Optimal Public Debt, Capital Taxation, and Access to World Liquidity

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Abstract

How do international capital flows affect the optimal levels of public debt and capital taxation? We analyze this question in a heterogeneous-agent model with capital accumulation and possibly imperfect international capital mobility. In this economy, international lending provides a safe asset, while international borrowing can finance capital accumulation. An Utilitarian government optimally sets the corporate income tax, which affects international capital flows, as well as public debt and taxes on capital and labor income for domestic agents. We find that international capital mobility does not substantially alter the optimal steady-state allocation compared to a closed economy, as optimal public debt adjusts to offset the undesirable effects of capital flows. However, the optimal dynamics of the economy following a public spending shock differ markedly between the open and closed economy. International capital flows allow for greater tax smoothing but result in more volatile public debt. Optimal stabilization policies are therefore substantially different in the open economy.

Keywords: Heterogeneous agents, optimal fiscal policy, open economy.

JEL codes: E21, E44, D91, F40.

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1 Introduction

How do international capital flows affect the optimal levels of public debt and capital taxation? Should the government use the tax system to attract foreign capital in order to finance an increase in public spending? These important questions surprisingly lack clear answers in the existing literature. While recent advances have improved our understanding of optimal public debt and capital taxation in closed economies (see the literature review below), the role of international capital flows in shaping the optimal tax system has not yet been systematically explored.

We study optimal fiscal policy in a small open economy model with heterogeneous agents, where both international capital flows and domestic savings can finance public debt and capital accumulation. We assume that capital flows respond to capital taxation because international mobility is imperfect. In this setting, new trade-offs emerge for the government: lowering capital taxes attracts foreign capital inflows, while raising them increases tax revenues and allows reductions in other, more distortionary taxes.

We use heterogeneous-agent models—more precisely, models with incomplete insurance against idiosyncratic risk—because they provide a coherent and realistic framework to study optimal public debt and capital taxation in closed economies. In these models, the scarcity of safe private assets implies that positive public debt can increase welfare. Extending this framework to an open economy naturally leads us to consider the role of international capital as a form of "private liquidity," following the terminology of Woodford (1990).

The government has four policy instruments: a linear labor income tax, public debt, a linear tax on domestic capital income, and a linear tax on foreign capital income. The rationale for distinguishing between the capital taxes on domestic and foreigners is as follows. Most closed-economy models include a single capital tax on domestic agents, empirically corresponding to the combination of the corporate income tax and the household capital income tax (see Mendoza et al. (1994) and Trabandt and Uhlig (2011)). In an open economy, however, these two

taxes are not substitutes. The corporate income tax is paid by both domestic and foreign agents, whereas the household capital income tax is paid only by domestic residents. Therefore, we explicitly distinguish between these two capital taxes, which together can be implemented through an appropriate mix of corporate and household capital income taxation.

We solve for the optimal Ramsey allocation under commitment, assuming a utilitarian government that maximizes the welfare of domestic agents. We first derive the first-order conditions of the planner's problem in a general heterogeneous-agent model, identifying key properties of the optimal allocation. We then focus on a simpler environment with deterministic income fluctuations and credit constraints, as in Woodford (1990), to obtain analytical results both at the steady state and following a public spending shock. Our main findings are threefold.

First, in the general heterogeneous-agent model, the Modified Golden Rule holds: the steady-state marginal product of capital equals the government's discount rate, assumed to be the same as that of private agents. In addition, the optimal tax on foreign capital depends on the elasticity of international capital flows with respect to the real interest rate. These two properties imply that the international capital flows induced by optimal policy do not depend on inequality or capital accumulation. Consequently, a sufficient statistic for the effect of capital flows on steady-state optimal labor and domestic capital taxation is the equilibrium interest payment from the domestic economy to the rest of the world, which can be determined independently. An increase in this interest payment has the same effect on optimal fiscal policy as an exogenous increase in public spending.

Second, the steady-state level of public debt is chosen such that domestic savings net of foreign capital inflows are consistent with the optimal capital stock. As a result, the government sets the tax on foreign agents as a function of international capital flows, adjusts domestic taxes to target the optimal allocation, and uses public debt to ensure market clearing.

Third, we analyze the optimal dynamics of fiscal policy after a transitory pub-

lic spending shock in the simpler model. Compared to the closed economy, international capital flows drastically alter the dynamics of both allocations and instruments. Tax rates adjust more smoothly in the open economy, while public debt becomes more volatile. Capital inflows finance much of the additional public spending, with only small adjustments in foreign capital taxes and limited volatility of domestic taxes. The greater the degree of international capital mobility—that is, the higher the elasticity of capital flows to interest rate changes—the smoother the dynamics of domestic capital taxation.

These results imply a general and somewhat surprising conclusion: international capital flows do not significantly affect the optimal steady-state fiscal structure, but they fundamentally change the optimal dynamic response of fiscal policy to aggregate shocks.

Literature review. Since the seminal contribution of Woodford (1990), which introduced a theory of public debt as private liquidity, the optimal supply of public debt in heterogeneous-agent models has been extensively studied under various fiscal instruments and welfare criteria (Aiyagari, 1995, Aiyagari and McGrattan, 1998, Bhandari et al., 2021, Collard et al., 2023, and LeGrand et al., 2025). Recently, LeGrand and Ragot (2025) have shown that heterogeneous-agent models can generate realistic predictions for optimal fiscal policy and public debt.

These models naturally generate a demand for liquidity, linking them to the literature on safe assets provision (Brunnermeier et al., 2024). They can produce an equilibrium in which the return on safe assets is lower than economic growth. Our model, which incorporates fiscal policy, produces a wedge between the marginal product of capital and the return on savings—but as an optimal fiscal outcome. The mechanism for the determination of public debt is thus different from Reis (2022).

A number of studies have employed heterogeneous-agent open-economy models to analyze international capital flows (e.g., Mendoza et al., 2009) or to investigate the effects of inequality and aggregate shocks in economies with realistic marginal

propensities to consume (de Ferra et al., 2020, Guo et al., 2023, Auclert et al., 2024, Acharya and Challe, 2025).

2 The general case

2.1 Environment

Time is discrete, $t = 0, 1, 2, \ldots$ We consider an open economy. It is populated by domestic households, whose population size amounts to 1. Foreign investors also intervene in the domestic through the capital market. Domestic agents are distributed along a set I with measure ℓ. We follow Green (1994) and assume that the law of large numbers holds.

The economy features a representative firm producing the unique consumption good, as well as a benevolent fiscal authority that raises distorting taxes and public debt to finance an exogenous stream of public spending. Finally, foreign investors also demand domestic interest-bearing assets.

Risks. Agents face an idiosyncratic productivity risk, denoted by y, that takes values in a finite set $\mathcal{Y}$. Agents working l hours with hourly wage w and productivity y earn the labor income wyl. Individual productivity processes are independent Markov chain with transition matrix $\Pi \in \mathbb{R}^{|\mathcal{Y}|\times|\mathcal{Y}|}$ and stationary distribution $S \in \mathbb{R}^{|\mathcal{Y}|}$—that is assumed to exist and to be unique.

In addition to this idiosyncratic productivity risk, the economy is affected by an aggregate shock s that can affect TFP or public spending. We assume that the aggregate shock becomes known to all agents in the first period—making the aggregate shock a so-called MIT shock.

Production. The unique consumption good of the economy is produced by a representative firm maximizing its profits. The firm uses labor L and capital K, that must be installed one period ahead, to produce output Y. The production technology $F(K, L)$ is of the Cobb-Douglas type. The capital share is denoted

$\alpha \in (0,1)$, while the depreciation of capital is $\delta > 0$. Denoting by Z_t the TFP at date t, the output production is period t can be written as:

$$Y_t = F(K_{t-1}, L_t) = Z_t K_{t-1}^{\alpha} L_t^{1-\alpha} - \delta K_{t-1}. \tag{1}$$

Capital and labor are competitively rent by the firm at pre-tax factor factor prices $\tilde{r}_t$ and $\tilde{w}_t$, respectively. Profit maximization implies the following expressions:

$$\tilde{w}_t = F_L(K_{t-1}, L_t), \qquad \tilde{r}_t = F_K(K_{t-1}, L_t), \tag{2}$$

and with constant returns $F(K_{t-1}, L_t) = \tilde{w}_t L_t + \tilde{r}_t K_{t-1}$.

Preferences and agents' choices. We assume that in each period t, agents consume a quantity c_t of the unique good, supply l_t hours of labor, and choose an amount a_t of savings. Their preferences are assumed to be time-separable and of the expected utility type. The discount factor is constant and denoted $\beta \in (0,1)$. The period utility over consumption c and labor supply l is time invariant and denoted by $U(c,l)$. We assume that U verifies the standard properties. It is twice continuously differentiable, increasing concave in consumption and decreasing convex in labor supply. We denote by U_x the first-order derivative of U with respect to x and similarly by U_{xy} the second-order derivative.

The tax system Domestic agents pay a linear tax τ^L on their labor income, such that the government levies a constant share of aggregate labor supply, $\tau_t^L L_t$, in each period t. Conversely, agents receive the post-tax wage rate $w_t := (1-\tau^L)\tilde{w}_t$.

In the closed economy, it is frequent to consider a single capital tax. However, considering an open economy, one must differentiate between the capital tax paid by foreign agents, denoted τ^F and the one paid by domestic agents, denoted τ^K. Indeed, in most countries, firms pay corporate income tax, which is a capital tax paid by both agents, both domestic and foreign. In addition, domestic agents an additional capital income tax. As a consequence, one must consider the tax τ^K as the total capital tax paid by domestic agents.

We assume that domestic agents pay the tax τ^K on all their interest-bearing asset holdings. The government receives tax payments $\tau_t^K \int_i a_{i,t}\ell(di)$ levied on all domestic asset holdings. The post-tax gross interest rate faced by domestic agents is $R_t := 1 + (1 - \tau_t^K)\tilde{r}_t$.

The government also levies the linear capital tax, τ^F, on foreign asset holdings. The post-tax gross rate faced by foreign investors equals $R_t^F := 1 + (1 - \tau_t^F)\tilde{r}_t$. We summarize the definitions of post-tax rates here:

$$w_t := (1 - \tau^L)\tilde{w}_t, \tag{3}$$

$$R_t := 1 + r_t = 1 + (1 - \tau_t^K)\tilde{r}_t, \tag{4}$$

$$R_t^F := 1 + r_t^F = (1 - \tau_t^F)\tilde{r}_t. \tag{5}$$

International capital markets The literature has identified various determinants of capital flows (Gourinchas and Rey (2014) or Ahmed Hannan (2018) or for two surveys). In our model without aggregate risk, we assume that international capital inflows in the domestic country at period t is an increasing function of the post tax return on capital holding of foreigners between period $t$and period $t + 1$, R_{t+1}^F. Denoting the foreign asset holdings as F_t^W, we make the following assumption.

Assumption 1. *We assume that the foreign holdings F_t is a time-invariant function of the next-period post-tax interest rate R_{t+1}^F:*

$$F_t^W := F^W(R_{t+1}^F),$$

where F^W is twice continuously differentiable.

This standard formulation embeds different cases, according to the integration of the domestic country to the world financial markets. For highly integrated countries the sensitivity of capital inflow to the interest rate, $\frac{\partial F_t^W}{\partial R^F}$ is high, and it is infinite under perfect capital mobility. With perfect financial market, the post-tax interest rate isindeed pinned down by the world interest rate, denoted as

R^*,$R^F = R^*$. However, both empirical work and theoretical work (Gabaix and Maggiori (2015), Farhi and Maggiori (2017)) have stressed world financial market imperfections in explaining long-run capital flows. In this case, $\frac{\partial F_t^W}{\partial R^F} < +\infty$ and the lower the derivative the higher the frictions in the world financial markets. We consider on purpose a simple reduced form of capital frictions to be able to derive theoretical results .

Finally, the value F_t^W is the capital inflows in the domestic country. A positive $F^W$is a net debt of the domestic country to the rest of the world. As a consequence, it is the opposite of the Net Foreign Asset (NFA) Position. $NFA_t = -F_t^W$. It can be either positive or negative. In the numerical simulations below, we will consider different values for both $\frac{\partial F_t^W}{\partial R^F}$ and the steady-state NFA.

Market clearing. The demand for domestic assets is composed of the sum of domestic and foreign net demand F_t^W, while capital and public debt make up the supply.

We denote as A_t the period t total net saving of households

$$A_t := \int_i a_{i,t} \ell(di)$$

The clearing of the domestic financial market implies the following equality:

$$A_t + F_t^W = B_t + K_t. \tag{6}$$

The labor market clearing condition is standard:

$$\int_i y_{i,t} l_{i,t} \ell(di) = L_t. \tag{7}$$

The government budget constraint A benevolent government finances an exogenous stream of public spending out of linear labor and capital taxes, as well as out of raising public debt. Public debt is assumed to be default free and with only a one period maturity. The outstanding amount in period t is B_t.

As τ_t^F is the capital tax on foreign agents, the government will raise $\tau_t^F \tilde{r}_t F_{t-1}^W$

from foreign asset holdings.The government will use the revenues from labor and capital taxes and the issuance of the new public debt to finance public spending G_t and public debt repayment $(1+\tilde{r}_t)B_{t-1}$:

$$G_t + (1+\tilde{r}_t)B_{t-1} = \tau_t^L \tilde{w}_t L_t + \tau_t^K \tilde{r}_t A_t + \tau_t^F \tilde{r}_t F_{t-1}^W + B_t.$$

Taking advantage of the property of constant return-to-scale, $F(K_{t-1}, L_t) = \tilde{w}_t L_t + \tilde{r}_t K_{t-1}$, we obtain:

$$G_t + B_{t-1} + (1-\tau_t^L)\tilde{w}_t L_t + \tilde{r}_t(K_{t-1} + B_{t-1}) = \tau_t^K \tilde{r}_t A_t + \tau_t^F \tilde{r}_t F_{t-1}^W + B_t.$$

Using the financial market clearing condition (6)—that we further discuss below—and the definitions of post-tax rates (3)–(5), we finally deduce that the governmental budget constraint can be written in post-tax terms as follows:

$$G_t + B_{t-1} + w_t L_t + r_t A_{t-1} + r_t^F F_{t-1}^W = F(K_{t-1}, L_t) + B_t. \tag{8}$$

This expression of the governmental budget constraint is independent of tax expressions—that are subsumed in the post-tax rates. This will enable us to express the Ramsey program based on post-tax returns only and without mentioning tax rates.

2.2 Competitive equilibrium

The agents' program consists in choosing their path for consumption, labor supply and savings to maximize their intertemporal utility. Formally:

$$\max_{\{c_{i,t}, l_{i,t}, a_{i,t}\}_{t\geq 0}} \mathbb{E}_0 \sum_{t=0}^{\infty} \beta^t \mathbb{E}_0 U(c_{i,t}, l_{i,t}), \tag{9}$$

$$c_{i,t} + a_{i,t} = R_t a_{i,t-1} + w_t y_{i,t} l_{i,t}, \tag{10}$$

$$a_{i,t}^f \geq -\underline{a},\ c_{i,t} \geq 0,\ l_{i,t} \geq 0, \tag{11}$$

where the expectation operator $\mathbb{E}$ concerns idiosyncratic states only as we consider a MIT shock. Equation (10) is the individual budget constraint, stating that consumption and savings should be financed out of capital and labor income and past

capital. Equations in (11) summarize the positivity constraint for consumption and labor choices, as well as the credit constraint. Agents are indeed prevented from borrowing more than the exogenous limit $\underline{a}$. Denoting by $\beta^t \nu_{i,t} \geq 0$ the Lagrange multiplier on the date-t credit constraint, the agents' program imply the two following first-order conditions (henceforth, FOCs):

$$U_c(c_{i,t}, l_{i,t}) = \beta R_{t+1} \mathbb{E}_t U_c(c_{i,t+1}, l_{i,t+1}) + \nu_{i,t}, \tag{12}$$

$$-U_l(c_{i,t}, l_{i,t}) = w_t y_{i,t} U_c(c_{i,t}, l_{i,t}). \tag{13}$$

As is standard, equation (12) is the Euler equation, while equation (13) is the labor FOC.

We can now define the competitive equilibrium in this economy.

Definition 1 (Competitive equilibrium)**.** A competitive equilibrium is a collection of individual variables $(c_{i,t}, l_{i,t}, a_{i,t})_{t\geq 0}^{i\in\mathcal{I}}$, aggregate quantities $(K_t, L_t, F_t^W, Y_t)_{t\geq 0}$, prices $(\tilde{w}_t, \tilde{r}_t)_{t\geq 0}$, fiscal policy $(\tau_t^K, \tau_t^F, \tau_t^L, B_t)_{t\geq 0}$, and public spending $(G_t)_{t\geq 0}$ such that for an initial distribution of wealth and productivity $(a_{i,-1}, y_{i,0})_{i\in\mathcal{I}^f}$ and for initial values of foreign asset demand, capital stock, and public debt verifying $K_{-1} + B_{-1} = A_{t-1} + F_{-1}^W$, with $A_{t-1} = \int_i a_{i,-1}\ell(di)$, the following holds. i) Given prices, individual strategies $(c_{i,t}, l_{i,t}, a_{i,t})_{i,t\geq 0}$ solve the agent's optimization program in equations (9)–(11). ii) Financial, labor, and goods markets clear: for any $t \geq 0$, equations (6) and (7) hold. iii) The government budget is balanced: equation (8) holds for all $t \geq 0$. iv) The pre-tax factor prices $(\tilde{w}_t, \tilde{r}_t)_{t\geq 0}$ are consistent with the firm's program (2) v) Post-tax rates $(w_t, R_t, R_t^F)_{t\geq 0}$ verify equations (3)–(5).

2.3 Ramsey equilibrium

The program. The Ramsey program consists for the planner to select the fiscal policy implying the competitive equilibrium with the largest aggregate welfare. The aggregate welfare is computed using a standard Utilitarian criterion: All agents define are identically weighted by the planner. Formally, the aggregate

social welfare W_0 can thus be written as:

$$W_0 = \mathbb{E}_0 \sum_{t=0}^{\infty} \beta^t \int_i U(c_{i,t}, l_{i,t}) \ell(di). \tag{14}$$

In the spirit of Chamley (1986), the Ramsey program can then be written using post-tax rates as follows:

$$\max_{\left\{w_t, R_t, R_t^F, B_t, (c_{i,t}, l_{i,t}, a_{i,t}, \nu_{it})_{i \in \mathcal{I}}\right\}_{t \geq 0}} W_0, \tag{15}$$

$$\forall i \qquad c_{i,t} + a_{i,t} = R_t a_{i,t-1} + w_t y_{i,t} l_{i,t}, \tag{16}$$

$$U_c(c_{i,t}, l_{i,t}) = \beta R_{t+1} \mathbb{E}_t U_c(c_{i,t+1}, l_{i,t+1}) + \nu_{i,t}, \tag{17}$$

$$-U_l(c_{i,t}, l_{i,t}) = w_t y_{i,t} U_c(c_{i,t}, l_{i,t}). \tag{18}$$

$$\nu_{i,t}(a_{i,t} + \underline{a}) = 0,\ a_{i,t} \geq -\underline{a},\ c_{i,t} \geq 0,\ l_{i,t} \geq 0, \tag{19}$$

$$F(K_{t-1}, L_t) + B_t - B_{t-1} = G_t + w_t L_t + (R_t - 1) A_{t-1} + (R_t^F - 1) F_{t-1}^W, \tag{20}$$

$$B_t + K_t = A_t + F_t^W, \tag{21}$$

$$L_t = \int_i y_{i,t} l_{i,t} \ell(di), A_t = \int_i a_{i,t} \ell(di) \tag{22}$$

The interpretation of the program is rather straightforward. Equation (15) is the Ramsey planner objective, which aims to find the fiscal policy and the allocation maximizing aggregate welfare. Equations (16)–(19) are the individual-level constraints imposing the planner to choose an allocation among competitive equilibrium. Equation (20) is the planner's budget constraint, imposing a balanced budget. Equations (21) and (22) are the asset and labor market clearing conditions. Taxes and pre-tax interest rates are deduce from the allocation and the values of post-tax instruments.

The FOCs. We denote by $\beta^t \mu_t$ the Lagrange multiplier on the governmental budget constraint (20). The FOC with respect to public debt B_t implies the following equation:

$$\mu_t = \beta \mu_{t+1} (1 + F_{K,t+1}), \tag{23}$$

where $F_{K,t} := \frac{\partial F}{\partial K}(K_{t-1}, L_t)$. This equation is a Euler-like equation showing that the planner relies on public debt to smooth out the shadow cost of the governmental budget constraint. Similarly, the FOC implied by the foreign interest rate R_t^F is:

$$\mu_t(F_{t-1}^W + (R_t^F - 1)F_{R^F,t-1}^W) = \mu_t F_{K,t} F_{t-1}^{W\prime},$$

where $W_{R^F,t-1} := \frac{\partial W_{t-1}}{\partial R^F}(R_t^F)$. Using (23), we deduce:

$$\beta R_t^F \mu_t = \mu_{t-1} \frac{\frac{R_t^F F_{R^F,t-1}^W}{W_{t-1}}}{1 + \frac{R_t^F F_{R^F,t-1}^W}{F_{t-1}^W}},$$

or after using (23) one more time:

$$\frac{R_t^F}{1+\tilde{r}_t} = \frac{\frac{R_t^F F_{R^F,t-}^W}{W_{t-1}}}{1 + \frac{R_t^F F_{R^F,t-1}^W}{F_{t-1}^W}}, \tag{24}$$

which shows that $R_t^F < 1 + \tilde{r}_t$—the tax τ_t^F is always positive—whenever the elasticity is greater than -1.

This allows us to derive the following proposition.

Proposition 1. *At the steady state of the Ramsey equilibrium, we have:*

- The Modified Golden Rule holds : $\beta(1+\tilde{r}) = \beta(1+F_K) = 1$;
- $R^F = \frac{1}{\beta}\frac{\epsilon(R^F)}{1+\epsilon(R^F)}$, where $\epsilon(R^F) := \frac{R^F F_{R^F}^W}{F^W}$ is the elasticity of the foreign demand.

The first point is very standard. The pre-tax interest rate is equal to the discount rate. Since the production function is homogeneous of degree 1, this relationship also characterizes the capital-to-labor ratio (K/L) at the steady state. The second point tells that the steady-state interest rate for foreign investors, R^F, solely depend at the steady state on the elasticity of the demand function, i.e., on the quantity $\frac{R^F F_{R^F}^W}{F^W}$. The more elastic the foreign demand, the higher the interest faced by foreigners. In particular $R^F < 1 + \tilde{r}$ and the capital tax on foreign holdings is negative when the elasticity is greater than -1.

Understand the the effect of capital flows at the steady state. Proposition 1 shows that the steady-state post-tax interest rate paid to foreign agents is pinned down by preferences and the elasticity of foreign demand. As a consequence, the steady state capital flow is $F^W = F^W(R^F)$. Define $\tilde{G}$ as:

$$\tilde{G} := G + (R^F - 1)F^W$$

As a consequence, the steady state budget constraint of the government can be written as:

$$\underbrace{\tilde{G}}_{\text{Net financing needs}} = F(K, L) - wL - (R - 1)A$$

The steady-state capital flows only depends on R^F, which depends on τ^F but not on other fiscal instruments. In addition, the contribution of capital flows to the budget of the government (compared to the close economy case) is only $(R^F - 1)F^W$,which is thus also independent on all equilibrium fiscal instruments, except τ^F. As a consequence, the effect of capital flows on steady-state fiscal system is summarized by the effect of $(R^F - 1)F^W$ on the financing needs $\tilde{G}$, and $\tilde{G}$ is a sufficient statistics for the steady-state fiscal system. It is thus equivalent to an increase in public spending G when $F^W > 0$, i.e the government has to pay interest payment to the rest of the world. And it is equivalent to a decrease in G when $F^W < 0$, as the economy receives some interest payment from the rest of the world.

Then considering the financial market equilibrium, one finds that public debt is a residual

$$B = A + F^W(R^F) - K$$

In other words, the optimal public debt is determined such that the domestic saving net of foreign capital inflows is consistent with the optimal capital stock.

3 A simple environment with deterministic fluctuations

3.1 Assumptions

We study here optimal fiscal policy in a simple model, in which we can derive analytical results. The main simplifying assumption is to consider deterministic productivity fluctuations, as in Woodford (1990) and LeGrand and Ragot (2025). This approach offers analytical solutions—including a characterization of the Ramsey allocation.

The simplifying assumptions introduced in the environment of Section 2 are as follows.

Assumption 2. *We make the following assumptions:*

1. *The credit constraint is set to zero:* $\underline{a} = 0$.

2. *The productivity process can take only two values:* 0 *and* 1*:* $\mathcal{Y} = \{0, 1\}$. *The transition matrix is anti-diagonal:* $\Pi = \begin{bmatrix} 0 & 1 \\ 1 & 0 \end{bmatrix}$ *and there is initially a unit mass of agents in each productivity level.*

3. *The period utility function is of the Greenwood-Hercowitz-Huffman (GHH) type:*

$$U(c, l) = \log\left(c - \chi^{-1} \frac{l^{1+1/\varphi}}{1+1/\varphi}\right),$$

where $\varphi > 0$ *is the Frisch elasticity of labor supply;* $\chi > 0$ *scale labor disutility.*

The planner uses four instruments: two linear capital taxes—one for domestic investors, another one for foreign ones, a linear labor tax, and public debt. Agents experience deterministic changes in productivity, which they can smooth through savings, constrained by borrowing limits. Given the assumed initial distribution and the anti-diagonal structure of the transition matrix, the total population is

normalized to 2. In each period, a population of mass one is employed (denoted by subscript e) and another of mass one is unemployed (denoted by subscript u).

3.2 The Ramsey program

We can leverage the simplicity of the setup with deterministic fluctuations to streamline the Ramsey program. Individual budget constraints are:

$$c_{e,t} + a_{e,t} = R_t a_{u,t-1} + w_t l_{e,t}, \tag{25}$$

$$c_{u,t} + a_{u,t} = R_t a_{e,t-1}, \tag{26}$$

A preliminary observation of these two equations is that in any non-trivial equilibrium, employed agents cannot be credit-constrained at any time. If they were, unemployed agents—who have no labor income—would be forced to consume nothing. Such an allocation would be dominated by a marginal transfer from employed to unemployed. Consequently, there exist only two possible steady-state equilibria: one where unemployed agents are not credit-constrained, and one where they are. In the remainder of this paper, we will focus on the case where credit-constrained agents are *always* credit constrained and verify that this is indeed the case at the equilibrium:

$$a_{u,t} = 0 \text{ for all } t.$$

Before detailing the resolution of the program, we provide an overview of the characterization of the Ramsey solution—that allows us to show to which extend the Ramsey allocation departs from the first best. We start with the labor supply. Because of our productivity assumptions ($y_{e,t} = 1$ and $y_{u,t} = 0$), the aggregate labor supply is equal to the labor supply of employed agents. The latter can be easily expressed by taking advantage of the FOC (18) on individual labor supply with a GHH utility function. We obtain:

$$L_t = l_{e,t} = (\chi w_t)^{\varphi}. \tag{27}$$

We deduce from individual budget constraints (25) and (26) that the plan-

ner can set the consumption of employed agents using the wage rate w_t and the consumption of unemployed agents using the interest rate R_t. Indeed, these two instruments are independent. The Euler equation is not a constraint as it actually allows the planner to recover the savings from the instruments. In other words, up to a transformation of instruments, we can assume that the planner directly chooses consumption levels $c_{e,t}$ and $c_{u,t}$. Similarly, public debt is an independent planner's instrument. However, because of the financial market conditions, it is similar to assume that the planner sets the capital level in the economy.

Using these remarks, we deduce that the sole constraint that is left is the governmental budget constraint. Given our choice for instruments, it is more convenient to express as a resource constraint. The economy-wide resource constraint can be expressed as:

$$c_{e,t} + c_{u,t} + G_t + K_t + R_t^F F_{t-1}^W = F(K_{t-1}, L_t) + F_t^W + K_{t-1}.$$

Consumption levels are planner's instruments, which also influence the labor supply. Foreign asset demand is by assumption pinned down by the interest rate R_t^F. Finally capital is set via public debt.

We deduce that the Ramsey program can be written as follows.

$$\max_{(c_{e,t}, c_{u,t}, K_t, R_t^F)} \sum_{t=0}^{\infty} \beta^t \left(\ln\left(c_{e,t} - \chi^{-1} \frac{L_t^{1+1/\varphi}}{1+1/\varphi} \right) + \log(c_{u,t}) \right)$$

$$\text{s.t. } c_{e,t} + c_{u,t} + G_t + K_t + R_t^F F_{t-1}^W = F(K_{t-1}, L_t) + W_t + F_{t-1}^W,$$

where we should remember that $L_t := L_t(c_{e,t})$ and $F_t := F^W(R_{t-1}^F)$.

3.3 First-order conditions

Compared to the first-best allocation, the main inefficiency is that the planner cannot independently set the labor supply. The Ramsey planner's FOCs can be

written for capital and interest rate as:

$$\mu_t = \beta\mu_{t+1}(1 + F_K(K_t, L_{t+1})),$$
$$\frac{R^F_{t-1}}{1+\tilde{r}_t} = \frac{R^F_{t-1}\frac{F^{W\prime}_{t-1}}{F^W_{t-1}}}{1 + R^F_{t-1}\frac{F^{W\prime}_{t-1}}{F^W_{t-1}}},$$

which are identical to the FOCs (23) and (24) derived in the general case. For consumption choices, we obtain:

$$\frac{1}{c_{u,t}} = \mu_t, \tag{28}$$
$$\frac{1 - \chi^{-1}L_t^{1/\varphi}\frac{\partial L_t}{\partial c_{e,t}}}{c_{e,t} - \chi^{-1}\frac{L_t^{1+1/\varphi}}{1+1/\varphi}} = \mu_t\left(1 - \tilde{w}_t\frac{\partial L_t}{\partial c_{e,t}}\right). \tag{29}$$

The FOC (28) is identical to its first-best counterpart: the planner sets the marginal utility of unemployed agents equal to marginal value of public fund. The FOC (29) is a combines the first-best FOCs of consumption and labor supply. In particular, could the labor be independently set, the planner would equalize the marginal utility of employed agents to the marginal value of public fund.

To compute the derivative $\frac{\partial L_t}{\partial c_{e,t}}$, we rely on the Euler equation (12), with which individual budget constraints (25) and (26) and the log-GHH utility function imply $a_{e,t} = \beta\left(c_{e,t} - \chi^{-1}\frac{L_t^{1+1/\varphi}}{1+1/\varphi}\right)$. Using the employed budget constraint again, we deduce $c_{e,t} = \frac{L_t}{1+\beta}\left(w_t + \beta\chi^{-1}\frac{L_t^{1/\varphi}}{1+1/\varphi}\right) = (1-\eta)\chi^{\varphi}w_t^{\varphi+1}$, with $\eta := \frac{1}{1+\varphi}\frac{\beta}{1+\beta}$ and where the last equality comes from (27): $L_t = (\chi w_t)^{\varphi}$. Using the chain rule, we have:

$$(1-\eta)\chi^{-1}L_t^{\frac{1+\varphi}{\varphi}} = (1-\eta)\chi^{\varphi}w_t^{\varphi+1} = c_{e,t}$$
$$\frac{\partial L_t}{\partial c_{e,t}} = \frac{\varphi}{\varphi+1}\frac{1}{(1-\eta)w_t},$$

implying that the above FOCs become

$$\frac{1}{c_{e,t} - \chi^{-1}\frac{L_t^{1+1/\varphi}}{1+1/\varphi}} = \mu_t\frac{1 - \frac{\varphi}{\varphi+1}\frac{1}{1-\eta}\frac{\tilde{w}_t}{w_t}}{1 - \frac{\varphi}{\varphi+1}\frac{1}{1-\eta}}. \tag{30}$$

Whenever the labor tax is positive $\frac{\tilde{w}_t}{w_t} > 1$ and $\frac{1-\frac{\varphi}{\varphi+1}\frac{1}{1-\eta}\frac{\tilde{w}_t}{w_t}}{1-\frac{\varphi}{\varphi+1}\frac{1}{1-\eta}} < 1$, which implies:

$$\frac{1}{c_{e,t} - \chi^{-1}\frac{L_t^{1+1/\varphi}}{1+1/\varphi}} < \frac{1}{c_{u,t}} = \mu_t. \tag{31}$$

Unlike in the first best, the planner does not equalize the marginal utility of both agents. Some inequality is optimal, with employed agents being better off than unemployed ones.

To fully solve the model, we use FOC (28) to express μ_t as a function of $c_{u,t}$. We also use FOC (30) to express $c_{e,t}$ as a function of K_{t-1} and $c_{u,t}$. Noticing that $c_{e,t} - \chi^{-1}\frac{L_t^{1+1/\varphi}}{1+1/\varphi} = \beta^{-1}\frac{\eta}{1-\eta}c_{e,t}$ and $1 - \eta - \frac{\varphi}{\varphi+1} = \beta^{-1}\eta$, we have from (30):

$$\frac{1}{c_{e,t}} = \mu_t\left(1 - \frac{\varphi}{\varphi+1}\frac{1}{1-\eta}\frac{\tilde{w}_t}{w_t}\right).$$

Using $\tilde{w}_t = (1-\alpha)K_{t-1}^{\alpha}L_t^{-\alpha}$ and $\frac{L_t^{-\alpha}}{w_t} = \chi^{-\alpha\varphi}w_t^{-\alpha\varphi-1} = \chi^{-\alpha\varphi}\left(\frac{c_{e,t}}{\chi^{\varphi}(1-\eta)}\right)^{-\frac{1+\alpha\varphi}{1+\varphi}}$, we deduce with $\mu_t c_{u,t} = 1$:

$$c_{e,t} - c_{u,t} = (1-\alpha)K_{t-1}^{\alpha}\frac{\varphi}{\varphi+1}\left(\frac{\chi c_{e,t}}{1-\eta}\right)^{\frac{\varphi(1-\alpha)}{1+\varphi}}. \tag{32}$$

The latter equations shows that the Ramsey allocation optimally implements ex post inequality in consumption: $c_{e,t} > c_{u,t}$ and the inequality is increasing with the capital stock in the economy. Finally the resource constraint pins down the allocation.

At the steady state, we deduce from (31) that $\beta R = \frac{R}{1+\tilde{r}} < 1$, which means that the steady-state capital tax is positive and that unemployed agents are credit constrained at the steady state. The relative inequalities can be written as:

$$\frac{c_e}{c_u} = \left(1 - (1-\alpha)\frac{K^{\alpha}}{L^{\alpha}}\frac{\varphi}{\varphi+1}\frac{1}{(1-\eta)c_e w}\right)^{-1},$$

where K/L is pinned down by model parameters (from $\beta(1+\tilde{r}) = 1$). In other words, the relative inequality $\frac{c_e}{c_u}$ is decreasing with the size of the economy.

We summarize these results in the following proposition.

Proposition 2. *In the economy with deterministic fluctuations, the equilibrium*

has the following features:

- *The marginal utility of employed agents is always lower than the of unemployed agents;*
- *The consumption level of employed agents is always higher than the one of unemployed and the gap is increasing in the size of the economy.*

At the steady state, we further have:

- *The capital tax is always positive;*
- *The relative inequality c_e/c_u is decreasing with the size of the economy.*

4 Numerical results

4.1 Calibration

A period is a year. We consider $\beta = 0.96$. The capital share is $\alpha = 0.3$ and we consider full depreciation $\delta = 1$. Government consumption is assumed to be 10% of GDP, $g := G/Y = 10\%$. In this simple model, the steady-state capital tax is very sensitive to the Frisch elasticity of labor supply. We previously saw that when $\varphi = 0$, then $\tau^K = 0$. We target a value of τ^K equal to 0.3 in a closed economy (which is defined as Economy 1 below), what seems a consistent value for the US for instance.

Empirical analysis of the effect of interest rate on capital flows show first that countries can have a positive or a negative Net Foreign Asset (NFA) position. Second, net capital inflows is shown to increase with the interest rate on foreign investment. Third, the sensitivity of capital flows to the real interest rate can vary substantially across countries. It is high for countries integrated to world financial markets, but lower for countries with a low financial integration.

To capture these three facts, we consider the simple following functional form

for the the international capital flows:

$$F^W(R^F) := 2F_0(R^F - R^*), \tag{33}$$

where $F_0 > 0$. The rational for this specification is the following. First, there exists a foreign "neutral" interest rate R^*, such that $F^W(R^F) = 0$ when $R^F = R^*$. Second, $F^W(R^F) > 0$, when $R > R^F$ and $F^W(R^F) < 0$ when $R^F < R^*$. In other words, capital inflows increase with R^F, and the domestic country is a net borrower if $R^F > R^*$ and a net lender otherwise. Third, the long-run change in the capital flows over GDP for marginal a change in the level of the net interest rate $r^F := R^F - 1$ is $\frac{\partial(F/Y)}{\partial r^F}|_Y = \frac{2F_0}{Y}$.

Considering the specification, and the steady-state value of R^F, given in (33), one finds

$$R^F = \frac{1}{2}\left(\frac{1}{\beta} + R^*\right)$$

and

$$F^W\left(R^F\right) = F_0\left(\frac{1}{\beta} - R^*\right)$$

The two expressions show that the two parameters R^* and F^* can be easily estimated from two targets. For a given sensitivity $\epsilon := \frac{\partial(F/Y)}{\partial r^F}|_Y$ and a given NFA F (which can be either positive or negative) and GDP Y, one finds $F_0 = \epsilon Y/2$ and $R^* = 1/\beta - 2\frac{F}{\epsilon Y}$.

The value of ϵ is estimated in the data, with different estimation techniques. Empirically, the short run value of ϵ can be low in the short-run in developing countries, where additional financial frictions, such as capital controls are implemented or lack of financial information. Note that ϵ should be understood as the empirical long-run elasticity, which can be expected to be significantly higher than the short-run one. Alternatively, ϵ should be close to ∞ in case of perfect financial market integration, because foreigners would not accept to lend to the country at a rate, which is different from the one of their alternative investment opportunities, R^*. For this reason, we consider different cases, one where ϵ is low, and one where ϵ is high, for both borrowing and lending countries.

More specifically, we consider three economies.

Economy 1. This economy is a closed economy, where $F_0 = 0$. As a consequence, both the current account and the trade balance is 0. The economy is in closed, and previous results of the literature, such as LeGrand and Ragot (2025), prevail.

Economy 2. The country is assumed to be a net borrower and financial market to be integrated. We assume that $\epsilon = 200$, which generated a high level of capital mobility. We also target a 25% international borrowing, while is the order of magnitude of the NFA in developed countries which are net borrowers, such as France (-25) or the UK (-30%) in 2024. We obtain $r^* = 3.92\%$, whereas $\tilde{r} = 4.17\%$ and $r = 2.86\%$. As a consequence, the difference between the return on saving for foreigners and for domestic is roughly 1%. We deduce $F_0 = 58.52$.

Economy 3. We assume a low integration to the world financial market and set $\epsilon = 20$. We also target the same NFA as in Economy 2 of -25% of GDP. In this case, we find $r^* = 1.67\%$ and $F_0 = 5.85$.

Economy 4. We consider a lender country integrated to the world financial market. We consider $\epsilon = 200$. The NFA is targeted at $+25\%$. We compute $r^* = 4.42\%$, whereas $\tilde{r} = 4.17\%$ and $r = 2.91\%$. We find $F_0 = 58.52$.

Economy 5. We consider a lender country, with a low integration to the world financial market and set $\epsilon = 20$. The NFA is targeted at $+25\%$. We find that $r^* = 6.67\%$, whereas $\tilde{r} = 4.17\%$ and $r = 2.92\%$. We find $F_0 = 5.85$.

4.2 Steady state results

Table 1 provides the optimal fiscal system. The last column is change in GDP, where the GDP in autarky is normalized to 100 to ease comparison. We report change of GDP in basis point (bp), which is a percent of a percent (10^{-4}).

	Description	τ^L (%)	τ^K (%)	τ^F (%)	B/Y (%)	NFA/Y
Economy 1	Autarky	13.8	30.1	-	1.0	0
Economy 2	Borrower, high integration	15.2	31.5	3.0	25.2	-25
Economy 3	Borrower, low integration	14.8	31.3	30.0	25.4	-25
Economy 4	Lender, high integration	12.3	30.0	-3.0	-24	25
Economy 5	Borrower, low integration	11.7	29.9	-30	-24	25

Table 1: Optimal fiscal system for the five economies, described in the text. All values are in percent, except the last column in bps.

First, the economy in autarky (Economy 1) generates as small value for the labor tax (13.8%) and a capital tax of 30.1% to finance the public good, G. In this economy, the supply of asset is close to optimal, and the optimal level of public debt is small (1% of GDP).

Second, in the borrowing and integrated economy (Economy 2), the government sets a capital tax on foreigners at 3%, in order to get some revenue and attract foreign capital. The capital inflow is 25% of GDP, which corresponds roughly to the value of public debt (25.2% of GDP). To pay interest payment on public debt and the ROW, the labor tax is increased to 15.2% and the capital tax is increased to 31.5%.

In Economy 3, capital mobility is low, such that the government sets a capital on foreigners to 30%. This allows to decrease slightly both the labor tax (14.8%) and the capital tax (31.3%) compared to the economy with high financial market integration.

Lender countries receive revenues from their lending to the rest of the world. This allows to decrease the labor and capital tax. To benefit from the lending from the ROW, the government subsidies the lending to the ROW ($\tau^F < 0$) for the country to obtain a remuneration of saving, which is higher than the domestic

discount rate $R^F > 1/\beta$. In these economies, public debt must be negative in equilibrium. In other words, the government is accumulating some assets on the ROW.

4.3 Dynamics

We now study the dynamics of the optimal fiscal system after a transitory public spending shock. The dynamics of public spending is assumed to be:

$$G_t = G_{ss} + \rho_G \left(G_{t-1} - G_{ss}\right) + \epsilon_t^G.$$

We will consider an initial shock $\epsilon_0^G = 1\%$ of GDP and $\rho_G = 0.95$. We provide a first-order approximation of the dynamics after such a shock. We solve the model in the timeless perspective. This implies that the optimal policy rules conditional on shocks on G are anticipated. As the model is solved at the first-order, the policy rules are symmetric if the shock is negative.

The current model allows to investigate the robustness of these results in the open economy. To simplify the discussion of the results, and without loss of generality, we first focus the discussion on the comparison of Economy 1 (autarky) and Economy 2 (borrower with high integration), and then between Economy 2 (high integration) and Economy 3 (low integration). Indeed, the deviations from steady state values happen to be independent from the steady state NFA, whereas the elasticity ϵ is an important element of the dynamics.

The optimal change in external financing. We first represent the optimal dynamics of the tax system and of the allocation after a public spending shock of 1% of GDP, in the closed economy (Economy 1) and the open economy with high integration (Economy 2). Figure 1 plots in Panel 1 the path of the public spending shock, G, which increases by 1% of GDP on impact. Panel 2 reports the path of GDP in proportional deviation from steady-state value. Panels 4 to 6 plot the level change in τ^L, τ^K and τ^F (in percent). Panel 3, 7 to 9 plot the paths

of aggregate consumption C, foreign position F, public debt B, and capital K in percentage of steady-state GDP to ease the interpretation.

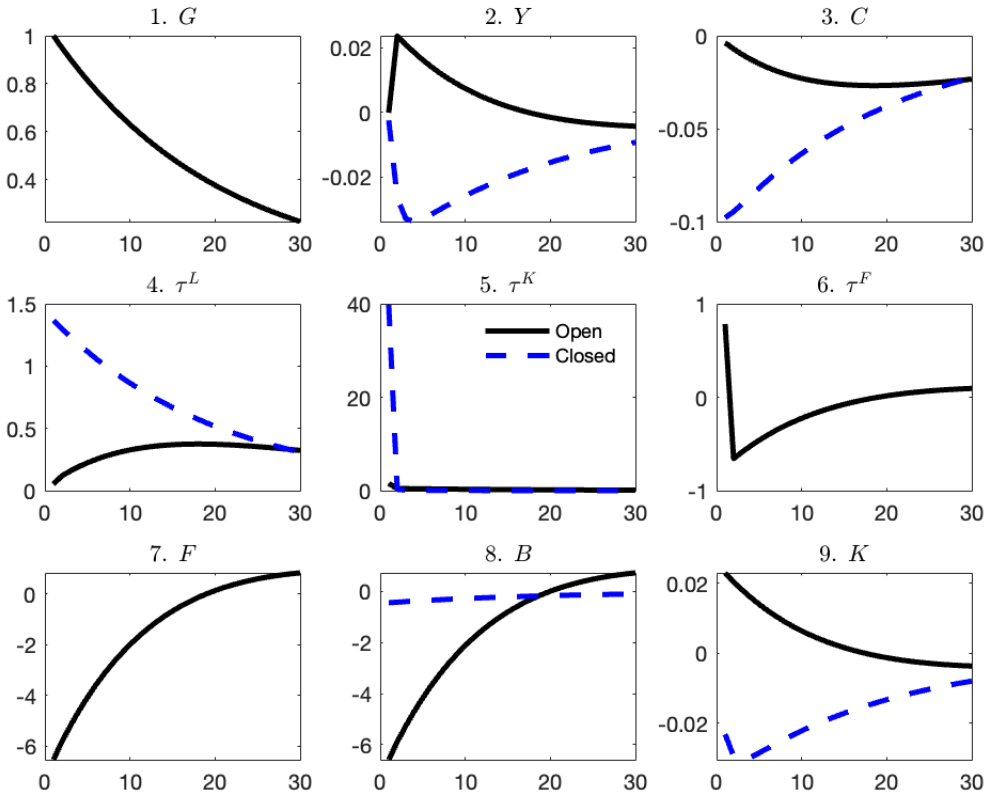


Figure 1: Dynamics of key variables after the same public spending shock of 1% of GDP for the open economy (Economy 3, black line) and the closed economy (Economy 1, blue dashed line). The figure reports the proportional deviation in percent of steady state GDP for G, Y, F, B, and K. It reports the proportional deviation in percent from steady-state value for L. It reports level deviation (in percent) for τ^L, τ^K, τ^F. See text for details.

First, Panel 2 reports two very different paths for GDP after the same shock. GDP decreases in the close economy, but increases in the open economy. In the closed economy, the public spending shock is financed by a one-period sharp increase in capital tax on impact from 30% to 70% and a persistent increase in labor tax. Public debt barely decreases due to the front-loading of the fiscal adjustment, which is consistent with LeGrand and Ragot (2025). The economy has fewer resources after such a shock, aggregate savings are lower and aggregate capital stock decreases by 0.02% of GDP (Panel 9).

In the open economy, the adjustment is very different. GDP slightly increases after a positive shock on public spending. Public debt sizably decreases by 6% of GDP (from 25% to 19%), and this decrease is associated with decreasing capital inflows (Panel 7). Overall capital stock is slightly increasing (Panel 9) in the open economy. This implies a decrease in the marginal productivity of capital. This lower capital productivity, together with the slight movement in the capital tax τ^F on foreign capital holding (Panel 6), generates a decrease in the foreign interest rate r^F. This explains with the high sensitivity of capital flows to r^F, the drop in the capital inflows (Panel 7). In the economy, both the labor (Panel 4) and capital (Panel 5) taxes barely move. In other words, instead of crowding out capital as in the closed economy, the increase in public spending crowds out foreign inflows.

The optimal policy in the open economy generates a lower fluctuations in aggregate consumption (Panel 3), has international capital flows that allow for a slight increase in capital (Panel 9). As a short summary, taxes are roughly constant in the open economy and both public debt and capital inflows adjust.

The role of the sensitivity of capital flows. To assess the role of integration to the world market, we now compare the economy with a high sensitivity of capital flows to the interest rate (Economy 2) to the one with a low sensitivity (Economy 3), both economies having the same NFA at the steady-state. Figure 2 reports the results for the same variables as in Figure 1. As before, Economy 2 is solid black line, whereas Economy 3 is the red dotted line.

First, one can observe that, when the sensitivity decreases the taxes are more volatile and public debt is less volatile. Indeed, one can observe that both the labor (Panel 4) and the capital (Panel 5) taxes are more volatile, as in Economy 1. Both public debt (Panel 8) and capital inflows (Panel 7) decrease less on impact. Capital increases more in the low sensitivity economy (Panel 9). This generates a higher drop in the return on capital, inducing a fall in capital inflow (Panel 7), although the sensitivity is lower than Economy 2.

In short the situation in Economy 3 is intermediate between Economies 1 and 2.

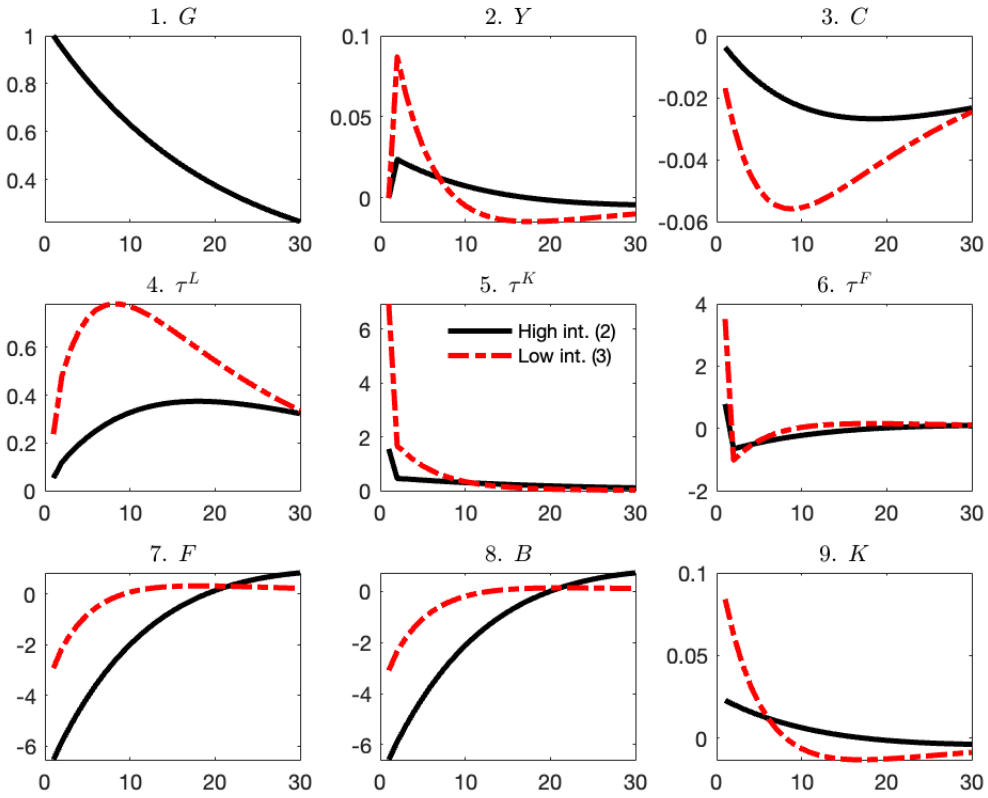


Figure 2: Dynamics of key variables after the same public spending shock of 1% of GDP for the open economy with high sensitivity (Economy 3, black line) and the open economy with low sensitivity (Economy 3, red dotted line). The figure reports the proportional deviation in percent of steady state GDP for G, Y, F, B, and K. It reports the proportional deviation in percent from steady-state value for L. It reports deviation in percent for τ^L, τ^K, τ^F. See text for details.

The planner stills partly relies on domestic capital and labor taxes. Since foreign holdings are

Borrower and lenders. We also compare the deviations of economies with a negative NFA (Economy 2) to the ones of an economy with a positive NFA (Economy 4), with the same sensitivity. We check that the changes are the same, and the deviations as reported in Table 1 cannot be distinguished. As a consequence, we do not report the IRFs here.

5 Conclusion

This paper has characterized the optimal conduct of fiscal policy in a small open economy with heterogeneous agents, where international capital mobility is imperfect. By extending the theory of optimal public debt and capital taxation to an open-economy setting, we have shown that international capital flows do not fundamentally modify the steady-state allocation implied by optimal policy. Instead, they primarily reshape the dynamic response of fiscal instruments to shocks.

At the steady state, the Modified Golden Rule continues to hold: the marginal product of capital equals the government's discount rate. The optimal tax on foreign capital is pinned down by the elasticity of international capital flows with respect to the real interest rate, and the equilibrium level of public debt ensures that domestic savings net of capital inflows are consistent with the optimal capital stock. As a result, the long-run fiscal structure remains close to that of a closed economy, despite the presence of cross-border capital movements.

In contrast, the short-run dynamics of optimal policy differ markedly once international capital markets are introduced. Capital inflows allow the government to smooth taxes over time and to finance temporary increases in public spending with more volatile public debt but smaller changes in domestic tax rates. The higher the degree of capital mobility, the greater the scope for intertemporal tax smoothing.

These findings have two broader implications. First, the traditional closed-economy insights on optimal fiscal policy remain robust for long-run analysis but can be misleading for short-run stabilization policy. Second, understanding the interaction between fiscal instruments and international capital markets is essential for assessing debt sustainability and tax design in open economies. Future research could extend this framework by considering nominal frictions, to analyze exchange rate dynamics and optimal monetary policy.

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