return from the previous period, $\left(\frac{1+r_{t-1}^d}{\pi_t}\right)d_{j,t-1}^p$; dividends from the banking sector, that is, the fraction of after-tax distributed profits; the cost of participating in the labor union paid to the unions, $\frac{T_t^{up}}{\gamma_p}$; lump-sum transfers received from the government, $\frac{T_t^g}{\gamma_p+\gamma_i+\gamma_e+\gamma_m}$; and payments on government bonds $\frac{\alpha_{RW}(1-\alpha_{B_g})(1+r_t^d)Bg_{t-1}}{\gamma_p}$, where γ_i, γ_e, and γ_m represent the mass of the rest of consumers in the model (impatient, hand-to-mouth and entrepreneurs); α_{RW} is the share of public debt in the hands of resident agents (that is, "domestic" public debt) from which a share α_{B_g} is in the hands of banks and $(1-\alpha_{B_g})$ in the hands of patient households.[1]

[1] We assume that all households have access to a Arrow-Debreu securities, although we do not write the whole set of possible Arrow-Debreu securities in the budget constraint to save on notation.

A.2 Impatient households

There is a continuum of impatient households in the economy indexed by j, with mass γ_i, whose utility depends on consumption $c^i_{j,t}$, housing services $h^i_{j,t}$ and hours worked $\ell^i_{j,t}$, and has the following form:

$$E_0 \sum_{t=0}^{+\infty} \beta_i^t \left[(1 - a_{ci}) log(c^i_{j,t} - a_{ci} c^i_{t-1}) + a_{hi} log(h^i_{j,t}) - \frac{a_{\ell i} \ell^{i\,1+\phi}_{j,t}}{1+\phi} \right] \tag{2}$$

where c^i_t denotes the consumption of the average patient household, $c^i_t = \gamma_i^{-1} \left(\int_0^{\gamma_i} c^i_{j,t} dj \right)$. The jth impatient household budget constraint, expressed in terms of final goods, is given by:

$$(1 + \tau^c_t) c^i_{j,t} + (1 + \tau^h_t) q^h_t (h^i_{j,t} - (1 - \delta_h) h^i_{j,t-1}) + \frac{1 + r^{bi}_{t-1}}{\pi_t} b^i_{j,t-1} =$$
$$(1 - \tau^w_t) w^i_{j,t} \ell^i_{j,t} + b^i_{j,t} - \frac{T^{ui}_t}{\gamma_i} + \frac{T^g_t}{\gamma_p + \gamma_i + \gamma_e + \gamma_m},$$

where $w^i_{j,t}$ denotes the real wage in terms of consumption goods and r^{bi}_{t-1} is the nominal interest rate on loans.

This budget constraint reflects the fact that impatient households do not receive any dividends. Having said that, their expenses and incomes are similar to the ones described for patient households. The main difference is $b^i_{j,t}$, which represents bank loans. Additionally, impatient households face a borrowing constraint. In terms of final goods, they cannot borrow more than a certain proportion of the expected value in period t of the value in period $t+1$ of their housing stock in period t discounted by $(1 + r^{bi}_t)$:

$$(1 + r^{bi}_t) b^i_{j,t} \leq m^i E_t \left\{ q^h_{t+1} h^i_{j,t} \pi_{t+1} \right\},$$

where m^i is the loan-to-value ratio for all impatient households' mortgages.[2]

A.3 Hand-to-mouth households

There is a continuum of hand-to-mouth households in the economy indexed by j, with mass γ_m, whose utility function depends on consumption $c^m_{j,t}$ and hours worked $\ell^i_{j,t}$, and has the following form:

$$E_0 \sum_{t=0}^{+\infty} \beta_m^t \left[(1 - a_{cm}) log(c^m_{j,t} - a_{cm} c^m_{t-1}) - \frac{a_{\ell m} \ell^{m\,1+\phi}_{j,t}}{1+\phi} \right] \tag{3}$$

[2] In our model the loan-to-value ratio is exogenous. See Falagiarda and Saia (2017) for a DSGE model with constrained households and banks in which the presence of endogenous loan-to-value ratios exacerbates the procyclicality of lending.

where c_t^m denotes the average household consumption of hand-to-mouth, $c_t^m = \gamma_m^{-1}\left(\int_0^{\gamma_m} c_{j,t}^m dj\right)$. The jth hand-to-mouth household budget constraint is given by:

$$(1+\tau_t^c)c_{j,t}^m = (1-\tau_t^w)w_{j,t}^m \ell_{j,t}^m - \frac{T_t^{um}}{\gamma_m} + \frac{T_t^g}{\gamma_p + \gamma_i + \gamma_e + \gamma_m}$$

where $w_{j,t}^m$ is the real wage in terms of consumption good.

This budget constraint reflects the fact that hand-to-mouth households do not receive any dividend. Having said that, the only expense of hand-to-mouth households is after-tax consumption. The sources of income are labor income, net of the cost of participating in the labor union paid to the unions, and the lump-sum transfers received from the government. Hand-to-mouth households do not have bank deposits or bank loans.

A.4 Labor unions and labor packers

There are three types of labor unions and three types of "labor packers", one for each type of household. Given the similarity of the problem of choosing wages and labor supply for the three types of households, we present a general derivation of the problem using the superindex s to denote patient households, $s = p$; impatient households, $s = i$; and hand-to-mouth households, $s = m$.

There is a continuum of labor unions of each type in the economy indexed by j. Each household (j, s) delegates its labor decision to labor unions (j, s). The labor union (j, s) sells labor in a monopolistically competitive market to the "labor packer" of type s. The labor packer of type s sells bundled labor in a competitive market to intermediate good producers. The labor packer of type s uses the following production function to bundle labor:

$$\ell_t^s = \left(\int_0^{\gamma_s} \left(\ell_{j,t}^s\right)^{\frac{\varepsilon^\ell - 1}{\varepsilon^\ell}} dj\right)^{\frac{\varepsilon^\ell}{\varepsilon^\ell - 1}},$$

where ℓ_t^s is the labor of households of type s and ε^ℓ is the substitution elasticity among different types of labor. The labor packer of type s chooses $l_{j,t}^s$ for all j in order to maximize:

$$w_t^s \ell_t^s - \int_0^{\gamma_s} w_{j,t}^s \ell_{j,t}^s dj.$$

subject to the production function and taking all wages as given. Both $w_{j,t}^s$ and w_t^s refer to real wages in terms of the consumption good. The standard input demand function associated with this problem is:

$$\ell_{j,t}^s = \left(\frac{w_{j,t}^s}{w_t^s}\right)^{-\varepsilon^\ell} \ell_t^s.$$

The standard aggregate real wage is $w_t^s = \left(\int_0^{\gamma_s} w_{j,t}^{1-\varepsilon^\ell} dj\right)^{\frac{1}{1-\varepsilon^\ell}}$. The labor union of type (s,j) sets the nominal wage, $W_{j,t}^s$, by maximizing the following objective function, which represents the utility of the household supplying the labor from the resulting wage income net of a quadratic cost for adjusting the nominal wage:

$$E_0 \sum_{t=0}^{+\infty} \beta_s^t \left\{ U_{c,j,t}^s \theta_t^{wc} \left[w_{j,t}^s \ell_{j,t}^s - \frac{\eta_w}{2} \left(\pi_{j,t}^{ws} - \pi_{t-1}^{\iota_w} \pi^{1-\iota_w} \right)^2 w_t^s \right] - \frac{a_{\ell s} {\ell_{j,t}^s}^{1+\phi}}{1+\phi} \right\}$$

subject to:

$$\ell_{j,t}^s = \left(\frac{w_{j,t}^s}{w_t^s} \right)^{-\varepsilon^\ell} \ell_t^s,\ w_{j,t}^s = \frac{W_{j,t}^s}{P_t}, \text{ and } \pi_{j,t}^{ws} = \left(\frac{w_{j,t}^s}{w_{j,t-1}^s} \right) \pi_t,$$

where $\theta_t^{wc} \equiv \left(\frac{1-\tau_t^w}{1+\tau_t^c} \right)$ and $U_{c,j,t}^s$ represents the instantaneous marginal utility of the household taken as given by unions. Finally, the cost of participating in the labor union is equal to the quadratic cost of changing the wage:

$$T_t^{us} = \gamma_s \frac{\eta_w}{2} \left(\pi_t^{ws} - \pi_{t-1}^{\iota_w} \pi^{1-\iota_w} \right)^2 w_t^s$$

for all types of households.

A.5 Entrepreneurs

There is a continuum of entrepreneurs in the economy indexed by j, with mass γ_e, whose utility function depends on consumption $c_{j,t}^e$, and has the following form:

$$E_0 \sum_{t=0}^{+\infty} \beta_e^t (1 - a_{ce}) log(c_{j,t}^e - a_{ce} c_{t-1}^e) \tag{4}$$

where c_t^e denotes the average consumption of the entrepreneur, $c_t^e = \gamma_e^{-1} \left(\int_0^{\gamma_e} c_{j,t}^e dj \right)$. The jth entrepreneur's budget constraint is given by:

$$\begin{aligned} &(1+\tau_t^c) c_{j,t}^e + \frac{1+r_{t-1}^{be}}{\pi_t} b_{j,t-1}^e + q_t^k k_{j,t}^e = \\ &(1-\tau_t^k) r_t^k k_{j,t}^e + q_t^k (1-\delta) k_{j,t-1}^e + b_{j,t}^e + \frac{J_t^R}{\gamma_e} + \frac{J_t^x}{\gamma_e} + \frac{J_t^k}{\gamma_e} + \frac{J_t^h}{\gamma_e} + \frac{T_t^g}{\gamma_p + \gamma_i + \gamma_e + \gamma_m}. \end{aligned}$$

where τ_t^k denotes taxes on returns on capital, q_t^k is the price of the capital good in terms of the consumption good, r_t^k is the return on capital in terms of the consumption good, and r_{t-1}^{be} is the nominal interest rate on loans.

Entrepreneurs buy the capital good from the capital good producers and rent it to the intermediate good producers. They also own the intermediate good producers' firms, the capital good producers' firms and the housing producers' firms and have bank loans. The flow of expenses of entrepreneurs is given by consumption (plus consumption taxes) $(1+\tau_t^c)c_{j,t}^e$, capital purchases $q_t^k k_{j,t}^e$, and interest plus principal of loans taken out during the previous period, $\frac{1+r_{t-1}^{be}}{\pi_t} b_{j,t-1}^e$. Sources of income are determined by rental capital (minus capital taxes), $(1-\tau_t^k) r_t^k k_{j,t}^e$; loans, $b_{j,t}^e$; capital from the previous period $q_t^k(1-\delta)k_{j,t-1}^e$; dividends from retail firms, $\frac{J_t^R}{\gamma_e}$; dividends from intermediate good producers $\frac{J_t^x}{\gamma_e}$; dividends from capital good producers, $\frac{J_t^k}{\gamma_e}$, dividends from housing producers, $\frac{J_t^h}{\gamma_e}$, and lump-sum taxes paid to the government, $\frac{T_t^g}{\gamma_p+\gamma_i+\gamma_p}$.

In addition, impatient entrepreneurs face a borrowing constraint. In terms of final goods, they cannot borrow more than a certain proportion of the expected value in period t of the value in period $t+1$ of their capital stock in period $t+1$ discounted by $(1+r_t^{be})$:

$$(1+r_t^{be})b_{j,t}^e \leq m^e E_t \left\{ q_{t+1}^k \pi_{t+1}(1-\delta)k_{j,t}^e \right\},$$

where m^e stands for the loan-to-value ratio for capital.

A.6 Intermediate good producers

There is a continuum of competitive intermediate good producers in the economy indexed by j, with mass γ_x. Intermediate good producers sell intermediate goods in a competitive market to retailers. The jth intermediate good producer has access to a technology represented by a production function:

$$y_{j,t}^x = A\left(k_{j,t-1}^{ee}\right)^{\alpha}\left[\left(\ell_{j,t}^{pp}\right)^{\mu_p}\left(\ell_{j,t}^{ii}\right)^{\mu_i}\left(\ell_{j,t}^{mm}\right)^{\mu_m}\right]^{1-\alpha}\left(\frac{K_{t-1}^g}{\gamma_x}\right)^{\alpha_g},$$

where $k_{j,t-1}^{ee}$ is the capital rented by the firm from entrepreneurs, $\ell_{j,t}^{pp}$ is the amount of "packed" patient labor input rented by the firm, $\ell_{j,t}^{ii}$ is the amount of "packed" impatient labor input rented by the firm, $\ell_{j,t}^{mm}$ is the amount of "packed" hand-to-mouth labor input rented by the firm, and K_{t-1}^g is public capital. A_t stands for the exogenous aggregate productivity level.

In addition to the cost of the inputs required for production, the intermediate good producers face a fixed cost of production, Φ_x, which guarantees that the economic profits are equal to zero in the steady state.Hence, the profits of the representative intermediate good producers can be written as:

$$\frac{J_t^x}{\gamma_x} = \frac{y_t^x}{x_t} - w_t^p \ell_t^{pp} - w_t^i \ell_t^{ii} - w_t^m \ell_t^{mm} - r_t^k k_{t-1}^{ee} - \Phi_x.$$

A.7 Capital good producers

There is a continuum of capital goods producers in the economy indexed by j, with mass γ_k. Capital goods producers sell new capital goods, $k_{j,t}$, in a competitive market, to entrepreneurs.

The jth capital goods producer produces these new capital goods out of the non-depreciated portion of old capital goods, $(1-\delta)k_{j,t-1}$, bought from entrepreneurs at price q_t^k, and of gross investment goods, $i_{j,t}^z$, bought from investment good packers at price p_t^I. However, whereas old non-depreciated capital goods can be converted one to one to new capital, gross investment goods are subject to non-linear adjustment costs, which causes a one to less than one conversion, such that, all in all, the amount of new capital goods evolves according to the following law of motion:

$$k_{j,t} = (1-\delta)k_{j,t-1} + i_{j,t}.$$

where $i_{j,t}$ is effective investment, which is related to investment (gross of adjustment costs) through the following expression:

$$i_{j,t}^k = i_{j,t}\left[1 + \frac{\eta_i}{2}\frac{i_{j,t}}{k_{j,t-1}}\right],$$

so that $i_{j,t} \leq i_{j,t}^k$. Then, each capital good producer chooses $k_{j,t}$ and $i_{j,t}$ in order to maximize profit subject to the law of motion for capital. Because of complete markets we get $i_{j,t} = i_t$ and hence:

$$q_t^k - p_t^I\left(1 + \frac{\eta_i i_t}{k_{t-1}}\right) = 0 \text{ and } k_t = (1-\delta)k_{t-1} + i_t.$$

Finally, the profits of the representative capital good producer are:

$$\frac{J_t^k}{\gamma_k} = \left[q_t^k - p_t^I\left(1 + \frac{\eta_i}{2}\frac{i_t}{k_{t-1}}\right)\right] i_t.$$

A.8 Housing producers

Following Gómez-González and Rees (2018) we model production of housing in a similar way to productive capital production. There is a continuum of housing producers with mass γ_h working in a competitive market and selling their production to patient and impatient households. Under the assumption of complete markets the evolution of housing is characterized by:

$$h_t = (1-\delta_h)h_{t-1} + i_t^{ho}$$

where i_t^{ho} is effective housing investment, which is augmented by some adjustment costs to become gross of adjustment costs housing investment, i_t^{hz}:

$$i_t^{hz} = i_t^{ho}\left[1 + \frac{\eta_h}{2}\frac{i_t^{ho}}{h_{t-1}}\right]$$

Output and input housing prices are linked through the following expression:

$$q_t^h = p_t^H\left(1 + \frac{\eta_h i_t^{ho}}{h_{t-1}}\right)$$

where p_t^H is the price of domestic-produced output in terms of consumption goods. Contrary to capital investment goods, housing is a non-tradable good. This price can differ from the price paid by households, q_t^h due to adjustment costs. The profits of the representative housing producer are:

$$\frac{J_t^h}{\gamma_h} = \left[q_t^h - p_t^H \left(1 + \frac{\eta_h}{2}\frac{i_t^{ho}}{h_{t-1}}\right)\right] i_t^{ho}.$$

A.9 Retailers

There is a continuum of retailers indexed by j, with mass γ. Each retailer buys the intermediate good from intermediate goods producers, differentiates it and sells the resulting varieties of intermediate goods, in a monopolistically competitive market, to goods packers, who, in turn, bundle the varieties together into a domestic good and sell it, in a competitive market, to consumption and investment goods packers that bundle home and imported production. We assume that retail prices are indexed by a combination of past and steady-state inflation of retail prices with relative weights parameterized by ι_p. In addition, retailers are subject to quadratic price adjustment costs, where η_p controls the size of these costs. Then, each retailer chooses the nominal price for its differentiated good, $P_{j,t}^H$ to maximize:

$$E_0 \sum_{t=0}^{+\infty} \beta_p^t \lambda_{j,t}^p \left[p_t^H \frac{P_{j,t}^H y_{j,t}}{P_t^H} - \frac{y_{j,t}^{xx}}{x_t} - \frac{\eta_p}{2}\left(\frac{P_{j,t}^H}{P_{j,t-1}^H} - \left(\pi_{t-1}^H\right)^{\iota_p}\left(\pi_{ss}^H\right)^{1-\iota_p}\right)^2 y_t\right]$$

subject to:

$$y_{j,t} = y_{j,t}^{xx} \text{ and } y_{j,t} = \left(\frac{P_{j,t}^H}{P_t^H}\right)^{-\varepsilon^y} y_t,$$

here we have used $\lambda_{j,t}^p$ because capital goods producers are owned by patient households, $p_t^H = \frac{P_t^H}{P_t}$, $\pi_t^H = \frac{P_t^H}{P_{t-1}^H}$, and ε^y is the elasticity of substitution among retailing goods.

The demand faced by retailers is derived from the optimization problem solved by goods packers. Finally, the representative retailer's profits are:

$$\frac{J_t^R}{\gamma} = y_t\left[1 - \frac{1}{x_t} - \frac{\eta_p}{2}\left(\pi_t^H - \left(\pi_{t-1}^H\right)^{\iota_p}\left(\pi_{ss}^H\right)^{1-\iota_p}\right)^2\right],$$

where x_t is the inverse of the price of intermediate goods in terms of the consumption good.

A.10 Banks

There is a continuum of bank branches with mass γ_b. Each bank branch is composed of three units: a wholesale unit and two retail units. The two retail units are responsible for selling differentiated loans and differentiated deposits, in monopolistically competitive markets, to loan and deposit packers. The wholesale unit manages the capital position of the bank, receives loans from abroad, and raises wholesale domestic loans and deposits. The loan-retailing unit also gives loans to the government in a competitive market.

A.10.1 Wholesale unit

The wholesale unit of branch j combines bank capital, $k^b_{j,t}$, wholesale deposits, $d^b_{j,t}$, and foreign borrowing, $-\frac{B^*_{j,t}}{\gamma_b}$, in order to issue wholesale domestic loans, $b^b_{j,t}$, in a competitive market. Thus, the balance sheet of the wholesale unit of branch j is:

$$b^b_{j,t} = d^b_{j,t} - \frac{B^*_{j,t}}{\gamma_b} + k^b_{j,t}. \tag{5}$$

Bank capital, in nominal terms, $\hat{k}^b_j$ evolves according to the following law of motion:

$$\hat{k}^b_{j,t} = (1-\delta_b)\hat{k}^b_{j,t-1} + (1-\tau^{Jb}_t)\omega_b \hat{j}^b_{j,t-1},$$

where $\hat{j}^b_{j,t}$ represents the profits of the bank in nominal terms, and δ_b the depreciation rate on bank capital[3]. Notice that profits are reduced according to the tax τ^{Jb}_t.

Given these definitions, the problem of the wholesale unit of branch j is to choose the amount of wholesale loans, $b^b_{j,t}$, and wholesale deposits, $d^b_{j,t}$, and foreign borrowing, B^*_t, in order to maximize cash flows:

$$\max_{b^b_{j,t}, d^b_{j,t}, B^*_{j,t}} r^b_t b^b_{j,t} - r^*_t d^b_{j,t} + r^*_t \frac{B^*_{j,t}}{\gamma_b} - \frac{\eta_b}{2}\left(\frac{k^b_{j,t}}{b^b_{j,t}} - \nu_b\right)^2 k^b_{j,t},$$

where we account for the fact that banks have to pay a cost, that we assume quadratic, whenever the capital-to-assets ratio $\frac{k^b_{j,t}}{b^b_{j,t}}$ deviates from an exogenously given target, η_b. Other variables in the function are r^b_t and r^*_t that represent the gross real interest rates for wholesale lending and borrowing respectively.

Wholesale banks can borrow from the deposit retailing branch, $d^b_{j,t}$, or from the rest of the world, $B^*_{j,t}$ at the same interest rate due to an arbitrage condition. Following Schmitt-Grohe and Uribe (2003), to ensure the stationarity of equilibrium we assume that there is a risk premium, ϕ_t, so that the interest that banks pay for borrowing differ from the monetary interest rate set by the central bank, r_t

$$r^*_t = \phi_t r_t$$

[3] The depreciation rate on bank capital admits two interpretations. First, a high value of this parameter indicates a bad management of capital. Second, it can be associated with the defaulting rate, a high rate affects positively to the parameter.

This risk premium increases with the external debt according to the expression:

$$\log \phi_t = -\widetilde{\phi}\left(\exp\left(B_t^*\right) - 1\right)$$

From the first order condition the following relationship is obtained between wholesale lending and borrowing interest rate:

$$\left(r_t^b - r_t^*\right) = -\eta_b \left(\frac{k_t^b}{b_t^b} - \nu_b\right)\left(\frac{k_t^b}{b_t^b}\right)^2 \tag{6}$$

A.10.2 Deposit-retailing unit

The deposit-retailing unit of branch j combines bank capital and sells a differentiated type of deposit, $d_{j,t}^{pp}$, in a monopolistically competitive market, to deposit packers, who bundle the varieties together and sell the packed deposits, in a competitive market, to patient households, d_t^{pp}. Finally, each deposit-retailing unit uses its resources to buy $d_{j,t}^b$ from the wholesale banks. Thus, the balance sheet of the deposit-retailing unit of branch j is $d_{j,t}^b = d_{j,t}^{pp}$. The deposit-retailing unit of branch j chooses the real gross interest rate paid by its type of deposit, $r_{j,t}^d$ in order to maximize:

$$E_0 \sum_{t=0}^{+\infty} \beta_p^t \lambda_t^p \left[r_t^* d_{j,t}^b - r_{j,t}^d d_{j,t}^{pp} - \frac{\eta_d}{2}\left(\frac{r_{j,t}^d}{r_{j,t-1}^d} - 1\right)^2 r_t^d d_t^{pp} \right]$$

subject to:

$$d_{j,t}^b = d_{j,t}^{pp} \text{ and } d_{j,t}^{pp} = \left(\frac{r_{j,t}^d}{r_t^d}\right)^{-\varepsilon^d} d_t^{pp},$$

where we have used $\lambda_{j,t}^p$ because capital goods producers are owned by patient households, and ε^d is the elasticity of substitution between types of deposits, which is related with the steady state markup, $\varepsilon^d \equiv \left(\frac{\theta^d}{\theta^d - 1}\right)$, with θ^d standing for the steady state markup.

The demand faced by deposit-retailing units is derived from the optimization problem solved by deposit packers, left implicit.

A.10.3 Loan-retailing unit

The loan-retailing unit of branch j borrows from the wholesale unit, $b_{j,t}^b$, creates differentiated loans and sells the resulting loan, in a monopolistically competitive market, to loan packers, who sell the packed loans to impatient households, $b_{j,t}^{ii}$ and entrepreneurs, $b_{j,t}^{ee}$. Each loan-retailing unit also lends to the government, B_t^g, in a competitive market at a rate $\theta_{ss}^g r_t^b$, i.e., charging a mark-up over the cost of the funds, but taking both the mark-up and the cost of the funds as given. Thus, the balance sheet of the loan-retailing unit of branch j is:

$$b_{j,t}^{ii} + b_{j,t}^{ee} + \frac{\alpha_{B_g} \alpha_{RW} B_t^g}{\gamma_b} = b_{j,t}^b.$$

The loan-retailing unit of branch j chooses the real gross interest rates for its loans to impatient households, $r_{j,t}^{bi}$, and entrepreneurs, $r_{j,t}^{be}$, in order to maximize profits subject to:

$$b_{j,t}^{ii} + b_{j,t}^{ee} + \frac{\alpha_{B_g}\alpha_{RW}B_t^g}{\gamma_b} = b_{j,t}^b,\ b_{j,t}^{ii} = \left(\frac{r_{j,t}^{bi}}{r_t^{bi}}\right)^{-\varepsilon^{bi}} b_t^{ii}, \text{ and } b_{j,t}^{ee} = \left(\frac{r_{j,t}^{be}}{r_t^{be}}\right)^{-\varepsilon^{be}} b_t^{ee},$$

where ε^{bi} and ε^{be} are the elasticities of substitution between types of loans for impatient households and for entrepreneurs, respectively, which are related with the markups.

The demand faced by the loan-retailing unit is derived from the optimization problem solved by loan packers is also left implicit.

A.10.4 Banks' profits

The profit of the representative bank branch in terms of consumption good units is given by:

$$j_t^b = (r_t^{bi} - \tau_t^b)b_t^{ii} + (r_t^{be} - \tau_t^b)b_t^{ee} + \theta_{ss}^g r_t^b \left(\alpha_{RW}\frac{B_t^g}{\gamma_b}\right) - (r_t^d + \tau_t^d)d_t^{pp} + r_t^* \frac{B_t^*}{\gamma_b} - \frac{\eta_b}{2}\left(\frac{k_t^b}{b_t^b} - \nu_b\right)^2 k_t^b$$
$$-\frac{\eta_d}{2}\left(\frac{r_t^d}{r_{t-1}^d} - 1\right)^2 (r_t^d + \tau_t^d)d_t - \frac{\eta_{bi}}{2}\left(\frac{r_t^{bi}}{r_{t-1}^{bi}} - 1\right)^2 (r_t^{bi} - \tau_t^b)b_t^{ii} - \frac{\eta_{be}}{2}\left(\frac{r_t^{be}}{r_{t-1}^{be}} - 1\right)^2 (r_t^{be} - \tau_t^b)b_t^{ee}.$$

where τ_t^b is the tax rate on bank loans and τ_t^d the tax rate on bank deposits. Both affect the *ex ante* amount of bank profits.

A.11 External sector

We consider a world of two asymmetric countries in which the home country is small relative to the other (the rest of the world), whose equilibrium is taken as exogenous (see Monacelli, 2004, and Gali and Monacelli, 2005).

A.11.1 Imports

There is a continuum of consumption good packers in the economy indexed by j with mass γ_c that buy domestic goods from good packers, $c_{j,t}^h$, and import foreign goods, $c_{j,t}^f$, pack them and sell the bundle, in a competitive market, to households and entrepreneurs for consumption. The packing technology is expressed by the following CES composite baskets of home- and foreign-produced goods:

$$c_{j,t}^c = \left((1-\omega^c)^{\frac{1}{\sigma_c}}\left(c_{j,t}^h\right)^{\frac{\sigma_c-1}{\sigma_c}} + (\omega^c)^{\frac{1}{\sigma_c}}\left(c_{j,t}^f\right)^{\frac{\sigma_c-1}{\sigma_c}}\right)^{\frac{\sigma_c}{\sigma_c-1}}.$$

There is also a continuum of investment good packers in the economy indexed by j with mass γ_z that buy domestic goods from good packers, $i_{j,t}^h$, and import foreign goods, $i_{j,t}^f$, pack them and sell the bundle, in a competitive market, to capital producers. The technology is given by:

$$i^z_{j,t} = \left(\left(1-\omega^i\right)^{\frac{1}{\sigma_i}} \left(i^h_{j,t}\right)^{\frac{\sigma_i-1}{\sigma_i}} + \left(\omega^i\right)^{\frac{1}{\sigma_i}} \left(i^f_{j,t}\right)^{\frac{\sigma_i-1}{\sigma_i}} \right)^{\frac{\sigma_i}{\sigma_i-1}},$$

where σ_c and σ_i are the consumption and investment elasticities of substitution between domestic and foreign goods and ω^c and ω^i are inversely related to the degree of home bias and, therefore, directly related to openness.

Each period, the consumption goods packer j chooses $c^h_{j,t}$ and $c^f_{j,t}$ to minimize production costs subject to the technological constraint. A similar problem is faced by the investment good packers.

Because profits have to be zero, we have the following relationships:

$$1 = \left(\left(1-\omega^c\right) \left(p^H_t\right)^{1-\sigma_c} + \left(\omega^c\right) \left(p^M_t\right)^{1-\sigma_c} \right)^{\frac{1}{1-\sigma_c}}$$

and

$$p^I_t = \left(\left(1-\omega^i\right) \left(p^H_t\right)^{1-\sigma_i} + \left(\omega^i\right) \left(p^M_t\right)^{1-\sigma_i} \right)^{\frac{1}{1-\sigma_i}}.$$

Given the small open economy assumption, the price of imports in domestic currency is defined as $p^M_t = er_t(1+\tau^m_t)$, where er_t is the real exchange rate.[4] We define:

$$C_t = \gamma_c c^c_t,\ C^h_t = \gamma_c c^h_t,\ I_t = \gamma_z i^z_t, \text{ and } I^h_t = \gamma_z i^h_t,$$

where C_t is aggregate consumption and I_t is aggregate investment. Aggregate imports are defined as:

$$IM_t = \gamma_c c^f_t + \gamma_z i^f_t = C^f_t + I^f_t.$$

Therefore, the following equalities hold in aggregate:

$$C_t = \gamma_c c^c_t = p^H_t \gamma_c c^h_t + p^M_t \gamma_c c^f_t = \gamma_p c^p_t + \gamma_i c^i_t + \gamma_e c^e_t + \gamma_m c^m_t$$

and

$$I_t = \gamma_z i^z_t = \frac{p^H_t}{p^I_t} \gamma_z i^h_t + \frac{p^M_t}{p^I_t} \gamma_z i^f_t = \gamma_k i_t.$$

[4] One could define $er_t = \frac{ER_t P^*_t}{P_t}$, where τ^m_t represents the import tariff, ER_t is the nominal exchange rate, and P^*_t stands for the exogenous world price index. In a full custom union such as the EU, the tariff rate is zero.

A.11.2 Exports

Good packers are the ones that export. We assume that there is some degree of imperfect exchange rate pass through. To make this assumption operational, we consider a fraction $(1 - ptm)$ of good packers whose prices at home and abroad differ. The remaining fraction of good packers, ptm, sets a unified price across countries (i.e., the law of one price holds). Thus, the export price deflator relative to consumption goods, p_t^{EX}, is defined as:

$$p_t^{EX} = (1 - \tau_t^x) p_t^{H(1-ptm)} er_t^{ptm},$$

where τ_t^x is an export subsidy and the parameter ptm determines the degree of pass through.

There is a continuum of foreign consumers and investors with mass γ^* whose demands for domestic goods from good packers are given by:

$$c_t^{*f} = \omega^f \left(\frac{p_t^{EX}}{er_t} \right)^{-\sigma_c^*} c_t^* \text{ and } i_t^{*f} = \omega^f \left(\frac{p_t^{EX}}{er_t} \right)^{-\sigma_c^*} i_t^*,$$

where c_t^* and i_t^* represent the (exogenous) aggregate consumption and investment demand in the rest of the world, and ω^f captures the impact of factors other than prices affecting Spanish exports.

Therefore, exports of the home economy $ex_t = c_t^{*f} + i_t^{*f}$ can be written as

$$ex_t = \omega^f \left(\frac{p_t^{EX}}{er_t} \right)^{-\sigma_c^*} (c_t^* + i_t^*).$$

Finally, we can define aggregate exports as $EX_t = \gamma^* ex_t$.

A.11.3 Accumulation of foreign assets

The net foreign asset position B_t^* evolves according to the following expression (denominated in the home currency):

$$B_t^* = \frac{(1 + r_{t-1}^*)}{\pi_t} B_{t-1}^* + \left[p_t^{EX} \gamma^* ex_t - p_t^M \left(\gamma_c c_t^f + \gamma_z i_t^f \right) \right]$$

where a negative/positive sign for B_t^* implies a borrowing/lending position for the domestic economy with respect to the rest of the world and r_t^* stands for the interest rate paid/received for borrowing/lending abroad. Also, the trade balance TB_t is defined as:

$$TB_t = p_t^{EX} \gamma^* ex_t - p_t^M \left(\gamma_c c_t^f + \gamma_z i_t^f \right).$$

A.12 Monetary authority

The domestic economy belongs to a monetary union (say, the EMU), and monetary policy is managed by the central bank (say, the ECB) through the following Taylor rule that sets the nominal area-wide reference interest rate allowing for some smoothness of the interest rate's response to inflation and output:

$$(1+r_t) = (1+r_{ss})^{(1-\phi_r)}(1+r_{t-1})^{\phi_r}\left(\frac{\pi_t^{emu}}{\pi_{ss}^{emu}}\right)^{\phi_\pi(1-\phi_r)}\left(\frac{y_t^{emu}}{y_{t-1}^{emu}}\right)^{\phi_y(1-\phi_r)},$$

where π_t^{emu} is EMU inflation as measured in terms of the consumption price deflator and $\frac{y_t^{emu}}{y_{t-1}^{emu}}$ measures the gross rate of growth of EMU output.

The domestic economy contributes to EMU inflation and output growth according to its economic size in the Eurozone, ω_{Sp}:

$$\pi_t^{emu} = (1-\omega_{Sp})\left(\overline{\pi_t^{remu}}\right) + \omega_{Sp}\pi_t' \text{ and } \frac{y_t^{emu}}{y_{t-1}^{emu}} = (1-\omega_{Sp})\left(\overline{\left(\frac{y_t^{remu}}{y_{t-1}^{remu}}\right)}\right) + \omega_{Sp}\frac{y_t}{y_{t-1}},$$

where $\overline{\pi_t^{remu}}$ and $\overline{\left(\frac{y_t^{remu}}{y_{t-1}^{remu}}\right)}$ are average (exogenous) inflation and output growth in the rest of the Eurozone.

The real exchange rate is given by the ratio of relative prices between the domestic economy and the remaining EMU members, so real appreciation/depreciation developments are driven by the inflation differential of the domestic economy vis-à-vis the euro area:

$$\frac{er_t}{er_{t-1}} = \frac{\overline{\pi_t^{remu}}}{\pi_t}.$$

A.13 Fiscal authority

There is a fiscal authority with a flow of expenses determined by government consumption, government investment, transfers to households and interests plus the old debt borrowed during the previous period. The fiscal authority collects revenues with new debt and distortionary taxation on consumption, housing services, labor income, capital income, bank profits, loans, and deposits. Hence, we have:

$$C_t^g + I_t^g + \left(\frac{1+\theta_{ss}^b r_{t-1}^b}{\pi_t}\right) + T_t^g + B_{t-1}^g = B_t^g + \tau_t^c\left(\gamma_p c_t^p + \gamma_i + t^i + \gamma_e c_t^e + \gamma_m c_t^m\right) +$$
$$\frac{\tau_t^m}{1+\tau_t^m}p_t^M IM_t - \frac{\tau_t^x}{1-\tau_t^x}p_t^{EX}EX_t + \tau_t^h q_t^h\left[\gamma_p(h_t^p-(1-\delta_h)h_{t-1}^p) + \gamma_i(h_t^i-(1-\delta_h)h_{t-1}^i)\right] +$$
$$\tau_t^w\left(w_t^p\gamma_p\ell_t^p + w_t^i\gamma_i\ell_t^i + w_t^m\gamma_m\ell_t^m\right) + \tau_t^k r_t^k K_t + \tau_t^{Jb}J_{t-1}^b + \tau_t^d d_t^p + \tau_t^b(b_t^i + b_t^e).$$

Government consumption and investment levels, as well all tax rates are assumed to be constant, except banking taxes, which move from zero in the baseline scenario to positive values in the simulated scenarios.

In the benchmark model, lump-sum taxes adjust to guarantee the non-explosiveness of government debt according to the following rule:

$$T_t^g = T_{t-1}^g - \rho_{tgb1}\left(\psi_t^{bg} - \psi_{ss}^{bg}\right) - \rho_{tgb2}\left(\psi_t^{bg} - \psi_{t-1}^{bg}\right),$$

where ψ_t^{bg} represents the proportion of public debt over aggregate output, namely, $\psi_t^{bg} = \frac{B_t^g}{Y_t}$ and ψ_{ss}^{bg} refers to its steady-state target value. In turn, public debt adjusts to satisfy the budget constraint given the above levels of C_t^g, I_t^g and T_t^g. Finally, public capital evolves with investment according to the law of motion:

$$K_t^g = (1-\delta_g)K_{t-1}^g + I_t^g.$$

The aggregate resource constraint is:

$$\begin{aligned} p_t^H Y_t^1 &= C_t + p_t^I I_t + p_t^H I_t^{ho} + p_t^H C_t^g + p_t^H I_t^g + p_t^{EX} EX_t - p_t^M IM_t = \\ &= p_t^H C_{ht} + p_t^H I_{ht} + p_t^H I_t^{ho} + p_t^H C_t^g + p_t^H I_t^g + p_t^{EX} EX_t, \end{aligned}$$

where Y_t^1 is GDP.

A.14 Parameter setting

Although the model can produce numerical results for any country in a currency union, such as EMU, for illustrative purposes the model is simulated for the Spanish economy. In order to assign a value to the large number of structural parameters we use different methodologies. First, there is a set of parameters that are borrowed from the previous literature. Second, some parameters are obtained by estimations from outside the model using a macroeconomic database of the Spanish Ministry of Finance, which was created to serve as a consistent framework for the model calibration. Third, there is a set of parameters that we choose in order to match some first-order moments of the data at the steady state of the model.

We also estimate some parameters related to price and wage indexation by means of Bayesian inference. Finally, we normalize to one the size of most groups of agents: γ_x, γ_k, γ, γ_b, γ_c, γ_z, and γ^*, whereas the different weights of households' types add to one.

The sample period considered for calibration and estimation runs from 1992:4 to 2019:4, just before the start of the Covid-19 pandemic. More details on the calibration and estimation of the model can be found in Boscá et al (2020), although, as we pointed out, in this paper we work with a deterministic version of the estimated model, omitting all stochastic shocks in the economy.

Table 1 displays the performance of the model in terms of steady state computed ratios as compared with observed data. Table 2 shows the effective tax rates for the taxes we consider

Table 1: STEADY-STATE FIRST-ORDER MOMENTS

	Data	Model
$\gamma_p c_p / C$	0.23	0.23
$\gamma_i c_i / C$	0.19	0.19
$\gamma_m c_m / C$	0.19	0.19
i/k	0.10	0.10
i^{ho}/Y^1	0.05	0.05
C^g/Y^1	0.18	0.18
I^g/K^g	0.06	0.06
TB/Y^1	0.00	0.00
c^*/i^*	2.70	2.70
Public debt held by domestic agents	0.55	0.55
Domestic public debt held by banks	0.36	0.36
J^x	0.00	0.00
r^g/r^{bi}	0.80	0.80
I^g/Y^1	0.03	0.03
B^i/Y^1	0.37	0.39
B^e/Y^1	0.45	0.43
Bank capital to assets	0.09	0.09

B^i and B^e represent credit to households and firms. The consumption shares ($\gamma_p c_p/C$, $\gamma_i c_i/C$, $\gamma_m c_m/C$) are not based on real data, but on our beliefs about the distribution of per capita consumption across the different household types.

in the baseline scenario, as well as the ratio of tax collection on GDP in percentage terms[5]. Total tax collection in Spain accounts for 35 percent of GDP approximately, being taxes on labor, which include also social security contributions, the main source of public revenues. As we can see, in the baseline scenario banking taxes are initially equal to zero. The analysis of the macroeconomic effects of increasing these taxes is precisely the objective of this paper and to do that we devote the next section.

[5] Because the model represents an economy in a monetary union the baseline taxes on imports and exports are zero, not displayed in the table.

Table 2: TAX RATE AND TAX COLLECTION

Tax	Tax rate (%)	$\frac{\text{Tax collection}}{\text{GDP}}$ (%)
τ^c	15	8.5
τ^w	31	15.7
τ^k	28	10.5
τ^h	8.6	0.5
τ^{Jb}	0	0
τ^d	0	0
τ^b	0	0

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