Winners and losers from international cooperation.

The case of non-commitment optimal policies in non-symmetric countries.

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Abstract Within a unified general equilibrium framework, we revisit the problem of international fiscal competition and cooperation when countries differ in some core economic fundamentals. We focus on cross-country differences in productivity, initial public debt and institutional quality. Solving for non-symmetric equilibria, both non-cooperative and cooperative, we show that international fiscal cooperation can create winners and losers even if it is superior to non-cooperation at aggregate level. In particular, our solutions imply that international cooperation hurts those countries with low productivity and poor institutional quality. By contrast, it benefits those countries with fragile public finances.

Keywords: Optimal taxation, international fiscal coordination, non-symmetric countries.

JEL classification: H2, F2, F4.

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1. Introduction (TO BE REVISED)

In a globalized world, and in a highly integrated Europe in particular, taxation on mobile factors is a major policy issue. In the absence of international cooperation, national governments have an incentive to cut tax rates in their attempt to attract mobile factors from abroad, and/or to prevent mobile factors from moving abroad, and this reduces tax revenues and the ability to finance socially beneficially programs. This is the so-called race-to-the-bottom problem. As shown by a vast literature, international tax cooperation typically leads to better outcomes.[1]

This paper revisits the classic problem of international tax competition and cooperation when countries differ. In a non-symmetric world, even when centralized decision-making (i.e. tax cooperation) is superior to decentralized decision-making (i.e. tax competition) at aggregate level, there can be winners and losers from cooperation. That is, a better aggregate outcome is not necessarily Pareto efficient. We will show that who is a winner and who is loser depends on the underlying kind of asymmetry.

Although economies can differ in many ways, some differences are considered to be more important. Here, within a unified general equilibrium framework, we will focus on cross-country asymmetries associated with differences in productivity, inherited public debt and institutional quality. We focus on these three fundamentals because they are widely recognized to be the key drivers of economic growth and future prospects. Productivity, quantified by TFP, is a measure of how efficiently the factors of production are being used (see e.g. Prescott (2002)). Inherited public debt, or strictly speaking its share in GDP, plays a key role in the effectiveness of fiscal policy and also a high public debt is the main culprit in crisis episodes (see e.g. Lorenzoni (2014) and D' Erasmo et al (2015)). Institutional quality, meaning the laws, regulations and property rights in a society, shape individual incentives and opportunities (see e.g. Acemoglu (2009, chapter 4)). Besides, these three core fundamentals, or strictly speaking cross-country differences in these fundamentals, are perceived to be the explanation for the different effects of the global financial crisis on different eurozone countries (see e.g. Micossi (2016)).

It is thus interesting to study how the above cross-country asymmetries shape the design of optimally chosen (both cooperatively and non-cooperatively) national tax-spending policies, and how, in turn, this optimal design shapes macroeconomic outcomes and the distribution of

[1] For reviews see e.g. Persson and Tabellini (1995, 2000) and Wilson (1999).

benefits and costs from international policy cooperation across countries. Following the literature on tax competition, national tax policies are chosen both non-cooperatively (Nash) and cooperatively (by a world panner like "Brussels"). In addition, driven by the work of Alesina et al (2005) on international unions, as well as by policy practice in the European Union, we distinguish two kinds of international policy cooperation: flexible and rigid cooperation which respectively mean that cooperative policies are country-specific or just single (one-size-fits-all).

Our main results are as follows. In all cases studied, as perhaps expected, non-cooperative policies are inferior to cooperative policies at aggregate level. Nevertheless, centralized decision-making leads to non-trivial distributional implications across countries so there are winners and losers from cooperation. This applies to both flexible and rigid cooperation. More specifically, we find the following.

When countries differ in productivity, as measured by differences in TFP, the relatively high tax rates on mobile factors, naturally arising under international cooperation to address the race-to-the-bottom problem, hurt the low-productivity country. The latter would need low, rather than high, tax rates to mitigate its low productivity problem. Thus, the winner is the high-productivity country.

When countries differ in public finances as captured by differences in inherited public debt, the relatively high tax rates on mobile factors, naturally arising under cooperation, suit more the needs of the country with weak public finances. The country with healthy public finances is better off without cooperation.

When countries differ in institutional quality, as measured by the degree of property rights, the optimally chosen tax rates under cooperation serve the needs of the country with strong institutions. By contrast, the high tax rates on mobile capital, naturally associated with cooperation, prove to be a luxury for the country with weak institutions. The latter would prefer to have low tax rates to mitigate its under-investment institutional problem.

Our paper is not the first one that solves for non-symmetric equilibria in international taxation problems. However, we differ from the literature because we study three key cross-country asymmetries, and their aggregate and distributional implications, within a unified general equilibrium setup.[2] Distinct differences in these three core fundamentals between the core and

[2] For example, Persson and Tabellini (1992) focus on asymmetries in the identity of governments and initial endowments; Bucovetsky (1991) focuses on differences in populations; Gordon (1986) on differences in inflation;

periphery countries (as shown in section 2 below) constitute a central problem in Europe and the eurozone.

The rest of the paper is organized as follows: Section 2 presents data that support our assumptions. Section 3 presents the model. Sections 4 and 5 solve respectively for symmetric and non-symmetric equilibria. Section 6 concludes.

2. Data on cross-country asymmetries (TO BE REVISED)

This section provides some data to support the types of asymmetries assumed in our model. We focus on differences in TFP, public finances and institutional quality between the core and the periphery countries in the eurozone (EZ).

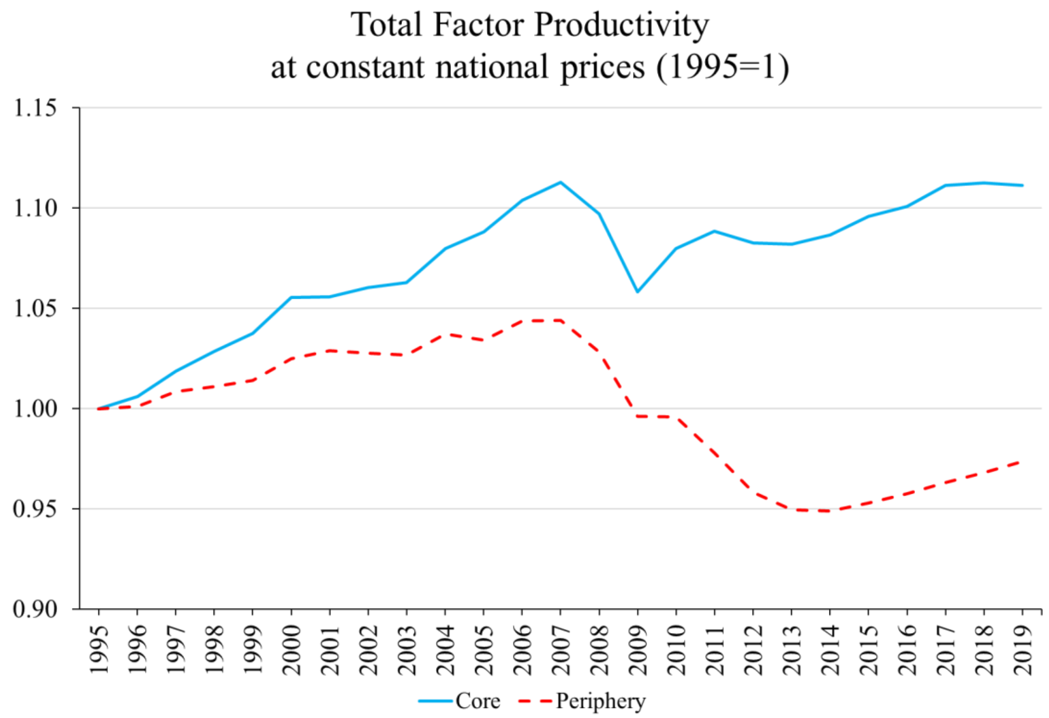

Figure 1: Total factor productivity (TFP), in the periphery and the core of Eurozone. Source: Penn World Table, version 10.0

Gordon and Varian (1989) on differences in technology; Mendoza and Tesar (2003, 2005) on differences in initial tax rates.

Figure 1 shows the productivity gap, as measured by differences in TFP, between the core and the periphery of the EZ from 1995 to 2019. The figure also shows that the gap has become bigger since the outburst of the global financial crisis in 2008.

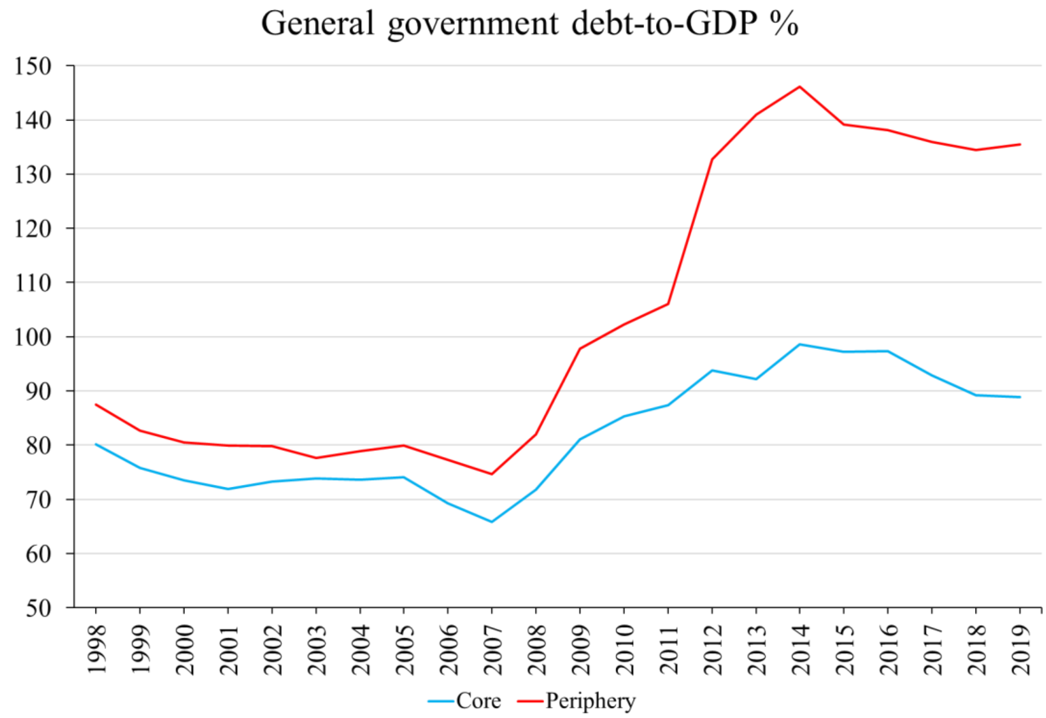

Figure 2: General government debt (% of GDP), in the periphery and the core of Eurozone.
Source: OECD database

Figure 2 displays the public debt-to-GDP ratio in the core and periphery of the EZ from 1995 to 2020. The graph depicts the convergence of debt ratios in the early euphoria period during the late 1990s and early to middle 2000s, that was suspended abruptly by the global financial crisis of 2008. The public finances of both the core and the periphery were struck hard by the crisis but the impact has been much more pronounced in the periphery.

3. Model

Consider a rather standard neoclassical world economy model consisting of two countries. For simplicity, we use a two-period economy as in e.g. Persson and Tabellini (1992, 1995, 2000) and many others in this literature.[3] In each country, there is a representative household, a representative firm and the national government. The household maximizes lifetime utility choosing consumption, work/leisure and savings between the two periods. The latter can be in the form of domestic capital, foreign capital and domestic government bonds. The firm maximizes profits choosing capital and labor inputs to produce a single traded good. With capital mobility across countries, the firm's capital can be owned by both domestic and foreign households/investors. Labor is also mobile internationally and hence, the members of the representative household can work both at home and abroad. The government is benevolent and, to finance utility-enhancing public goods/services, taxes labor and capital income invested in its own country (according to a residence-based system of taxation) and issues bonds held by domestic investors. Policy is chosen optimally. We will examine two types of optimal policy, one with commitment and the other without commitment. In the first, policy is chosen once-and-for-all in the beginning of the time horizon. In the latter, the government is free to re-optimize in each time period.

The domestic country will be denoted by the superscript *d* and the foreign country by the superscript *f*. The problems of agents (households, firms and the government) in each country are analogous so we will present the domestic economy only, except otherwise stated. We start by assuming that countries are identical and then allow for differences in TFP and public finances.

3.1. Households

In the domestic country, the household maximizes lifetime utility defined as:

$$U^d = \sum_{t=1}^{2} \beta^{t-1} u^d\left(c_t^d, l_t^d, s_t^d, g_t^d\right) \tag{1}$$

[3] For two-period models of international taxation, see also e.g. Kehoe (1989), Bucovetsky and Wilson (1991), Gordon (1986), Gordon and Varian (1989), Razin and Sadka (1991, 1994), Kammas and Philippopoulos (2009), etc. Infinite-horizon models include Kehoe (1987), Mendoza and Tesar (2003, 2005), Klein and Rios-Rull (2003), Klein et al (2008), Gross et al (2020), etc.

where $0 < \beta < 1$ is the time discount factor and c_t^d, l_t^d, s_t^d and g_t^d are consumption, work effort at home and abroad and publicly provided goods/services respectively.

In our numerical solutions, the period utility function is assumed to be of log-linear form:

$$u^d = \mu_1 \log c_1^d + \mu_2 \log\left(1 - l_1^d\right) + \mu_3 \log g_1^d \\ + \beta\left[\mu_1 \log c_2^d + \mu_2 \log\left(1 - l_2^d - s_2^d\right) + \mu_3 \log g_2^d\right] \tag{2}$$

where the parameters $0 \leq \mu_1, \mu_2, \mu_3 \leq 1$ are the weights given to the three arguments.

The budget constraints of the household in the two periods, $t = 1,2$, are respectively:

$$c_1^d + k_2^d + b_2^d + f_2^d \\ = \left(1 + \left(1 - \tau_{k,1}^d\right) r_1^d - \delta\right) k_1^d + \left(1 - \tau_{l,1}^d\right) w_1^d l_1^d + \left(1 + \rho_1^d\right) b_1^d \\ + \left(1 - \tau_{k,1}^d\right) \pi_1^d \tag{3}$$

$$c_2^d = \left(1 + \left(1 - \tau_{k,2}^d\right) r_2^d - \delta\right) k_2^d + \left(1 - \tau_{l,2}^d\right) w_2^d l_2^d + \left(1 - \tau_{k,2}^d\right) \pi_2^d \\ + \left(1 + \rho_2^d\right) b_2^d + \left(1 + \left(1 - \tau_{k,2}^f\right) r_2^f - \delta\right) f_2^d - m \frac{{f_2^d}^2}{2} \\ + \left(1 - \tau_2^f\right) w_2^f s_2^d - j \frac{\left(s_2^d - \bar{s}\right)^2}{2} \tag{4}$$

where k_2^d is capital invested at home at the end of the first period earning a gross return r_2^d in the next period, b_2^d is domestic government bonds purchased at the end of the first period earning a gross return ρ_2^d in the next period, f_2^d is capital invested abroad by domestic citizens at the end of the first period earning a gross return r_2^f in the next period, w_t^d is the real wage rate, π_t^d is dividends paid by firms, the parameter $0 < \delta \leq 1$ is the capital depreciation rate, the parameter $m \in [0, +\infty)$ is a measure of costs associated with investment abroad as in e.g. Persson and Tabellini (1992), the parameters $j \in [0, +\infty)$ and $0 < \bar{s} \leq 1$ capture the costs associated with household's members moving abroad as in e.g. Artuc et al. (2015) and $0 \leq \tau_{l,t}^d, \tau_{k,t}^d, \tau_{l,t}^f, \tau_{k,t}^f \leq 1$ are respectively tax rates on labor income earned at home, capital income earned at home, labor income earned abroad and capital income earned abroad respectively (the last two are set by the foreign government). Notice that, in a two-period model, the terminal non-Ponzi conditions are $k_3^d = b_3^d = f_3^d \equiv 0$.

The first-order conditions include the budget constraints and the optimality conditions for $l_1^d, l_2^d, s_2^d, k_2^d, b_2^d$ and f_2^d which are respectively:

$$\frac{\mu_1}{c_1^d}\left(1-\tau_{l,1}^d\right)w_1^d = \frac{\mu_2}{1-l_1^d} \tag{5}$$

$$\frac{\mu_2}{c_2^d}\left(1-\tau_{l,2}^d\right)w_2^d = \frac{\mu_2}{1-l_2^d-s_2^d} \tag{6}$$

$$\frac{\mu_2}{c_2^d}\left[\left(1-\tau_{l,2}^f\right)w_2^f - j\left(s_2^d-\bar{s}\right)\right] = \frac{\mu_2}{1-l_2^d-s_2^d} \tag{7}$$

$$\frac{c_2^d}{c_1^d} = \beta\left(1+\left(1-\tau_{k,2}^d\right)r_2^d-\delta\right) \tag{8}$$

$$\frac{c_2^d}{c_1^d} = \beta\left(1+\rho_2^d\right) \tag{9}$$

$$\frac{c_2^d}{c_1^d} = \beta\left(1+\left(1-\tau_{k,2}^f\right)r_2^f-\delta-mf_2^d\right) \tag{10}$$

where, conditions (5), (6) and (7) give the leisure-consumption trade-off in periods $t=1,2$ and equate the marginal value of labor to the after-tax return to labor, while conditions (8), (9) and (10) are standard Euler conditions for domestic capital, k_2^d, domestic bonds, b_2^d, and foreign capital, f_2^d.

3.2. Firms

The single traded good is produced by a single firm that acts competitively. In each period, $t=1,2$, the firm chooses capital and labor inputs, $\bar{k}_t^d$ and $\bar{l}_t^d$, to maximize profits:

$$\max_{\bar{k}_t^d,\bar{l}_t^d} \pi_\tau^d = y_t^d - r_t^d\bar{k}_t^d - w_t^d\bar{l}_t^d \tag{11}$$

subject to a Cobb-Douglas production function, $y_t^d = A\left(\bar{k}_t^d\right)^a\left(\bar{l}_t^d\right)^{1-a}$, where $a \in (0,1)$ and $A > 0$ are standard technology parameters.

The optimality conditions for the two inputs are simply:

$$r_t^d = a\frac{y_t^d}{\bar{k}_t^d} \tag{12}$$

$$w_t^d = (1-a)\frac{y_t^d}{\bar{l}_t^d} \tag{13}$$

so that profits are zero in equilibrium.

3.3. Government

The domestic government taxes labor income earned by both domestic and foreign workers at a rate $0 \leq \tau_{l,t}^{d} \leq 1$, capital income earned by both domestic and foreign investors at a rate $0 \leq \tau_{k,t}^{d} \leq 1$ and issues bonds to finance its expenditures. The government budget constraints in the two periods are:

$$g_1^d + \left(1 + \rho_1^d\right) b_1^d = \tau_{k,1}^d \left(r_1^d k_1^d + \pi_1^d\right) + \tau_{l,1}^d w_1^d l_1^d + b_2^d \tag{14}$$

$$g_2^d + \left(1 + \rho_2^d\right) b_2^d = \tau_{k,2}^d \left(r_2^d \left(k_2^d + f_2^f\right) + \pi_2^d\right) + \tau_{l,2}^d w_2^d \left(l_2^d + s_2^f\right) \tag{15}$$

where g_1^d and g_2^d are government expenditures in the two periods, f_2^f is capital invested at home by foreign citizens, s_2^f is the amount of foreign workers working at home and b_1^d and b_2^d are beginning-of-period public debt in periods 1 and 2. As said above, $b_3^d \equiv 0$.

3.4. World decentralized competitive equilibrium (for any feasible policy)

In a world decentralized competitive equilibrium (WDCE), which is for any feasible policy: (i) households maximize welfare in each country (ii) firms maximize profits in each country (iii) all constraints are satisfied in each country (iv) all markets clear including the world asset/capital and labor markets. With capital mobility, the market-clearing conditions for capital in the second period are $\bar{k}_2^d = k_2^d + f_2^f$ in the domestic economy and $\bar{k}_2^f = k_2^f + f_2^d$ in the foreign economy. With labor mobility, the market-clearing conditions for labor in the second period are $\bar{l}_2^d = l_2^d + s_2^f$ in the domestic economy and $\bar{l}_2^f = l_2^f + s_2^d$ in the foreign economy. Collecting equations, we have the WDCE system:

Domestic economy

$$c_1^d + k_2^d + b_2^d + f_2^d = \left(1 + \left(1 - \tau_{k,1}^d\right) r_1^d - \delta\right) k_1^d + \left(1 - \tau_{l,1}^d\right) w_1^d l_1^d + \left(1 + \rho_1^d\right) b_1^d \tag{16}$$

$$c_2^d = \left(1 + \left(1 - \tau_{k,2}^d\right) r_2^d - \delta\right) k_2^d + \left(1 - \tau_{l,2}^d\right) w_2^d l_2^d + \left(1 + \rho_2^d\right) b_2^d + \left(1 + \left(1 - \tau_{k,2}^f\right) r_2^f - \delta\right) f_2^d - m \frac{{f_2^d}^2}{2} + \left(1 - \tau_2^f\right) w_2^f s_2^d - j \frac{\left(s_2^d - \bar{s}\right)^2}{2} \tag{17}$$

$$\frac{\mu_1}{c_1^d}\left(1 - \tau_{l,1}^d\right) w_1^d = \frac{\mu_2}{1 - l_1^d} \tag{18}$$

$$\frac{\mu_2}{c_2^d}\left(1 - \tau_{l,2}^d\right) w_2^d = \frac{\mu_2}{1 - l_2^d - s_2^d} \tag{19}$$

$$\frac{\mu_2}{c_2^d}\left[\left(1 - \tau_{l,2}^f\right) w_2^f - j\left(s_2^d - \bar{s}\right)\right] = \frac{\mu_2}{1 - l_2^d - s_2^d} \tag{20}$$

$$\frac{c_2^d}{c_1^d} = \beta\left(1 + \left(1 - \tau_{k,2}^d\right) r_2^d - \delta\right) \tag{21}$$

$$\frac{c_2^d}{c_1^d} = \beta\left(1 + \left(1 - \tau_{k,2}^f\right) r_2^f - \delta - m f_2^d\right) \tag{22}$$

$$\frac{c_2^d}{c_1^d} = \beta\left(1 + \rho_2^d\right) \tag{23}$$

$$g_1^d + \left(1 + \left(1 - \tau_{k,1}^d\right) r_1^d - \delta\right) b_1^d = y_1^d \left(\tau_{k,1}^d a + \tau_{l,1}^d (1 - a)\right) + b_2^d \tag{24}$$

$$g_2^d + \left(1 + \rho_2^d\right) b_2^d = y_2^d \left(\tau_{k,2}^d a + \tau_{l,2}^d (1 - a)\right) \tag{25}$$

Foreign economy

$$c_1^f + k_2^f + b_2^f + f_2^f = \left(1 + \left(1 - \tau_{k,1}^f\right) r_1^f - \delta\right) k_1^f + \left(1 - \tau_{l,1}^f\right) w_1^f l_1^f + \left(1 + \rho_1^f\right) b_1^f \tag{26}$$

$$c_2^f = \left(1 + \left(1 - \tau_{k,2}^f\right) r_2^f - \delta\right) k_2^f + \left(1 - \tau_{l,2}^f\right) w_2^f l_2^f + \left(1 + \rho_2^f\right) b_2^f + \left(1 + \left(1 - \tau_{k,2}^d\right) r_2^d - \delta\right) f_2^f - m \frac{{f_2^f}^2}{2} + \left(1 - \tau_2^d\right) w_2^d s_2^f - j \frac{\left(s_2^f - \bar{s}\right)^2}{2} \tag{27}$$

$$\frac{\mu_1}{c_1^f}\left(1-\tau_{l,1}^f\right)w_1^f = \frac{\mu_2}{1-l_1^f} \tag{28}$$

$$\frac{\mu_2}{c_2^f}\left(1-\tau_{l,2}^f\right)w_2^f = \frac{\mu_2}{1-l_2^f-s_2^f} \tag{29}$$

$$\frac{\mu_2}{c_2^f}\left[\left(1-\tau_{l,2}^d\right)w_2^d - j\left(s_2^f-\bar{s}\right)\right] = \frac{\mu_2}{1-l_2^f-s_2^f} \tag{30}$$

$$\frac{c_2^f}{c_1^f} = \beta\left(1+\left(1-\tau_{k,2}^f\right)r_2^f-\delta\right) \tag{31}$$

$$\frac{c_2^f}{c_1^f} = \beta\left(1+\left(1-\tau_{k,2}^f\right)r_2^f-\delta-mf_2^f\right) \tag{32}$$

$$\frac{c_2^f}{c_1^f} = \beta\left(1+\rho_2^f\right) \tag{33}$$

$$g_1^f + \left(1+\left(1-\tau_{k,1}^f\right)r_1^f-\delta\right)b_1^f = y_1^f\left(\tau_{k,1}^f a + \tau_{l,1}^f(1-a)\right) + b_2^f \tag{34}$$

$$g_2^f + \left(1+\rho_2^f\right)b_2^f = y_2^f\left(\tau_{k,2}^f a + \tau_{l,2}^f(1-a)\right) \tag{35}$$

where, in the above, we use the following equations describing gross wages, capital and bond returns in the two countries at $t = 1{,}2$:

$$w_t^d = (1-a)\frac{y_t^d}{l_t^d + s_t^f} \tag{36}$$

$$w_t^f = (1-a)\frac{y_t^f}{l_t^f + s_t^d} \tag{37}$$

$$r_t^d = a\frac{y_t^d}{k_t^d + f_t^f} \tag{38}$$

$$r_t^f = a\frac{y_t^f}{k_t^f + f_t^d} \tag{39}$$

Thus, at this stage of the model, we have a system of 20 equations, (16)-(35), in 20 variables, $c_1^d, c_2^d, c_1^f, c_2^f, l_1^d, l_2^d, s_2^d, l_1^f, l_2^f, s_2^f, k_2^d, k_2^f, f_2^d, f_2^f, b_2^d, b_2^f, g_2^d, g_2^f, \rho_2^d, \rho_2^f$. This is given the independently set policy instruments, which include the tax rates, $\tau_{k,1}^d, \tau_{k,1}^f, \tau_{k,2}^d, \tau_{k,2}^f, \tau_{l,1}^d, \tau_{l,1}^f, \tau_{l,2}^d, \tau_{l,2}^f$, and the public spending items, g_1^d, g_1^f. In other words, in each period, one public financing policy instrument needs to follow residually to close the government budget constraint. Here, we assume that this role is played by the end-of-period public debt in the first period (b_2^d and b_2^f) and by the gross return of domestic government bonds in the second period (ρ_2^d and ρ_2^f); this is why these four variables, $b_2^d, b_2^f, \rho_2^d, \rho_2^f$, have been included in the category of endogenous variables. We report however that the specific classification of policy instruments into endogenous and independently set at this level is not important to our results below since policy will be chosen optimally. This comes next. Before we move on, we report that numerical solutions of the WDCE system are available upon request.

It is convenient for what follows to define the net factor returns:[4]

$$R_2^d \equiv 1-\delta+\left(1-\tau_{k,2}\right)r_2^d \tag{40}$$

$$W_1^d \equiv \left(1-\tau_{l,1}\right)w_1^d \tag{41}$$

$$W_2^d \equiv \left(1-\tau_{l,2}\right)w_2^d \tag{42}$$

So the DCE can be written as:

Domestic economy

$$c_1^d+k_2^d+f_2^d+b_2^d=\left(1+\left(1-\tau_{k,1}^d\right)r_1^d-\delta\right)\left(k_1^d+b_1^d\right)+W_1^d l_1^d \tag{16$'$}$$

$$c_2^d=R_2^d k_2^d+W_2^d l_2^d+R_2^f f_2^d-m\frac{\left(f_2^d\right)^2}{2}+W_2^f s_2^d-j\frac{\left(s_2^d-\bar{s}\right)^2}{2}+\left(1+\rho_2^d\right)b_2^d \tag{17$'$}$$

$$\frac{\mu_1}{c_1^d}W_1^d=\frac{\mu_2}{1-l_1^d} \tag{18$'$}$$

$$\frac{\mu_2}{c_2^d}W_2^d=\frac{\mu_2}{1-l_2^d-s_2^d} \tag{19$'$}$$

$$\frac{\mu_2}{c_2^d}\left[W_2^f-j\left(s_2^d-\bar{s}\right)\right]=\frac{\mu_2}{1-l_2^d-s_2^d} \tag{20$'$}$$

$$\frac{c_2^d}{c_1^d}=\beta R_2^d \tag{21$'$}$$

$$\frac{c_2^d}{c_1^d}=\beta\left(R_2^f-mf_2^d\right) \tag{22$'$}$$

[4] We do not define net factor return for the capital in the first period because first-period capital tax rate is not chosen optimally.

$$\frac{c_2^d}{c_1^d} = \beta\left(1+\rho_2^d\right) \tag{23'}$$

$$g_1^d + \left(1+\left(1-\tau_{k,1}^d\right)r_1^d - \delta\right)b_1^d = y_1^d\left(\tau_{k,1}^d a + (1-a)\right) - W_1^d l_1^d + b_2^d \tag{24'}$$

$$g_2^d + \left(1+\rho_2^d\right)b_2^d = y_2^d + (1-\delta)\left(k_2^d + f_2^f\right) - R_2^d\left(k_2^d + f_2^f\right) - W_2^d\left(l_2^d + s_2^f\right) \tag{25'}$$

Foreign economy

$$c_1^f + k_2^f + f_2^f + b_2^f = \left(1+\left(1-\tau_{k,1}^f\right)r_1^f - \delta\right)\left(k_1^f + b_1^f\right) + W_1^f l_1^f \tag{26'}$$

$$c_2^f = R_2^f k_2^f + W_2^f l_2^f + R_2^d f_2^f - m\frac{\left(f_2^f\right)^2}{2} + W_2^d s_2^f - j\frac{\left(s_2^f - \bar{s}\right)^2}{2} + \left(1+\rho_2^f\right)b_2^f \tag{27'}$$

$$\frac{\mu_1}{c_1^f}W_1^f = \frac{\mu_2}{1-l_1^f} \tag{28'}$$

$$\frac{\mu_2}{c_2^f}W_2^f = \frac{\mu_2}{1-l_2^f-s_2^f} \tag{29'}$$

$$\frac{\mu_2}{c_2^f}\left[W_2^d - j\left(s_2^f - \bar{s}\right)\right] = \frac{\mu_2}{1-l_2^f-s_2^f} \tag{30'}$$

$$\frac{c_2^f}{c_1^f} = \beta R_2^f \tag{31'}$$

$$\frac{c_2^f}{c_1^f} = \beta\left(R_2^d - m f_2^f\right) \tag{32'}$$

$$\frac{c_2^f}{c_1^f} = \beta\left(1+\rho_2^f\right) \tag{33'}$$

$$g_1^f + \left(1+\left(1-\tau_{k,1}^f\right)r_1^f - \delta\right)b_1^f = y_1^f\left(\tau_{k,1}^f a + (1-a)\right) - W_1^f l_1^f + b_2^f \tag{34'}$$

$$g_2^f + \left(1+\rho_2^f\right)b_2^f = y_2^f + (1-\delta)\left(k_2^f + f_2^d\right) - R_2^f\left(k_2^f + f_2^d\right) - W_2^f\left(l_2^f + s_2^d\right) \tag{35'}$$

which is a twenty-equation system in $c_1^d, c_2^d, c_1^f, c_2^f, l_1^d, l_2^d, s_2^d, l_1^f, l_2^f, s_2^f, k_2^d, k_2^f, f_2^d, f_2^f$, $b_2^d, b_2^f, g_2^d, g_2^f, \rho_2^d, \rho_2^f$, for any feasible policy $\tau_{k,1}^d, \tau_{k,1}^f, R_2^d, R_2^f, W_1^d, W_1^f, W_2^d, W_2^f$, and the public spending items, g_1^d, g_1^f.

4. The policy problems

(AS IN ECONOMIDES AND RIZOS, 2021) We will consider two types of optimal policy, with and without commitment. In the case with commitment, i.e. the so-called Ramsey policy in infinite-horizon models, policy is chosen once-and-for-all at the start of the time horizon before private agents make their choices. In the case without commitment, the government is free to re-optimize in each period, and this takes place before private agents make their current choices.

4.1. Optimal policy with commitment

We endogenise policy under commitment. Following the related literature on tax competition, we will compare the case in which national policies are chosen non-cooperatively, as in a typical Nash equilibrium, to the case in which national policies are chosen cooperatively by a fictional world social planner.

4.1.1. Sequence of events

In the beginning of the time horizon, each government chooses its tax-spending-debt policies once-and-for-all acting either non-cooperatively (Nash) or cooperatively. In turn, having observed policy, private agents make their decisions acting competitively. Since policy is chosen once-and-for-all before private decisions (especially, savings or investment) have been made, we solve for a commitment or Ramsey-type equilibrium (which can be either Nash or cooperative). To solve the model, we will typically work with backward induction. That is, we will first solve private agents' problems and derive the associated decentralized world equilibrium which is for any feasible policy mix in each country. Then, by taking all this into account, the two governments will choose their policies either by playing Nash or by acting cooperatively. In both cases, policymakers will be constrained by the WDCE system as presented above.

Since the problem is too complex to be specified in a primal form (meaning that one cannot express the objective function and the constraints as functions of the independent policy instruments only), we will follow usual practice by solving the problem in its dual form (see e.g. Atkinson and Stiglitz (1980) for the early literature and Ljungqvist and Sargent (2012) for a review of the more recent literature). This means that policymakers, in addition to the independent policy instruments as defined above, will re-choose all the allocations and the residually determined instruments of the WDCE system.

Notice that the tax rates on initial capital, $\tau_{k,1}^{d}$ and $\tau_{k,1}^{f}$, have to be taken as given by policymakers because, as is well known, if the taxation of initial capital (where the latter is fully inelastic) is allowed, the optimization problem is reduced to a first-best one and this makes the policy problem trivial (see e.g. Ljungqvist and Sargent (2012, chapter 16)). Besides, although this is for algebraic simplicity only, we will treat first-period public spending in the two countries, g_1^d and g_1^f, as exogenous variables.

4.1.2. Non-cooperative policies (Nash): Characterization of equilibrium

In a non-cooperative (Nash) game, each national government chooses its own policies to maximize the welfare of its own citizens by taking as given the policies of the other government and by taking into account the system of equations summarizing the WDCE.

In other words, the domestic government maximizes:

$$\begin{aligned} U^d = {} & \mu_1 \log c_1^d + \mu_2 \log\left(1 - l_1^d\right) + \mu_3 \log g_1^d \\ & + \beta\left[\mu_1 \log c_2^d + \mu_2 \log\left(1 - l_2^d - s_2^d\right) + \mu_3 \log g_2^d\right] \end{aligned} \tag{40}$$

subject to the WDCE in equations (16')-(35').

From the viewpoint of the domestic government, the solution to this dual optimization problem, in a Nash non-cooperative game, yields a system of 43 equations in 43 endogenous variables. Specifically, counting equations, we have the 20 constraints/equations of the WDCE, the optimality conditions for the 20 variables being determined by the WDCE system (as said, these variables are rechosen in a dual solution to the government's problem), plus the three optimality conditions for the domestic independent policy instruments, W_1^d, R_2^d, W_2^d. Counting endogenous variables, we have the 20 variables of the WDCE system, $c_1^d, c_2^d, c_1^f, c_2^f, l_1^d, l_2^d, s_2^d, l_1^f, l_2^f, s_2^f, k_2^d, k_2^f, f_2^d, f_2^f, b_2^d, b_2^f, g_2^d, g_2^f, \rho_2^d, \rho_2^f$, plus the 20 Lagrangean multipliers corresponding to the 20 equations of the WDCE system, plus the three optimally chosen instruments, W_1^d, R_2^d, W_2^d. This is given the independent policy choices of the other country, W_1^f, R_2^f, W_2^f, and the assumed exogenous policy variables, $\tau_{k,1}^d, \tau_{k,1}^f, g_1^d, g_1^f$. The foreign country solves an analogous problem and obtains a similar set of 43 equations in 43 unknowns. That is, in equilibrium, we will end up with 66 equations in 66 variables (namely, 43+43-20) since the 20 equations of the WDCE are common to both countries and the same applies to the associated 20 variables that are endogenous at WDCE level.[5]

4.1.3. Cooperative policies: Characterization of equilibrium

When national policies are chosen jointly by a fictional world social planner, the latter maximises a weighted average of households' welfare in each country with weights γ and $1-\gamma$. Thus, now the objective function is:

$$W^{COOP} = \gamma U^d + (1-\gamma) U^f \tag{41}$$

subject to the WDCE in equations (16')-(35').

We now have a system of 46 equations in 46 unknowns. Counting equations, we have the 20 constraints/equations of the WDCE, the optimality conditions for the 20 variables being determined by the WDCE system, plus the four optimality conditions for the independent policy instruments. Counting endogenous variables, we have the 20 variables of the WDCE system, $c_1^d, c_2^d, c_1^f, c_2^f, l_1^d, l_2^d, s_2^d, l_1^f, l_2^f, s_2^f, k_2^d, k_2^f, f_2^d, f_2^f, b_2^d, b_2^f, g_2^d, g_2^f, \rho_2^d, \rho_2^f$, plus the 20 Lagrangean multipliers corresponding to the 20 equations of the WDCE system, plus the 6 optimality conditions for the 6 independent policy instruments, $R_2^d, R_2^f, W_1^d, W_2^d, W_1^f, W_2^f$. This is again given the assumed exogenous policy instruments $\tau_{k,1}^d, \tau_{k,1}^f, g_1^d, g_1^f$.[6]

4.2. Optimal policy without commitment

(AS IN ECONOMIDES AND RIZOS, 2021)As it well known, the solution of optimal policy problem with commitment is, in general, time-inconsistent. We thus move to optimal policy without commitment.

[5] For details, see Appendix A.1. Note that, in the case of a symmetric Nash equilibrium, the system is reduced to 33 equations in 33 unknowns.

[6] For details, see Appendix A.2. Note that, in a symmetric cooperative equilibrium, the system is reduced to 23 equations in 23 unknowns.

4.2.1. Sequence of events

Without commitment, the timing is as follows (see also e.g. Fischer (1980), Persson and Tabellini, 2000, pp. 310-11): (a) Each government chooses its first-period policies acting either non-cooperatively (Nash) or cooperatively. (b) In turn, private agents in each country make their first-period decisions and, in particular, their savings decisions acting competitively. (c) Each government chooses its second-period policies acting either non-cooperatively (Nash) or cooperatively. (d) Private agents make their second-period decisions acting competitively. We will work with backward induction starting from the last stage. As is usually assumed (see e.g. Klein et al. (2008)), private agents act non-strategically taking economic and political choices as given in all stages.

4.2.2. Non-cooperative policies (Nash): Characterization of equilibrium

Solution of stage (d)

The household in the domestic country maximizes its second-period utility by choosing second-period consumption, c_2^d, and work/leisure at home and abroad, l_2^d, s_2^d, subject to its second-period budget constraint and treating policy as given. The equations summarizing this step are the household's second-period budget constraint and the optimality conditions for work at home and abroad. The household in the foreign country solves a similar problem and obtains similar equations.

The equations summarizing private agents' behavior are:

$$c_2^d = R_2^d k_2^d + W_2^d l_2^d + R_2^f f_2^d - m\frac{\left(f_2^d\right)^2}{2} + W_2^f s_2^d - j\frac{\left(s_2^d - \bar{s}\right)^2}{2} + \left(1+\rho_2^d\right)b_2^d \tag{42}$$

$$\frac{\mu_2}{c_2^d} W_2^d = \frac{\mu_2}{1 - l_2^d - s_2^d} \tag{43}$$

$$\frac{\mu_2}{c_2^d}\left[W_2^f - j\left(s_2^d - \bar{s}\right)\right] = \frac{\mu_2}{1 - l_2^d - s_2^d} \tag{44}$$

Solution of stage (c)

Now, we move on to the next step. Taking into account second-period private decisions, but taking as given all first-period decisions, the domestic government chooses its own second-period policy instruments R_2^d, W_2^d, g_2^d to maximize:

$$U_2^d = \mu_1 \log c_2^d + \mu_2 \log\left(1 - l_2^d - s_2^d\right) + \mu_3 \log g_2^d \tag{48}$$

subject to (42)-(44), the three optimality conditions in the foreign country and the second-period government and budget constraints in both countries (25, 35).

The solution of stage (c), in a non-cooperative (Nash) game, yields a system of 2 equations in 2 endogenous variables, namely, the two optimality conditions for the domestic independent policy instruments, R_2^d, W_2^d. This is given the independent policy choices of the other country, R_2^f, W_2^f. The foreign country solves an analogous problem and obtains a similar set of 2 equations in 2 unknowns in the second period. Note that we treat g_2^d, g_2^f as the residually determined policy instruments.

Solution of stage (b)

We now move to the first period. Private agents make their first-period choices by taking all policy variables as given. The household in the domestic country maximizes its lifetime discounted utility by choosing first-period consumption, c_1^d, work/leisure, l_1^d, and savings in the form of domestic capital, k_2^d, foreign capital, f_2^d, and private bonds, b_2^d, by taking into account its own budget constraint and its own labor supply decisions of stage (d). The optimality conditions associated with this step are:

$$c_1^d + k_2^d + f_2^d + b_2^d = \left(1 + \left(1 - \tau_{k,1}^d\right) r_1^d - \delta\right)\left(k_1^d + b_1^d\right) + W_1^d l_1^d \tag{45}$$

$$\frac{\mu_1}{c_1^d} W_1^d = \frac{\mu_2}{1 - l_1^d} \tag{46}$$

$$\frac{\mu_1}{c_1^d} = \beta \left\{ \frac{R_2^d \mu_1^2}{(\mu_1 + \mu_2) c_2^d} + \frac{R_2^d \mu_2^2}{(\mu_1 + \mu_2) W_2^d \left(1 - l_2^d - s_2^d\right)} \right\} \tag{47}$$

$$\frac{\mu_1}{c_1^d} = \beta \left\{ \frac{\left(R_2^f - m f_2^d\right) \mu_1^2}{(\mu_1 + \mu_2) c_2^d} + \frac{\left(R_2^f - m f_2^d\right) \mu_2^2}{(\mu_1 + \mu_2) W_2^d \left(1 - l_2^d - s_2^d\right)} \right\} \tag{48}$$

$$\frac{\mu_1}{c_1^d} = \beta \left\{ \frac{\left(1 + \rho_2^d\right) \mu_1^2}{(\mu_1 + \mu_2) c_2^d} + \frac{\left(1 + \rho_2^d\right) \mu_2^2}{(\mu_1 + \mu_2) W_2^d \left(1 - l_2^d - s_2^d\right)} \right\} \tag{49}$$

At this stage we have 5 new equations in 5 endogenous variables, namely, $c_1^d, l_1^d, k_2^d, f_2^d, \rho_2^d$.

Solution of stage (a)

Now the government chooses first-period policy W_1^d to maximize

$$U^d = \mu_1 \log c_1^d + \mu_2 \log\left(1 - l_1^d\right) + \mu_3 \log g_1^d + \beta\left[\mu_1 \log c_2^d + \mu_2 \log\left(1 - l_2^d - s_2^d\right) + \mu_3 \log g_2^d\right] \tag{51}$$

Subject to the equations above (42)-(49), the two optimality conditions of stage (c), the analogous set of equations in the foreign economy and the four budget constraints in the two countries.

The solution of this stage yields a system of 45 equations in 45 endogenous variables. Specifically, counting equations, we have the 20 constraints/equations of the WDCE, the optimality conditions for the 20 variables being determined by the WDCE system (as said, these variables are rechosen in a dual solution to the government's problem), the two optimality conditions from stage (c), plus the three optimality conditions for the domestic independent policy instruments, W_1^d, R_2^d, W_2^d. Counting endogenous variables, we have the 20 variables of the WDCE system, $c_1^d, c_2^d, c_1^f, c_2^f, l_1^d, l_2^d, s_2^d, l_1^f, l_2^f, s_2^f, k_2^d, k_2^f, f_2^d, f_2^f, b_2^d, b_2^f, g_2^d, g_2^f, \rho_2^d, \rho_2^f$, plus the 20 Lagrangean multipliers corresponding to the 20 equations of the WDCE system, plus the three optimally chosen instruments, W_1^d, R_2^d, W_2^d. This is given the independent policy choices of the other country, W_1^f, R_2^f, W_2^f, and the assumed exogenous policy variables, $\tau_{k,1}^d, \tau_{k,1}^f, g_1^d, g_1^f$. The foreign country solves an analogous problem and obtains a similar set of 45 equations in 45 unknowns.

Non-cooperative (Nash) equilibrium without commitment

That is, in equilibrium, we will end up with 70 equations in 70 variables (namely, 45+45-20) since the 20 equations of the WDCE are common to both countries and the same applies to the associated 20 variables that are endogenous at WDCE level.[7]

[7] For details, see Appendix A.1. Note that, in the case of a symmetric Nash equilibrium, the system is reduced to 35 equations in 35 unknowns.

4.2.3. Cooperative policies: Characterization of equilibrium

Solution of stage (d)

The solution here is identical to the one in stage (d) in the non-cooperative regime. Hence, we have 6 equations in 6 endogenous variables. Particularly, counting equations we have 4 optimality conditions for the 4 variables being determined by households in the WDCE in the second period, $l_2^d, s_2^d, l_2^f, s_2^f$, plus the two second-period budget constraints that define c_2^d and c_2^f.

Solution of stage (c)

When national policies are chosen jointly by a fictional world social planner, the latter maximises a weighted average of households' second-period welfare in each country with equal weights, γ, given to each one of them:

$$W_2^{COOP} = \gamma U_2^d + (1-\gamma) U_2^f \tag{52}$$

subject to the optimality conditions of stage (d) as well as the second-period government and budget constraints in both countries (25, 35).

The solution of stage (c), in this cooperative game, yields a system of 4 equations in 4 endogenous variables, namely, the four optimality conditions for the policy instruments, $\tau_{k,2}^d, \tau_{l,2}^d, \tau_{k,2}^f, \tau_{l,2}^f$. Hence, at this stage, we end up with a system of 4 equations in 4 variables.

Solution of stage (b)

Again, the solution of this stage is identical to the one in stage (b) in the non-cooperative regime. Hence, at this stage we have 10 new equations in 10 endogenous variables (43-50), namely, 8 optimality conditions in $l_1^d, k_2^d, f_2^d, \rho_2^d, l_1^f, k_2^f, f_2^f, \rho_2^f$ and the 2 first-period budget constraints that define c_1^d, c_1^f.

Solution of stage (a)

Now the world social planner chooses first-period policy in both countries $\tau_{l,1}^d, \tau_{l,1}^f$ to maximize

$$W^{COOP} = \gamma U^d + (1-\gamma)U^f \quad (53)$$

Subject to the optimality conditions above (4 equations in stage (d), 4 equations in stage (b), 8 equations in stage (a)) and the household and government budget constraints in both countries (8 equations).

The solution of this stage yields a system of 50 equations in 50 endogenous variables. Specifically, counting equations, we have the 20 constraints/equations of the WDCE, the optimality conditions for the 20 variables being determined by the WDCE system (as said, these variables are rechosen in a dual solution to the government's problem), the four optimality conditions from stage (c), plus the six optimality conditions for the endogenous policy instruments, $\tau^d_{l,1}, \tau^d_{k,2}, \tau^d_{l,2}, \tau^f_{l,1}, \tau^f_{k,2}, \tau^f_{l,2}$.

Cooperative equilibrium without commitment

That is, in equilibrium, we will end up with 50 equations in 50 variables.[8]

5. Symmetric countries and equilibria (TO BE REVISED)

We start with the case in which the countries are alike ex post. This can serve as a benchmark for the more interesting non-symmetric cases and can also help us to compare our results to the related literature on tax competition.

5.1. Parameterization (TO BE REVISED)

We start with a symmetric world and will present cross-country differences in the next section. Regarding the model's parameters, we employ values widely used by the literature (we report from the start that our results are robust to changes in these values at least within sensible ranges[9]). The aggregate productivity, A, which is a scale parameter, is set at 1. The power coefficient measuring the share of capital in production, α, is set at 0.4. We set the time discount factor, β, at 0.9. We assume that the social planner weighs equally the two countries so that we

[8] For details, see Appendix A.1. Note that, in the case of a symmetric Nash equilibrium, the system is reduced to 35 equations in 35 unknowns.

[9] A rather detailed robustness study is available upon request from the authors.

set $\gamma = 0.5$ in the planner's objective function. The depreciation rate of capital, δ, is set at 1, which is a typical assumption in two-period models (see e.g. Fischer (1980)). The weights given to consumption, leisure and public goods in the period utility function are $\mu_1 = 0.3$, $\mu_2 = 0.6$ and $\mu_3 = 1 - \mu_1 - \mu_2$ respectively (see e.g. Economides et al (2021)). The transaction cost parameter associated with moving capital abroad is set at $m = 0.1$ (see e.g. Persson and Tabellini (1992) and Kammas and Philippopoulos (2009)), which translates to almost perfect capital mobility across countries. These parameter values give economically sensible solutions in a two-period setup.

Regarding the exogenously set policy variables, the capital tax rate on the initial capital stock, $\tau_{k,1}$, is set at 0.10. The initial stock of public debt, b_1, is set at 0.5, which implies a first-period public debt-to-GDP ratio, b_1/y_1, around 50%. The initial stock of capital, k_1, is set at 10, while the level of public spending in the first period, g_1, is set at 0.05.

5.2. Optimal policy and allocation in symmetric equilibria (TO BE REVISED)

Working as explained in subsections 3.5.1 and 3.5.2 and using the parameter values presented in the above subsection, we now solve for a symmetric Nash equilibrium (SNE) and a symmetric cooperative equilibrium (SCE). To save on space in the main text, we report solutions for the key variables only (a detailed solution is provided in Appendix B.1). Table 1 reports the optimally chosen tax rates ($\tau_{k,2}, \tau_{l,1}, \tau_{l,2}$), as well as the solutions for output and public spending in the second period (y_2, g_2) and discounted lifetime utility (U).[10]

Notice three things before we discuss the solution in Table 1. First, we focus on second period macroeconomic outcomes, like y_2 and g_2, because, in a two-period model, several first-period variables, like capital, are given by initial conditions. Second, we focus on U simply because this is the objective of policymakers. Third, since here we solve for symmetric equilibria, obviously there is no difference between flexible and rigid cooperation.

Table 1 reveals that when policymakers commit themselves, the burden of taxation - after the first period during which capital is fully inelastic - should fall mainly on labor which is the relatively inelastic factor. Hence, in the second period, which can be thought of as the medium and long run in a two-period setup, the capital tax rates are lower than the labor tax rates and this happens irrespectively of the degree of international cooperation ($\tau_{k,2}$=0.0148<0.1637=$\tau_{l,2}$

[10] As said above, $U = u_1 + \beta u_2$ is household's discounted lifetime utility.

in a SNE and $\tau_{k,2}$=0.0912<0.1897=$\tau_{l,2}$ in a SCE). This is consistent with the Chamley-Fischer-Judd result which has served as the benchmark in the literature on dynamic optimal factor taxation. On top of this, looking at differences between Nash and cooperative equilibria, the optimally chosen capital tax rate, $\tau_{k,2}$, is clearly lower in a SNE than in a SCE (0.0148<0.0912). This is the race-to-the-bottom result; in the absence of cooperation, national policymakers compete through tax cuts with each other for internationally mobile factors, like capital in our model. It is worth pointing out that the race-to-the-bottom result is consistent with the seminal analysis of Cooper and John (1988). Namely, when the externality is positive, cooperative strategies are higher than non-cooperative ones; here, the externality, or the cross-border spillover, is positive because an increase in one country's capital tax rate triggers a capital flight that benefits the other country.

Table 1: Optimal policies and allocations in symmetric equilibria

	Nash	**Coop**
$\tau_{k,2}$	0.0148	0.0912
$\tau_{l,1}$	0.2128	0.1685
$\tau_{l,2}$	0.1637	0.1897
y_2	0.2834	0.2774
g_2	0.0683	0.0693
U	-1.3863	-1.3858

Notice, however, that although these two mechanisms work in the same direction pushing down the capital tax rate in the second period, $\tau_{k,2}$, the latter does not converge to zero, as it would have happened in an infinite-time horizon economy with a commitment Ramsey-type technology. Intuitively, the benefits from a relatively large capital stock last longer in a multi-period model than in a two-period model and this weakens the incentive to set a zero capital tax rate in a two-period model.

Regarding the resulting solutions for output, public spending and welfare, second-period output is lower under cooperation than under Nash, while the opposite applies to second-period public spending. This happens because second-period taxes are higher under cooperation and this is good for public good provision and bad for output produced. The net effect is positive so, as expected, cooperation is superior to Nash when the criterion is discounted lifetime utility (or welfare), although the gains are marginal. These results are, both qualitatively and quantitatively, as in most of the related literature (see e.g. Mendoza and Tesar (2005)). Namely, although cooperation implies relatively high capital taxes and hence small capital stocks over time which hurt the private economy, these tax rates also allow for higher public spending and the latter beneficial effect typically dominates at least when the criterion is social welfare (see Kammas and Philippopoulos (2009) for a detailed quantitative analysis).

6. Non-symmetric countries and equilibria (TO BE REVISED)

In this section, we solve for optimal fiscal policy (Nash and cooperative) in a non-symmetric world. Regarding the kind of asymmetries, following the evidence in section 2 above, we focus on three kinds of cross-country asymmetries: First, we will assume that countries differ in their total factor productivities (TFPs). Second, we will assume that countries differ in their initial public debt burdens. Third, we will assume that countries differ in their institutional quality, in particular, in the degree of protection of property rights. We will study one asymmetry at a time to understand how each one of them works.

In terms of modeling, the first two types of cross-country differences can be easily added to our model above. Total factor productivity and initial public debt are respectively a parameter and an initial condition only, so it is straightforward to add them to the model; of course, now we have to solve for non-symmetric equilibria, which makes the dimensionality of the system larger than in a symmetric case (see subsections 3.5.1, 3.5.2 and 3.5.3). By contrast, allowing for institutional problems necessitates some non-trivial modelling extensions which are presented in detail in Appendix C. Here, we just report that, in order to embed institutional asymmetries as implied by the data into our model, we assume that one of the two countries (say, a periphery eurozone country) suffers from weak property rights so that, in this country, producers can keep a fraction only of their output produced, while the rest can be taken away by rent-seekers who compete with each other for a share of the contestable prize in a Tullock-type redistributive contest that hurts everybody in equilibrium; that is, we model weak institutions as a coordination problem.[11]

6.1. Asymmetries in TFP (TO BE REVISED)

[11] Our modelling here is as in e.g. Angelopoulos et al (2009), Esteban and Ray (2011), Economides et al (2021) and Christou et al (2021). Hillman (2009) reviews the Tullock-type literature on rent seeking. Masuch et al (2018) discuss the relation between poor institutional quality and rent seeking and provide data for EU countries.

We start with cross-country differences in TFP. To do so, we distinguish between a high-TFP and a low-TFP country; in particular, we set $A = 1 > A^* = 0.8$, where A^* is the TFP in the less efficient country. This is the only difference in the model presented so far. Results for non-symmetric Nash equilibria (NSNE) and non-symmetric cooperative equilibria (NSCE), where the latter can be either flexible or rigid as defined in subsection 3.5.3, are reported in Table 2, which includes the same key variables as in Table 1 (a detailed solution is provided in Appendix B.2).

Table 2: Optimal policies and allocations with asymmetries in TFP

	Nash		**Flex coop**		**Rigid coop**	
$\tau_{k,2}$	0.038	-0.003*	0.080	0.058*	0.052	
$\tau_{l,1}$	0.200	0.235*	0.170	0.205*	0.201	
$\tau_{l,2}$	0.172	0.162*	0.185	0.184*	0.176	
y_2	0.296	0.193*	0.297	0.185*	0.309	0.177*
g_2	0.069	0.049*	0.069	0.050*	0.072	0.047*
U	-1.385	-1.572*	-1.383	-1.573*	-1.384	-1.573*

Note: A star (*) denotes the low-TFP country

Regarding the optimally chosen policy instruments, their qualitative properties are the same as discussed above in the symmetric case of Table 1. For instance, in both countries, the second-period tax rates on capital, $\tau_{k,2}$, are lower in a NSNE than in NSCE, and this holds irrespectively of whether cooperation is flexible or rigid. But there are also new results driven by differences in TFP. For instance, the values of $\tau_{k,2}$ differ across countries. The Nash capital tax rates are 3.8% in the high-TFP country and almost zero in the low-TFP country (actually, they are a subsidy in the low-TFP country), while they rise to 8% and 5.8% respectively under flexible cooperation, and to 5.2% when the planner follows a harmonized tax policy which is closer to the needs of the low TFP country. Thus, the zero-tax rate result for capital is restored in the low-TFP country without cooperation, which brings the model closer to the limiting zero capital tax rate in the Chamley-Judd dynamic literature.

We now turn to macroeconomic outcomes and welfare. As perhaps expected, total welfare, which is the objective of the world planner when choosing domestic and foreign policies jointly, is higher under cooperation (both flexible and rigid) than in a Nash equilibrium.[12] However, in a non-symmetric world, there are winners and losers from cooperation. Looking at the implications of the optimally chosen tax policies for discounted lifetime utility, cooperation (both flexible and rigid) benefits the high-TFP country and hurts the low-TFP country. And the same applies to second period output. Actually, the gains for the high-TFP country and the losses for the low-TFP country under cooperation are much clearer when the criterion is second-period output than welfare. Intuitively, high tax rates on capital, naturally associated with international cooperation to address the race-to-the-bottom problem, hurt the less productive country which would need low, rather than high, taxes to offset its low productivity problem.

6.2. Asymmetries in inherited public debt (TO BE REVISED)

In this new experiment, we consider cross-country differences in inherited public debt. Motivated by the empirical evidence in section 2, we distinguish between a low-debt and a high-debt country; in particular, we set $b_1/y_1 = 0.5 < (b_1/y_1)^* = 2$ for the initial debt to GDP ratios in the two countries. Results for the key variables are reported in Table 3 (a detailed solution is provided in Appendix B.3).

Table 3: Optimal policies and allocations with asymmetries in initial public debt

	Nash		**Flex coop**		**Rigid coop**	
$\tau_{k,2}$	0.013	0.026*	0.133	0.125*	0.146	
$\tau_{l,1}$	0.214	0.307*	0.145	0.246*	0.200	
$\tau_{l,2}$	0.163	0.219*	0.206	0.251*	0.234	
y_2	0.285	0.264*	0.269	0.263*	0.279	0.254*
g_2	0.068	0.061*	0.070	0.063*	0.088	0.053*
U	-1.386	-1.397*	-1.387	-1.394*	-1.390	-1.396*

Note: A star (*) denotes the high-debt country.

Regarding the optimally chosen policy instruments, their qualitative properties are similar to those in the previous subsection where the cross-country difference was in TFPs. Regarding

[12] Aggregate welfare under Nash is W_{Nash}= -1.47825, aggregate welfare under flexible cooperation is W_{Flex}=-1.47795 and aggregate welfare under rigid cooperation is W_{Rigid}=-1.47815.

lifetime discounted utility or welfare, although flexible cooperation is superior on aggregate,[13] it benefits the high-debt country and hurts the country with healthy public finances. That is, cooperation (both flexible and rigid, but especially the former) serves mainly the needs of the high-debt country. Intuitively, for the sake of cooperation, the low-debt country is forced to adopt relatively high tax rates that are more suitable to the public financing needs of the high-debt country. Notice that, for the same reason, namely high tax rates driven by the needs of the high-debt country, and no matter what the type of cooperation (flexible or rigid) is, both countries lose from cooperation when the criterion is second-period output.

6.3. Asymmetries in institutional quality (TO BE REVISED)

Our last experiment focuses on cross-country differences in institutional quality and, particularly, in the degree of protection of property rights. As explained above, building on the related quantitative macroeconomic literature on ill-defined property rights and rent seeking, we assume that firms in, say, the foreign country can keep only 90% of their output produced, because the rest is expropriated by households that engage in a rent-seeking competition with each other for the rest 10%. That is, the 10% of GDP plays the role of a contestable prize. As also said above, the enriched version of the model with such institutional issues is presented in Appendix C. Table 4 reports results for the key variables (a detailed solution is provided in Appendix B.4).

Table 4: **Optimal policies and allocations with asymmetries in institutional quality**

	Nash		**Flex coop**		**Rigid coop**	
$\tau_{k,2}$	0.046	-0.004*	0.030	0.035*	0.027	
$\tau_{l,1}$	0.191	0.246*	0.198	0.228*	0.218	
$\tau_{l,2}$	0.175	0.114*	0.171	0.128*	0.149	
y_2	0.298	0.238*	0.314	0.221*	0.327	0.209*
g_2	0.069	0.057*	0.069	0.057*	0.069	0.057*
U	-1.385	-1.430*	-1.383	-1.430*	-1.384	-1.431*

Note: A star (*) denotes the country with poor institutional quality.

[13] Aggregate welfare under Nash is W_{Nash}= -1.39155, aggregate welfare under flexible cooperation is W_{Flex}=-1.39045 and aggregate welfare under rigid cooperation is W_{Rigid}=-1.39305.

Regarding the optimally chosen policy instruments, as in all previous cases, the income from capital is under-taxed in a Nash equilibrium relative to the cooperative ones, flexible and rigid. Regarding welfare and, especially, second-period output, cooperation (both flexible and rigid) is productive for the country with good institutional quality, but it proves to be damaging for the country with weak institutions.[14] Observe the big output losses for the country with weak institutions under cooperation. The intuition is as in the case of different TFPs above. Namely, high tax rates on capital, naturally associated with international cooperation to address the race-to-the-bottom problem, hurt the country with weakly defined property rights. The latter would need low, rather than high, taxes to compensate investors for the lack of property rights which effectively reduce factor returns.

7. Concluding remarks and possible extensions (TO BE REVISED)

When we account for cross-country differences, international fiscal cooperation can create winners and losers even if it is superior to non-cooperation at aggregate level. In our paper, international cooperation, and especially the rigid one, proves to be too restrictive for countries with low TFP and poor institutions. These countries cannot afford the luxury of relatively high tax rates that naturally come with international cooperation. By contrast, in the case of asymmetries in inherited public debt, cooperation and the high tax rates associated with it, are more suitable to the needs of countries with weak public finances.

We close the paper with two possible extensions. Here we solved for optimal policies assuming a commitment technology. It is known however that policymakers are free to reoptimize so a natural extension could be to solve for non-commitment (time-consistent) equilibria. Another extension could be to allow for labor mobility or migration across countries so that both productive factors (capital and labor) are treated similarly. We leave these extensions for future work.

[14] Aggregate welfare is again higher under cooperation. In particular, aggregate welfare under Nash is W_{Nash}= -1.4072, aggregate welfare under flexible cooperation is W_{Flex}=-1.4069 and aggregate welfare under rigid cooperation is W_{Rigid}=-1.4071.

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Appendix

A. The three policy regimes

A.1 Nash equilibrium system

The domestic government's objective is U^d as defined in subsection 3.5.1. Then, its Lagrangean is:

$$L^d = U^d + \lambda_1 \left\{c_1^d + k_2^d - (1-\delta)k_1^d + f_2^d + g_1^d - y_1^d\right\}$$

$$+\lambda_2 \left\{c_2^d - (1-\delta)k_2^d + g_2^d - y_2^d + \left(1-\tau_{k,2}^d\right)r_2^d f_2^f\right.$$

$$\left. - \left[1 + \left(1-\tau_{k,2}^f\right)r_2^f - \delta\right]f_2^d + m\frac{{f_2^d}^2}{2}\right\}$$

$$+\lambda_3 \left\{\frac{\mu_1}{c_1^d}\left(1-\tau_{l,1}^d\right)w_1^d - \frac{\mu_2}{1-l_1^d}\right\}$$

$$+\lambda_4 \left\{\frac{\mu_1}{c_2^d}\left(1-\tau_{l,2}^d\right)w_2^d - \frac{\mu_2}{1-l_2^d}\right\}$$

$$+\lambda_5 \left\{\frac{c_2^d}{c_1^d} - \beta\left(1 + \left(1-\tau_{k,2}^d\right)r_2^d - \delta\right)\right\}$$

$$+\lambda_6 \left\{\frac{c_2^d}{c_1^d} - \beta\left(1 + \left(1-\tau_{k,2}^f\right)r_2^f - \delta - mf_2^d\right)\right\}$$

$$+\lambda_7\left\{g_1^d + \left(1 + \left(1-\tau_{k,1}^d\right)r_1^d - \delta\right)b_1^d - \tau_{k,1}^d r_1^d k_1^d - \tau_{l,1}^d w_1^d l_1^d - b_2^d\right\}$$

$$+\lambda_8\left\{g_2^d + \left(1 + \left(1-\tau_{k,2}^d\right)r_2^d - \delta\right)b_2^d - \tau_{k,2}^d r_2^d\left(k_2^d + f_2^f\right) - \tau_{l,2}^d w_2^d l_2^d\right\}$$

$$+\lambda_9\left\{c_1^f + k_2^f - (1-\delta)k_1^f + f_2^f + g_1^f - y_1^f\right\}$$

$$+\lambda_{10} \left\{c_2^f - (1-\delta)k_2^f + g_2^f - y_2^f + \left(1-\tau_{k,2}^f\right)r_2^f f_2^d\right.$$

$$\left. - \left[1 + \left(1-\tau_{k,2}^d\right)r_2^d - \delta\right]f_2^f + m\frac{{f_2^f}^2}{2}\right\}$$

$$+\lambda_{11} \left\{\frac{\mu_1}{c_1^f}\left(1-\tau_{l,1}^f\right)w_1^f - \frac{\mu_2}{1-l_1^f}\right\}$$

$$+\lambda_{12}\left\{\frac{\mu_1}{c_2^f}\left(1-\tau_{l,2}^f\right)w_2^f-\frac{\mu_2}{1-l_2^f}\right\}$$

$$+\lambda_{13}\left\{\frac{c_2^f}{c_1^f}-\beta\left(1+\left(1-\tau_{k,2}^f\right)r_2^f-\delta\right)\right\}$$

$$+\lambda_{14}\left\{\frac{c_2^f}{c_1^f}-\beta\left(1+\left(1-\tau_{k,2}^d\right)r_2^d-\delta-mf_2^f\right)\right\}$$

$$+\lambda_{15}\{g_1^f+\left(1+\left(1-\tau_{k,1}^f\right)r_1^f-\delta\right)b_1^f-\tau_{k,1}^f r_1^f k_1^f-\tau_{l,1}^f w_1^f l_1^f-b_2^f\}$$

$$+\lambda_{16}\{g_2^f+\left(1+\left(1-\tau_{k,2}^f\right)r_2^f-\delta\right)b_2^f-\tau_{k,2}^f r_2^f\left(k_2^f+f_2^d\right)-\tau_{l,2}^f w_2^f l_2^f\}$$

where $\lambda_1-\lambda_{16}$ are the 16 multipliers associated with the 16 equations of the WDCE system. Then, following the dual approach to the policy problem, we work as explained in subsection 3.5.1 in the main text. In other words, the foreign government acts similarly, so that we have 35 equations in 35 unknowns for each country, which, when put together to solve for the Nash equilibrium, are reduced to 54 equations in 54 variables (namely, 35+35-16) since the 16 equations of the WDCE are common to both countries and the same applies to the associated 16 variables that are endogenous at WDCE level.

A.2 Flexible cooperation system

The planner's objective is W^{COOP} as defined in subsection 3.5.2. Then the Lagrangean is:

$$L=W^{COOP}+\lambda_1\{c_1^d+k_2^d-(1-\delta)k_1^d+f_2^d+g_1^d-y_1^d\}$$

$$+\lambda_2\Bigg\{c_2^d-(1-\delta)k_2^d+g_2^d-y_2^d+\left(1-\tau_{k,2}^d\right)r_2^d f_2^f$$

$$-\left[1+\left(1-\tau_{k,2}^f\right)r_2^f-\delta\right]f_2^d+m\frac{{f_2^d}^2}{2}\Bigg\}$$

$$+\lambda_3\left\{\frac{\mu_1}{c_1^d}\left(1-\tau_{l,1}^d\right)w_1^d-\frac{\mu_2}{1-l_1^d}\right\}$$

$$+\lambda_4\left\{\frac{\mu_1}{c_2^d}\left(1-\tau_{l,2}^d\right)w_2^d-\frac{\mu_2}{1-l_2^d}\right\}$$

$$+\lambda_5\left\{\frac{c_2^d}{c_1^d}-\beta\left(1+\left(1-\tau_{k,2}^d\right)r_2^d-\delta\right)\right\}$$

$$+\lambda_6\left\{\frac{c_2^d}{c_1^d}-\beta\left(1+\left(1-\tau_{k,2}^f\right)r_2^f-\delta-mf_2^d\right)\right\}$$
$$+\lambda_7\left\{g_1^d+\left(1+\left(1-\tau_{k,1}^d\right)r_1^d-\delta\right)b_1^d-\tau_{k,1}^d r_1^d k_1^d-\tau_{l,1}^d w_1^d l_1^d-b_2^d\right\}$$
$$+\lambda_8\left\{g_2^d+\left(1+\left(1-\tau_{k,2}^d\right)r_2^d-\delta\right)b_2^d-\tau_{k,2}^d r_2^d\left(k_2^d+f_2^f\right)-\tau_{l,2}^d w_2^d l_2^d\right\}$$
$$+\lambda_9\left\{c_1^f+k_2^f-(1-\delta)k_1^f+f_2^f+g_1^f-y_1^f\right\}$$
$$+\lambda_{10}\left\{c_2^f-(1-\delta)k_2^f+g_2^f-y_2^f+\left(1-\tau_{k,2}^f\right)r_2^f f_2^d\right.$$
$$\left.-\left[1+\left(1-\tau_{k,2}^d\right)r_2^d-\delta\right]f_2^f+m\frac{{f_2^f}^2}{2}\right\}$$
$$+\lambda_{11}\left\{\frac{\mu_1}{c_1^f}\left(1-\tau_{l,1}^f\right)w_1^f-\frac{\mu_2}{1-l_1^f}\right\}$$
$$+\lambda_{12}\left\{\frac{\mu_1}{c_2^f}\left(1-\tau_{l,2}^f\right)w_2^f-\frac{\mu_2}{1-l_2^f}\right\}$$
$$+\lambda_{13}\left\{\frac{c_2^f}{c_1^f}-\beta\left(1+\left(1-\tau_{k,2}^f\right)r_2^f-\delta\right)\right\}$$
$$+\lambda_{14}\left\{\frac{c_2^f}{c_1^f}-\beta\left(1+\left(1-\tau_{k,2}^d\right)r_2^d-\delta-mf_2^f\right)\right\}$$
$$+\lambda_{15}\left\{g_1^f+\left(1+\left(1-\tau_{k,1}^f\right)r_1^f-\delta\right)b_1^f-\tau_{k,1}^f r_1^f k_1^f-\tau_{l,1}^f w_1^f l_1^f-b_2^f\right\}$$
$$+\lambda_{16}\left\{g_2^f+\left(1+\left(1-\tau_{k,2}^f\right)r_2^f-\delta\right)b_2^f-\tau_{k,2}^f r_2^f\left(k_2^f+f_2^d\right)-\tau_{l,2}^f w_2^f l_2^f\right\}$$

where $\lambda_1-\lambda_{16}$ are the 16 multipliers associated with the 16 equations of the WDCE system. Then, following the dual approach to the policy problem, we work as explained in subsection 3.5.2 in the main text. In other words, we now end up with 38 equations in 38 unknowns.

A.3 Rigid cooperation system

In the case of a rigid union, the planner solves the same problem as in the case of flexible cooperation above, but, instead of choosing a different tax rate for each economy $(\tau_{k,2}^d,\tau_{k,2}^f,\tau_{l,1}^d,\tau_{l,1}^f,\tau_{l,2}^d,\tau_{l,2}^f)$, it chooses union-wide tax rates $(\tau_{k,2},\tau_{l,1},\tau_{l,2})$ that apply to both countries. The Lagrangean is now:

$$
\begin{aligned}
L = W^{COOP} &+ \lambda_1\{c_1^d + k_2^d - (1-\delta)k_1^d + f_2^d + g_1^d - y_1^d\} \\
&+\lambda_2\left\{c_2^d - (1-\delta)k_2^d + g_2^d - y_2^d + \left(1-\tau_{k,2}\right)r_2^d f_2^f \right. \\
&\qquad \left. - \left[1 + \left(1-\tau_{k,2}\right)r_2^f - \delta\right]f_2^d + m\frac{{f_2^d}^2}{2}\right\} \\
&+\lambda_3\left\{\frac{\mu_1}{c_1^d}\left(1-\tau_{l,1}\right)w_1^d - \frac{\mu_2}{1-l_1^d}\right\} \\
&+\lambda_4\left\{\frac{\mu_1}{c_2^d}\left(1-\tau_{l,2}\right)w_2^d - \frac{\mu_2}{1-l_2^d}\right\} \\
&+\lambda_5\left\{\frac{c_2^d}{c_1^d} - \beta\left(1 + \left(1-\tau_{k,2}\right)r_2^d - \delta\right)\right\} \\
&+\lambda_6\left\{\frac{c_2^d}{c_1^d} - \beta\left(1 + \left(1-\tau_{k,2}\right)r_2^f - \delta - mf_2^d\right)\right\} \\
&+\lambda_7\{g_1^d + \left(1 + \left(1-\tau_{k,1}\right)r_1^d - \delta\right)b_1^d - \tau_{k,1}r_1^d k_1^d - \tau_{l,1}w_1^d l_1^d - b_2^d\} \\
&+\lambda_8\{g_2^d + \left(1 + \left(1-\tau_{k,2}\right)r_2^d - \delta\right)b_2^d - \tau_{k,2}r_2^d\left(k_2^d + f_2^f\right) - \tau_{l,2}w_2^d l_2^d\} \\
&+\lambda_9\{c_1^f + k_2^f - (1-\delta)k_1^f + f_2^f + g_1^f - y_1^f\} \\
&+\lambda_{10}\left\{c_2^f - (1-\delta)k_2^f + g_2^f - y_2^f + \left(1-\tau_{k,2}\right)r_2^f f_2^d \right. \\
&\qquad \left. - \left[1 + \left(1-\tau_{k,2}\right)r_2^d - \delta\right]f_2^f + m\frac{{f_2^f}^2}{2}\right\} \\
&+\lambda_{11}\left\{\frac{\mu_1}{c_1^f}\left(1-\tau_{l,1}\right)w_1^f - \frac{\mu_2}{1-l_1^f}\right\} \\
&+\lambda_{12}\left\{\frac{\mu_1}{c_2^f}\left(1-\tau_{l,2}\right)w_2^f - \frac{\mu_2}{1-l_2^f}\right\} \\
&+\lambda_{13}\left\{\frac{c_2^f}{c_1^f} - \beta\left(1 + \left(1-\tau_{k,2}\right)r_2^f - \delta\right)\right\} \\
&+\lambda_{14}\left\{\frac{c_2^f}{c_1^f} - \beta\left(1 + \left(1-\tau_{k,2}\right)r_2^d - \delta - mf_2^f\right)\right\} \\
&+\lambda_{15}\{g_1^f + \left(1 + \left(1-\tau_{k,1}\right)r_1^f - \delta\right)b_1^f - \tau_{k,1}r_1^f k_1^f - \tau_{l,1}w_1^f l_1^f - b_2^f\} \\
&+\lambda_{16}\{g_2^f + \left(1 + \left(1-\tau_{k,2}\right)r_2^f - \delta\right)b_2^f - \tau_{k,2}r_2^f\left(k_2^f + f_2^d\right) - \tau_{l,2}w_2^f l_2^f\}
\end{aligned}
$$

where $\lambda_1 - \lambda_{16}$ are the 16 multipliers associated with the 16 equations of the WDCE system. Then, following the dual approach to the policy problem, we work as explained in subsection 3.5.3 in the main text. In other words, we now end up with 35 equations in 35 unknowns.

B. Detailed solutions

B.1 Solution of symmetric equilibria

Table 5: **Optimal policies and allocations in symmetric equilibria**

Allocations	**Nash**	**Coop**
c_1	0.7394	0.7668
c_2	0.2151	0.2080
k_2	0.3454	0.3345
b_2	-0.1199	-0.0918
f_2	0.0000	0.0000
l_1	0.2660	0.2725
l_2	0.2484	0.2448
y_1	1.1349	1.1513
y_2	0.2834	0.2773
g_2	0.0683	0.0693
Tax rates		
$\tau_{k,2}$	0.0149	0.0911
$\tau_{l,1}$	0.2128	0.1686
$\tau_{l,2}$	0.1636	0.1896
Welfare		
U	-1.3863	-1.3859

Note: $k_1, b_1, g_1, \tau_{k,1}$ are set exogenously

B.2 Solution when countries differ in TFP

Table 6: **Optimal policies and allocations with asymmetries in TFP**

Allocations	**Nash**		**Flexible cooperation**		**Rigid cooperation**	
c_1	0.7597	0.5683*	0.7802	0.5798*	0.7674	0.5766*
c_2	0.2127	0.1579*	0.2090	0.1537*	0.2100	0.1555*
k_2	0.3426	0.2738*	0.3360	0.2678*	0.3412	0.2671*
b_2	-0.1082	-0.0995*	-0.0904	-0.0849*	-0.1089	-0.0835*
f_2	-0.0237	0.0237*	-0.0315	0.0315*	-0.0434	0.0434*
l_1	0.2636	0.2699*	0.2659	0.2764*	0.2584	0.2804*
l_2	0.2569	0.2346*	0.2579	0.2274*	0.2663	0.2194*
y_1	1.1287	0.9157*	1.1347	0.9290*	1.1153	0.9370*
y_2	0.2961	0.1925*	0.2971	0.1847*	0.3085	0.1769*
g_2	0.0686	0.0492*	0.0694	0.0497*	0.0722	0.0474*
Tax rates						
$\tau_{k,2}$	0.0375	-0.0030*	0.0795	0.0583*	0.0522	
$\tau_{l,1}$	0.1969	0.2354*	0.1696	0.2053*	0.2008	
$\tau_{l,2}$	0.1719	0.1621*	0.1852	0.1837*	0.1763	
Welfare						
U	-1.3850	-1.5715*	-1.3834	-1.5725*	-1.3835	-1.5728*

Notes: (i) A * (star) denotes the low-TFP country. (ii) $k_1, b_1, g_1, \tau_{k,1}$ are set exogenously

B.3 Solution when countries differ in initial public debt

Table 7: **Optimal policies and allocations with asymmetries in initial public debt**

Allocations	Nash		Flexible cooperation		Rigid cooperation	
c_1	0.7396	0.6995*	0.7780	0.7425*	0.7490	0.7695*
c_2	0.2153	0.2035*	0.2037	0.1949*	0.1937	0.1992*
k_2	0.3458	0.3197*	0.3283	0.3078*	0.3355	0.2981*
b_2	-0.1204	-0.0742*	-0.0766	-0.0369*	-0.1114	-0.0078*
f_2	-0.0021	0.0021*	0.0073	-0.0073*	0.0036	-0.0036*
l_1	0.2654	0.2416*	0.2773	0.2498*	0.2673	0.2579*
l_2	0.2494	0.2327*	0.2396	0.2324*	0.2488	0.2266*
y_1	1.1334	1.0713*	1.1636	1.0930*	1.1381	1.1140*
y_2	0.2849	0.2635*	0.2693	0.2625*	0.2791	0.2541*
g_2	0.0682	0.0614*	0.0698	0.0633*	0.0876	0.0528*
Tax rates						
$\tau_{k,2}$	0.0125	0.0259*	0.1331	0.1246*	0.1460	
$\tau_{l,1}$	0.2139	0.3065*	0.1446	0.2458*	0.1998	
$\tau_{l,2}$	0.1630	0.2194*	0.2057	0.2507*	0.2343	
Welfare						
U	-1.3863	-1.3968*	-1.3868	-1.3941*	-1.3898	-1.3963*

Notes: (i) A * (star) denotes the high-debt country. (ii) $k_1, b_1, g_1, \tau_{k,1}$ are set exogenously.

B.4 Solution when countries differ in institutional quality

Table 8: **Optimal policies and allocations with asymmetries in institutional quality**

Allocations	Nash		Flexible cooperation		Rigid cooperation	
c_1	0.7652	0.7251*	0.7725	0.7240*	0.7714	0.7191*
c_2	0.2120	0.1990*	0.2130	0.1961*	0.2144	0.1953*
k_2	0.3414	0.3109*	0.3443	0.3088*	0.3409	0.3139*
b_2	-0.1044	-0.1388*	-0.1065	-0.1303*	-0.1167	-0.1262*
f_2	-0.0283	0.0283*	-0.0539	0.0539*	-0.0710	0.0710*
l_1	0.2635	0.2580*	0.2575	0.2667*	0.2492	0.2735*
l_2	0.2584	0.2572*	0.2687	0.2432*	0.2801	0.2305*
y_1	1.1283	1.1143*	1.1129	1.1367*	1.0913	1.1540*
y_2	0.2982	0.2383*	0.3144	0.2208*	0.3268	0.2092*
g_2	0.0688	0.0566*	0.0686	0.0572*	0.0687	0.0569*
Tax rates						
$\tau_{k,2}$	0.0456	-0.0042*	0.0300	0.0347*	0.0265	
$\tau_{l,1}$	0.1913	0.2457*	0.1977	0.2277*	0.2179	
$\tau_{l,2}$	0.1745	0.1140*	0.1706	0.1280*	0.149	
Welfare						
U	-1.3845	-1.4299*	-1.3834	-1.4304*	-1.3836	-1.4306*

Notes: (i) A * (star) denotes the country with weak property rights. (ii) $k_1, b_1, g_1, \tau_{k,1}$ are set exogenously.

C. The extended model with weak institutions

For simplicity, there are institutional problems in the second period only. In what follows, we model what changes only.

Households

The household further divides its effort time between productive work, $s_2^d l_2^d$, and rent-extracting activities, $(1-s_2^d)l_2^d$, where $0 \le s_2^d < 1$ and $0 \le (1-s_2^d) < 1$ denote the fractions of non-leisure time that the household allocates to productive work and rent extractive activities respectively. The budget constraint of the domestic household in period 2 changes to:

$$c_2^d = (1+(1-\tau_{k,2}^d)r_2^d - \delta)k_2^d + (1-\tau_{l,2}^d)w_2^d s_2^d l_2^d + (1-\tau_{k,2}^d)\pi_2^d + (1+\rho_2^d)b_2^d$$
$$+ \left(1+\left(1-\tau_{k,2}^f\right)r_2^f - \delta\right)f_2^d - m\frac{{f_2^d}^2}{2} + \frac{(1-s_2^d)l_2^d}{\sum_{h=1}^N (1-s_{h,2}^d)l_{h,2}^d}\theta^d y_2^d$$

The last term of the budget constraint denotes a contestable prize available due to poor institutions. The household aims to grab a fraction of that prize which depends on the extractive effort he/she puts relative to the extractive efforts put by all other households in the country. The parameter $0 \leq \theta < 1$ is the economy-wide degree of rent extraction and higher values imply weaker protection of property rights.

The optimality conditions for effort time, l_2^d, and the fraction of it allocated to productive work, s_2^d, are:

$$\frac{\mu_1}{c_2^d}\left\{(1-\tau_{l,2}^d)w_2^d s_2^d + \frac{(1-s_2^d)}{\sum_{h=1}^N (1-s_{h,2}^d) l_{h,2}^d}\theta^d y_2^d\right\} = \frac{\mu_2}{1-l_2^d}$$

$$(1-\tau_{l,2}^d)w_2^d l_2^d = \frac{l_2^d}{\sum_{h=1}^N (1-s_{h,2}^d) l_{h,2}^d}\theta^d y_2^d$$

Firms

Firms keep only a fraction of their output produced in the second period. Thus, they choose capital $\bar{k}_2^d$, and labor services, $\bar{l}_2^d$, to maximize:

$$\max_{\bar{k}_2^d, \bar{l}_2^d} \pi_2^d = \left(1-\theta^d\right) y_2^d - r_2^d \bar{k}_2^d - w_2^d \bar{l}_2^d$$

given technology, $y_2^d = A\left(\bar{k}_2^d\right)^a \left(\bar{l}_2^d\right)^{1-a}$, and the degree of property rights, θ^d. The first-order conditions are:

$$r_2^d = \left(1-\theta^d\right) a \frac{y_2^d}{\bar{k}_2^d}$$

$$w_2^d = \left(1-\theta^d\right)(1-a)\frac{y_2^d}{\bar{l}_2^d}$$

Government

The second-period government budget constraint is now:

$$g_2^d + (1+\rho_2^d) b_2^d = \tau_{k,2}^d\left(r_2^d\left(k_2^d + f_2^f\right) + \pi_2^d\right) + \tau_{l,2}^d w_2^d s_2^d l_2^d$$

Therefore, in the WDCE system, and in turn in the optimization policy problems, there are the above changes in the existing equations as well as an extra equation in each country (the household's optimality condition for the fraction of effort time allocated to productive work vis-à-vis rent seeking. The way we work is as in the baseline model.