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rising intangible capital  
and financial globalization**

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# International tax competition with rising intangible capital and financial globalization

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## Abstract

The last three decades have been characterized by two important trends: (a) the rise in intangible capital as a share of total capital, and (b) the increase in cross-country ownership of assets (financial globalization). We study the importance of these two trends for international tax competition in a two-country model where governments choose profit and income tax rates without commitment to future policies and without international coordination. The quantitative exercise shows that the higher share of intangible capital led to lower profit tax rates while the increased cross-country ownership of assets led to higher taxation of profits. The contrasting effects resulted in a small change in profit rate of 1.3% and a small welfare gain of 0.1%.

## 1 Introduction

An important principle in taxation theory is that taxes should not be uniform across all sources of incomes. Instead, the tax rate on a particular source should depend on the elasticity with which that source responds to a change in tax rate. The same principle applies to the taxation of capital income vis-a-vis other types of income. In a globalized world where asset markets are highly integrated, the ability of a government to unilaterally tax capital income is somewhat reduced because multinationals have greater discretion in determining *where* to pay taxes. So it is not surprising that governments find optimal to lower capital income taxes in absence of cross-country coordination. It is under this consideration that the idea that countries should coordinate a minimum profit tax rate has gained momentum and culminated with a set of principles agreed in 2021 by the finance

ministers of the G7 countries. But why is the issue of harmful tax competition receiving more attention now than in the past? After all, the process of financial globalization is not a new phenomena.

In this paper we explore two major changes that could have been important in affecting the incentives of governments to tax profits. The first is the growth in the share of intangible capital. The second is the increase in cross-country ownership of assets.

Figure 1 shows the share of intangible capital in total capital for US public companies from 1975 to 2019. The figure shows two of the series plotted in Eberly (2022) based on two definitions of intangible capital using Compustat data. The first definition includes capitalized estimates of R&D expenses, while the second and broader measure includes also capitalized estimates of SG&A expenses (Selling, General and Administrative). Taking the average of the two series, the share of intangible capital has increased from about 25% in 1975 to about 50% in 2019. The large increase in the share of intangible capital is also shown in Falato, Kadyrzhanova, Sim, and Steri (2022) and Crouzet, Eberly, Eisfeldt, and Papanikolaou (2022).

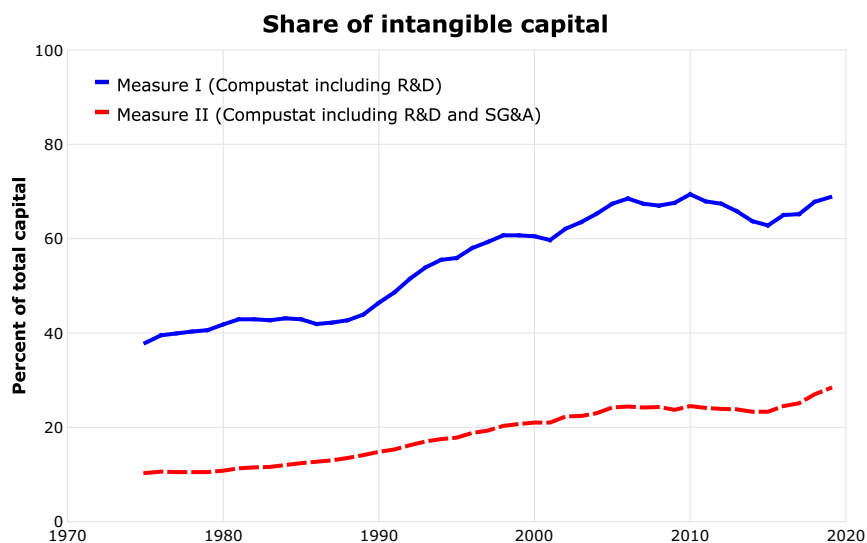


Figure 1: The growing share of intangible capital. Source: Eberly (2022).

An important property of intangible capital, vis-a-vis tangible capital, is its non-rivalry feature: once accumulated, intangible capital can be used simultaneously in multiple geographical locations by the same company. This raises the issue of how multinationals choose to allocate the cost of intangible capital among various worldwide operations. Although the cost allocation may be irrelevant for global profits, it could be important for the total taxation of the profits. In general, a multinational has an incentive to allocate larger shares of operating costs to subsidiaries that operate in countries with higher taxation of profits, provided that the multinational has the flexibility to do so. The difficulty in determining the precise contribution of intangible capital to the various

worldwide operations gives multinationals some discretion in allocating the cost. Because of this, a country that chooses to unilaterally raise the profit tax rate might end up collecting less tax revenues because multinationals will respond by shifting taxable income to other (low tax) countries. This may refrain governments from raising profit taxes and, potentially, seeding the conditions for a race to bottom in international tax competition.

The second trend examined in this paper is the growth in financial globalization. Figure 2 shows the stock of Foreign Direct Investments (FDI) and the stock of Portfolio Equity Investment (PEI) for industrialized countries over the period 1990-2020. Both assets and liabilities of these two categories of capital have increased substantially during the last thirty years. The increase in FDI means that multinationals invest more abroad. The increase in PEI can be interpreted as indicating that the share of foreign ownership of multinationals has increased over time. It is important to emphasize that it is the growth in the ‘gross’ stocks (both FDI and PEI) that is especially relevant for the optimal taxation of profits. The net foreign asset positions, which for many countries are relatively small, is not as important as the gross positions.

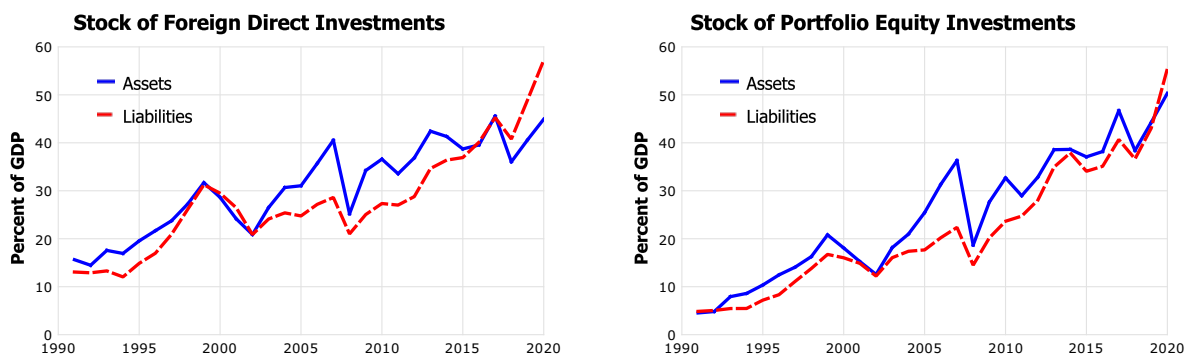


Figure 2: Foreign direct investments and portfolio equity investments in industrialized countries, 1990-2020. Source: External Wealth of Nations database (Lane and Milesi-Ferretti (2018)).

An implication of growing cross-country ownership is that larger shares of profits earned in a country belong to foreigners. As a result, governments have higher incentive to tax profits. Effectively, higher taxes on profits redistribute income from foreign residents to domestic residents and the magnitude of the redistribution increases with financial globalization. This is the mechanism through which higher cross-country ownership of assets could lead to higher taxation of capital incomes.

This mechanism differs from the most popular view in which greater financial integration causes lower taxation of capital. According to this view, the reason capital taxes should fall as international capital markets become more integrated is because globalization facilitates the international reallocation of capital. For this mechanism to be relevant in an environment in which governments cannot commit to future policies, firms must have the ability to reallocate quickly capital already installed. Although there are instances in

which this is possible, it is unlikely that companies have the ability to reallocate quickly a large share of installed capital. Taxes, of course, affect investments, that is, the accumulation of new capital. However, what matters for investment decisions are (primarily) future taxes, not current taxes. But in an environment without commitment, current governments do not have the credibility to promise lower taxes for the future. Current governments only choose current tax rates.

To study the impact of higher shares of intangible capital and higher diversification of international investments, we consider a two-country model with multinational firms that invest in two types of capital—tangible and intangible—and in two locations—domestically and abroad. Governments fund exogenous public spending by choosing two types of taxes: profit taxes based on the ‘source’ principle, and income taxes based on the ‘residence’ principle. Importantly, the tax rates are chosen without commitment to future policies (time-consistency) and without coordination among governments (policy competition).

There are two forces that play a central role in determining the equilibrium taxation of profits. On the one hand, the lack of policy commitment could lead to excessive taxation if the profits earned in a country belong to foreigners. Here the lack of policy commitment is key: taxing the income generated by installed capital does not distort the allocation of resources but it redistributes income away from foreigners to domestic residents. However, the market anticipation of higher tax rates for the future discourages investments, which results in a sub-optimal equilibrium characterized by lower capital. This is a standard problem in optimal taxation where capital taxes are ex-ante inefficient but ex-post desirable. On the other hand, a higher tax rate on profits chosen unilaterally by a country causes a shift in taxable profits to other (low tax) nations, which reduces the total tax revenues collected by the country. The possibility of tax shifting creates a counterbalancing force to the temptation of taxing capital, and might result in profit tax rates that are too low (race-to-the-bottom). Whether the equilibrium taxation of profits is too high or too low depends on the relative importance of these two forces. If the time-consistency problem is the main concern, capital taxes could be too high. If the race to the bottom is the main concern, capital taxes could be too low.

The relative importance of these two forces (time-consistency and tax-shifting) changes with the growing share of intangible capital and with financial globalization. On the one hand, the growing share of intangible capital makes the race-to-the-bottom more relevant because it enhances the tax-shifting ability of multinational companies. On the other, the increasing international diversification of investments alleviates the race-to-the-bottom because governments have greater ability to tax foreigners. Whether the first force dominates the second is a quantitative question which we address with a calibration exercise. More specifically, we calibrate the model to match empirical targets at the beginning of the 1990s and then we ask how the increase in the share of intangible capital and international investment diversification of the last thirty years affected equilibrium taxes and welfare.

We find that a larger share of intangible capital leads to a significant decrease in profit

tax rates, while a higher level of cross-country investment diversification results in a notable increase in profit tax rates. However, due to these opposing effects, the combined impact of the observed changes in intangible capital share and portfolio diversification only led to a modest reduction in profit tax rates of 1.3 percent and a corresponding welfare gain of 0.1 percent in terms of consumption equivalence. The reduction in the profit tax rate and the associated welfare gains would have been much greater in the absence of financial globalization, with no changes in cross-country asset ownership.

We also consider an extended version of the model that incorporates two types of heterogeneous households: those who solely earn labor incomes and those who earn both labor and other types of incomes. This extension allows us to examine how inequality (the disparity in incomes between the two types of households), political bias (a higher weight assigned to one of the two types of households), and political myopia (a greater tendency to discount future outcomes in policymaking) impact equilibrium taxation and welfare for both types of households. The presence of heterogeneity is crucial for comprehending why certain policymakers may advocate for higher taxation on profits, even if it does not lead to welfare improvements

## 2 Related literature

The study of optimal taxation in dynamic environments with and without commitment has a long tradition. A well known result is that the taxation of capital is optimal in the short run but should be reduced over time. In the long-run it should be close to zero. See Benhabib and Rustichini (1997), Chamley (1986), Chari, Christiano, and Kehoe (1994), Judd (1987), Jones, Manuelli, and Rossi (1993), Klein and Rios-Rull (2003), Zhu (1992). This result relies on the commitment of the policy maker to future policies (Ramsey policies) and it has a simple intuition. In the current period capital has already been accumulated and its taxation does not distort the allocation. However, future taxes can discourage the accumulation of new capital, which is inefficient. More recent studies re-examine the issue using more complex models and show that the optimal taxation of capital could be positive also in the long-run. See, for example, Aiyagari (1995) and Golosov, Kocherlakota, and Tsyvinski (2003). But even if the optimal tax rate on capital should be positive in the long-run, the tension between short-term and long-term taxation remains.

In reality, we rarely see countries with capital taxes that are close to zero. Several factors could contribute to this, including the fact that taxes have redistributive effects. The taxation of capital then is the result of the political outcome where efficiency is not the only consideration. But another reason taxes on capital could be higher than predicted by standard models is that Ramsey policies are not implementable due to the lack of commitment. There is also a rich literature that studies optimal and time-consistent fiscal policies. The general result is that the absence of policy commitment creates the conditions for higher taxation of capital. Examples include Krusell and Rios-Rull (1999) and Klein, Krusell, and Rios-Rull (2008).

The studies and results discussed above are conducted in environments with a single country (closed economy). But a country is not isolated from others and its fiscal policy affects other countries. This is especially important in the wave of globalization where economies are becoming more interdependent and the issue of international tax competition has become more important. It is important then to extend these models to an environment with multiple countries.

An early contribution in this literature is Kehoe (1989). This paper uses a two-period model to show that international tax competition could be welfare improving because it corrects for the excessive taxation of capital due to the lack of commitment. More specifically, the lack of policy commitment induces governments to choose high tax rates on capital that are inefficient because they discourage savings. However, tax competition introduces a counterbalancing force because, with high tax rates, capital could fly overseas. Tax competition, then, could improve welfare while tax coordination may not be desirable.

Following Kehoe (1989), several papers explored the importance of tax competition quantitatively. Examples include Ha and Sibert (1997), Klein, Quadrini, and Rios-Rull (2005), Mendoza and Tesar (2003) and Quadrini (2005). A common feature of these papers is that tax competition affects the optimal choices of taxes which in turn affect the allocation of savings. In our model, instead, the primary mechanism that discourages the taxation of capital is the discretion with which multinational can allocate taxable income across their worldwide operations. What is central in our model is not that multinational firms can re-allocate capital to other countries. Rather, it is their ability to use accounting strategies to reduce taxable income in high-tax countries and increase taxable income in low-tax countries. This can be accomplished without making any changes in actual investments and production.

To our knowledge this is the first paper that studies how the growth of intangible capital affects equilibrium (endogenous) taxation and welfare. The study of financial globalization for equilibrium taxation, instead, is not new in the literature. However, our analysis and results are different. While the most common conclusion of the existing literature is that capital liberalization leads to lower taxation of capital, we find exactly the opposite. The reason is that the literature has mainly considered the role of financial integration in facilitating the cross-country reallocation of capital. But there is another dimension of financial globalization that has not been fully explored: This is the cross-country growth in gross financial holdings, that is, the surge in both foreign assets and foreign liabilities. The implication of this surge is that a large share of profits generated in a country belong to foreigners (since more of these profits are generated by foreign multinationals). This implies that the taxation of domestic profits generates a larger redistribution of income from foreigners to domestic residents, and increases the incentive of governments to tax profits.

Our paper is also related to Dyrda, Hong, and Steinberg (2023a). This study considers the possibility that multinational firms use profit shifting to reduce their tax bill when intangible capital is an important factor of production. However, the goal of this paper is to consider the macroeconomic and welfare implications of recent tax reforms (which

are exogenous in their model), while the goal of our paper is to characterize how governments choose their taxes (endogenous policies). Dyrda, Hong, and Steinberg (2023b), in this issue, characterizes the optimal taxation of multinationals in an environment with policy cooperation. While the analysis of this paper is *normative* in nature (the optimal taxation chosen by a global planner), we conduct a *positive* analysis that characterizes the equilibrium taxes if governments are unable to coordinate their policies.

### 3 The model

There are two countries that are symmetric in technology and preferences. We refer to the first country as ‘Home’ country and to the second as ‘Foreign’ country. Following the notational convention often used in international economics, we use an asterisk to indicate variables pertaining to the Foreign country.

Each country is populated by a continuum of households of total measure 1 with lifetime utility

$$\sum_t \beta^t u(c_t),$$

where  $c_t$  is consumptions at time  $t$ . The per-period utility takes the standard form  $u(c) = c^{1-\sigma}/(1-\sigma)$ . Households cannot change the country of residence and supply one unit of labor inelastically in the domestic market.

There is a measure 1 of competitive multinational firms headquartered in each country. Multinationals produce intermediate goods domestically and abroad which are then used to produce final goods. A multinational headquartered in the Home country differs from a multinational headquartered in the Foreign country in two dimensions. The first is the share of domestic production (and investment) dictated by technological differences that will be described below. The second is the share of domestic ownership.

To simplify the analysis, we assume that a fixed share  $\theta$  of a Home multinational is owned by Home households and the remaining share  $1-\theta$  is owned by Foreign households. Symmetrically, a share  $\theta$  of a Foreign multinational is owned by Foreign households and the remaining share  $1-\theta$  is owned by Home households. We think that  $\theta > 1/2$  since the ownership structure of multinationals is typically characterized by home bias.

In addition to the ownership of multinational firms, households trade a zero-coupon bond denominated in units of tradable final goods. The price of the bond (also in units of the final good) is denoted by  $p_t$ , while the traded units of the bonds are denoted by  $b_t$  and  $b_t^*$ . Since countries are symmetric, in equilibrium we will have  $b_t + b_t^* = 0$ .

A multinational headquartered in the Home country produces intermediate goods in the Home country and in the Foreign country with the following production functions

$$\begin{aligned} m_t &= F(x_t, k_t, l_t) = z \left( x_t^\alpha k_t^{1-\alpha} \right)^\nu l_t^{1-\nu}, \\ \hat{m}_t &= F(x_t, \hat{k}_t, \hat{l}_t) = \hat{z} \left( x_t^\alpha \hat{k}_t^{1-\alpha} \right)^\nu \hat{l}_t^{1-\nu}, \end{aligned}$$

where  $z$  is the (constant) domestic productivity and  $\hat{z}$  is the (constant) productivity abroad. The variable  $x_t$  is the input of intangible capital which is the same for domestic



and abroad productions. The variables  $k_t$  and  $\hat{k}_t$  are the inputs of tangible capital, while  $l_t$  and  $\hat{l}_t$  are the inputs of labor hired domestically (in the Home country) and abroad (in the Foreign country). Notice that we use the hat sign to indicate variables that pertain to multinational operations abroad.

The corresponding production functions for a multinational headquartered in the Foreign country are

$$\begin{aligned} m_t^* &= F(x_t^*, k_t^*, l_t^*) = z \left( (x_t^*)^\alpha (k_t^*)^{1-\alpha} \right)^\nu (l_t^*)^{1-\nu}, \\ \hat{m}_t^* &= \hat{F}(x_t^*, \hat{k}_t^*, \hat{l}_t^*) = \hat{z} \left( (x_t^*)^\alpha (\hat{k}_t^*)^{1-\alpha} \right)^\nu (\hat{l}_t^*)^{1-\nu}. \end{aligned}$$

The intangible capital owned by a multinational ( $x_t$  for home multinationals and  $x_t^*$  for Foreign multinationals), is non-rival. Thus, it can be used by the multinational domestically and abroad. This explains the absence of the hat sign in the input of tangible for production abroad.

In each country, the intermediate inputs produced by domestic and foreign multinationals are used to produce a homogeneous and tradable final good with the production functions

$$\begin{aligned} y_t &= Q(m_t, \hat{m}_t^*) \equiv m_t^\lambda (\hat{m}_t^*)^{1-\lambda}, \\ y_t^* &= Q(m_t^*, \hat{m}_t) \equiv (m_t^*)^\lambda \hat{m}_t^{1-\lambda}. \end{aligned}$$

While intermediate inputs are not tradable internationally but can be sold only to local final producers, final goods are freely tradable. Final output is used for both consumption and investment. The standard accounting identities in open economies hold in the model. See Appendix A for the formal definition of the various components of the Balance of Payments.

By having intermediate inputs to be imperfectly substitutes, we will have a well defined composition of domestic and non-domestic production from multinational firms. This, in turn, allows us to have a well defined composition of domestic and foreign investments, which we will use as calibration targets. In particular, the composition of domestic and non-domestic investments is determined by the parameter  $\lambda$ . We think of this parameter to be greater than 0.5 so that the model features investment home bias. As we will see, this is important for the source taxation of profits because higher investments from foreign multinationals make the local taxation of profits more attractive.

We assume that the production of final goods is done by competitive local firms and the prices of intermediate inputs are equal to their marginal product, that is,

$$\begin{aligned} q_t &= \frac{\partial Q(m_t, \hat{m}_t^*)}{\partial m_t}, \\ \hat{q}_t^* &= \frac{\partial Q(m_t, \hat{m}_t^*)}{\partial \hat{m}_t^*}, \\ q_t^* &= \frac{\partial Q(m_t^*, \hat{m}_t)}{\partial m_t^*}, \\ \hat{q}_t &= \frac{\partial Q(m_t^*, \hat{m}_t)}{\partial \hat{m}_t}. \end{aligned}$$

A key assumption is that multinationals have some discretion in the imputation of expenses associated with intangible capital. In particular, we assume that the total worldwide expenses imputed on intangible capital must be equal to its actual depreciation which, for convenience, we set to the same rate as tangible capital  $\delta$ . Denoting by  $\zeta_t$  and  $\hat{\zeta}_t$  the depreciation rates chosen by the Home multinational domestically and abroad, they must satisfy  $\zeta_t + \hat{\zeta}_t = \delta$ . Thus, as long as the sum of the two imputed rates is constant and equal to  $\delta$ , the Home multinational can choose different values of  $\zeta_t$  and  $\hat{\zeta}_t$ . For a Foreign multinational the constraint is  $\zeta_t^* + \hat{\zeta}_t^* = \delta$ .

The discretion in the choice of these rates allows multinationals to shift taxable profits in the country with the lower tax rate on profits. However, there is also a cost in doing so. The cost can be interpreted as the risk of being audited and being fined if deviating from the targeted rates without valid justification. The costs for the Home multinational in the domestic operation and in the operation abroad are, respectively,

$$\begin{aligned}\varphi(\zeta_t) \cdot x_t &\equiv \chi \cdot (\zeta_t - \lambda\delta)^2 \cdot x_t, \\ \hat{\varphi}(\hat{\zeta}_t) \cdot x_t &\equiv \chi \cdot (\hat{\zeta}_t - (1 - \lambda)\delta)^2 \cdot x_t,\end{aligned}$$

The parameter  $\lambda$  is the final production share of domestic production. If the multinational allocates the depreciation of intangible to domestic operations by  $\delta\lambda$  and foreign operations by  $(1 - \lambda)\delta$ , the cost will be zero. This will be the optimal choice when the two countries have the same tax rates on profits. However, this will not be the case when the tax rates differ as we will see below.

The costs for the Foreign multinational take the same form, that is,

$$\begin{aligned}\varphi(\zeta_t^*) \cdot x_t^* &\equiv \chi \cdot (\zeta_t^* - \lambda\delta)^2 \cdot x_t^*, \\ \hat{\varphi}(\hat{\zeta}_t^*) \cdot x_t^* &\equiv \chi \cdot (\hat{\zeta}_t^* - (1 - \lambda)\delta)^2 \cdot x_t^*,\end{aligned}$$

We can now define the profits earned by Home and Foreign multinationals in each of the two countries. Profits are the difference between what the firm produces in a country minus the costs incurred in that country, that is,

$$\pi_t = q_t F(x_t, k_t, l_t) - w_t l_t - [\zeta_t + \varphi(\zeta_t)] x_t - \delta k_t, \quad (1)$$

$$\hat{\pi}_t = \hat{q}_t \hat{F}(x_t, \hat{k}_t, \hat{l}_t) - w_t^* \hat{l}_t - [\hat{\zeta}_t + \hat{\varphi}(\hat{\zeta}_t)] x_t - \delta \hat{k}_t, \quad (2)$$

$$\pi_t^* = q_t^* F(x_t^*, k_t^*, l_t^*) - w_t^* l_t^* - [\zeta_t^* + \varphi(\zeta_t^*)] x_t^* - \delta k_t^*, \quad (3)$$

$$\hat{\pi}_t^* = \hat{q}_t^* \hat{F}(x_t^*, \hat{k}_t^*, \hat{l}_t^*) - w_t^* \hat{l}_t^* - [\hat{\zeta}_t^* + \hat{\varphi}(\hat{\zeta}_t^*)] x_t^* - \delta \hat{k}_t^*. \quad (4)$$

The variable  $w_t$  is the wage in the Home country and  $w_t^*$  the wage in the Foreign country. The variables  $\zeta_t$ ,  $\hat{\zeta}_t$ ,  $\zeta_t^*$ ,  $\hat{\zeta}_t^*$  are the imputed unitary expenses associated with intangible capital (as described above) and  $\delta$  is the actual depreciation rate for both tangible and intangible capital.

The initial states of a multinational headquartered in the Home country are given by the intangible capital,  $x_t$ , and the tangible capital installed in the two countries,  $k_t$  and  $\hat{k}_t$ . Similarly, the states of the Foreign multinational are  $x_t^*$ ,  $k_t^*$  and  $\hat{k}_t^*$ .

For notational convenience we will use  $a_t$  and  $a_t^*$ , respectively, to denote the total wealth of households in the Home and Foreign country,

$$\begin{aligned} a_t &= \theta(k_t + \hat{k}_t + x_t) + (1 - \theta)(k_t^* + \hat{k}_t^* + x_t^*) + b_t, \\ a_t^* &= \theta(k_t^* + \hat{k}_t^* + x_t^*) + (1 - \theta)(k_t + \hat{k}_t + x_t) + b_t^*. \end{aligned}$$

**Government:** Profits are taxed twice. They are first taxed at rate  $\tau_t$  in the Home country and  $\tau_t^*$  in the Foreign country, based on the ‘source’ principle. Then they are taxed again at rate  $\phi_t$  and  $\phi_t^*$ , based on the ‘residence’ principle.

We refer to  $\tau_t$  (based on the source principle) as ‘profit’ tax rate and to  $\phi_t$  (based on the residence principle) as ‘income’ tax rate. The profit taxes paid by a Home multinational are

$$\tau\pi_t + \tau_t^*\hat{\pi}_t.$$

The first part is the tax bill owed to the Home government, while the second part is the tax bill owed to the Foreign government. The profit taxes paid by a Foreign multinational are

$$\tau\hat{\pi}_t^* + \tau_t^*\pi_t^*,$$

where the first part is paid to the Home government while the second part is paid to the Foreign government.

The remaining profits after the payment of the profit taxes are taxed at the household level according to the residence of the firm’s owners. The income taxes collected by the Home government on the profits earned by their residents are

$$\phi_t \left[ \theta(1 - \tau_t)\pi_t + \theta(1 - \tau_t^*)\hat{\pi}_t + (1 - \theta)(1 - \tau_t)\hat{\pi}_t^* + (1 - \theta)(1 - \tau_t^*)\pi_t^* \right].$$

Home households receive net profits  $\theta[(1 - \tau_t)\pi_t + (1 - \tau_t^*)\hat{\pi}_t]$  from Home multinationals (since they own a share  $\theta$  of these firms), and  $(1 - \theta)[(1 - \tau_t)\hat{\pi}_t^* + (1 - \tau_t^*)\pi_t^*]$  from Foreign multinationals (since they own a share  $1 - \theta$  of these firms). On these profits they pay the income tax  $\phi_t$ .

The income taxes collected by the Foreign government are

$$\phi_t^* \left[ \theta(1 - \tau_t^*)\pi_t^* + \theta(1 - \tau_t)\hat{\pi}_t^* + (1 - \theta)(1 - \tau_t^*)\hat{\pi}_t + (1 - \theta)(1 - \tau_t)\pi_t \right].$$

We would like to emphasize that income taxes are paid by households on their share of profits earned by firms, not the dividends they actually receive. Taxes on profits based on the residence principle are different from dividend taxes. For example, with dividend taxes, if the firm re-invests all the profits rather than paying them as dividends, households do not pay any taxes, at least today. Instead, with an income tax on profits,

households will pay taxes even if the profits are not distributed with dividends. In the steady state, net profits are equal to dividends. However, for taxation incentives they are not the same. We will return later to the difference between households' taxation of profits and dividends.

Tax revenues are used to fund public expenditures for government purchases, which we denote by  $G_t$  and  $G_t^*$ , and government transfers, which we denote by  $T_t$  and  $T_t^*$ . The two types of public expenditures are exogenous in the model and government purchases do not enter directly the households' utility. We abstract from public borrowing so that the government budget must balance in every period.

Governments choose the current tax rates at the beginning of every period to maximize the welfare of its own residents—the households—without commitment. The budget constraint for the governments of the two countries are

$$G_t + T_t = \tau_t(\pi_t + \hat{\pi}_t^*) + \phi_t \left[ \theta(1 - \tau_t)\pi_t + \theta(1 - \tau_t^*)\hat{\pi}_t + (1 - \theta)(1 - \tau_t)\hat{\pi}_t^* + (1 - \theta)(1 - \tau_t^*)\pi_t^* + w_t \right], \quad (5)$$

$$G_t^* + T_t^* = \tau_t^*(\pi_t^* + \hat{\pi}_t) + \phi_t^* \left[ \theta(1 - \tau_t^*)\pi_t^* + \theta(1 - \tau_t)\hat{\pi}_t + (1 - \theta)(1 - \tau_t^*)\hat{\pi}_t + (1 - \theta)(1 - \tau_t)\pi_t + w_t^* \right]. \quad (6)$$

## 4 Policy equilibrium

The governments of the two countries choose their policies by playing a non-cooperative game that takes into account how their choices affect equilibrium allocations. Thus, we need to characterize first the competitive equilibrium associated with given policies. We start doing this in Subsection 4.1 with the presentation of the optimization problems solved by firms and households when current and future tax rates are determined by some general policy rule  $\Psi(\mathbf{s})$ . The variable  $\mathbf{s}$  denotes the set of aggregate states that will be specified below. The policy rule depends only on  $\mathbf{s}$  because the analysis is restricted to Markov strategies. After characterizing the agents' problem for given policy rules, Subsection 4.2 specifies the policy objectives of the two governments and defines the time-consistent policy function that will emerge in equilibrium.

### 4.1 Agents' problem and equilibrium for a given policy rule

In this subsection we characterize the agents' problem and define the competitive equilibrium for given policy rules. We start with the optimization problem solved by a multinational firm.

#### 4.1.1 Firm's problem

The problem solved by a multinational firm can be separated in two sub-problems. In the first the multinational chooses the allocation of intangible expenses and the inputs of

labor in domestic and non-domestic operations. In the second it chooses investments in both intangible and tangible capital. We start with the first problem.

Given the states  $k_t$ ,  $\hat{k}_t$ , and  $x_t$ , a multinational firm headquartered in the Home country  $\zeta_t$ ,  $\hat{\zeta}_t$ ,  $l_t$ , and  $\hat{l}_t$  to maximize profits by solving the problem

$$\begin{aligned} \max_{\zeta_t, \hat{\zeta}_t, l_t, \hat{l}_t} \quad & \left\{ (1 - \tau_t)\pi_t + (1 - \tau_t^*)\hat{\pi}_t \right\}, \\ \text{s.t.} \quad & \\ & \zeta_t + \hat{\zeta}_t = \delta, \end{aligned} \tag{7}$$

with domestic profits,  $\pi_t$ , and profits earned abroad,  $\hat{\pi}_t$ , defined in equations (1) and (2).

The objective is the maximization of the worldwide profits (sum of profits earned in the two countries) net of the profit taxes and the cost of shifting taxation. The solution is characterized by the first order conditions

$$\left[ 1 + \varphi_\zeta(\zeta_t) \right] (1 - \tau_t) = \left[ 1 + \hat{\varphi}_\zeta(\hat{\zeta}_t) \right] (1 - \tau_t^*), \tag{8}$$

$$q_t F_l(k_t, x_t, l_t) = w_t, \tag{9}$$

$$\hat{q}_t \hat{F}_l(\hat{k}_t, x_t, \hat{l}_t) = w_t^*, \tag{10}$$

where the subscript in the cost function denotes the first derivative.

Condition (8) is intuitive: higher is the domestic tax rate on profits, relatively to the tax rate paid abroad, and larger is the deviation of  $\zeta_t$  and  $\hat{\zeta}_t$  from their corresponding targets,  $\lambda\delta$  and  $(1-\lambda)\delta$ . When the profit tax rates are equalized between the two countries, the derivatives of the cost functions must be zero, which implies  $\zeta_t = \lambda\delta$  and  $\hat{\zeta}_t = (1-\lambda)\delta$ . The parameter  $\chi$  in the cost functions determines the sensitivity of  $\zeta_t$  and  $\hat{\zeta}_t$  to the tax differential: higher is the value of  $\chi$  and lower is the sensitivity of the responses of  $\zeta_t$  and  $\hat{\zeta}_t$  to the tax differential.

Conditions (9) and (10) determines the inputs of labor which are chosen to equalize the marginal productivity, domestic and abroad, to the wage rate in each country. The optimality conditions for a Foreign multinational are similar.

Even if capital cannot be reallocated internationally in the short run (although it can be done through new investments), when tax rates differ across countries, firms can reduce their tax bill by shifting the taxation of profits toward the country with the lowest tax rate. This introduces a mechanism for international tax competition. Even if higher profit taxes do not distort production in the current period, they can redistribute resources in favor of the domestic country. This is because some of the profits generated by multinationals headquartered in the Foreign country are generated in the Home country and part of the Home multinationals are owned by households that are residents of the Foreign country. This incentive, however, is alleviated by the flexibility with which multinationals can shift the taxation burden. Higher profit tax rates in the Home country will reduce the taxable profits in the Home country and increase them in the Foreign country.

We can now consider the investment decision of the Home multinational. Differently from the optimal hiring, the investment decision solves a dynamic problem which we write recursively as

$$V(\mathbf{s}, x, k, \hat{k}; \Psi) = \max_{n, i, \hat{i}} \left\{ d + \tilde{\beta} V(\mathbf{s}'; x', k', \hat{k}'; \Psi) \right\} \quad (11)$$

**s.t.**

$$d = (1 - \bar{\phi}) \left[ (1 - \tau)\pi + (1 - \hat{\tau})\hat{\pi} \right] - n - i - \hat{i}, \quad (12)$$

$$x' = x + n, \quad (13)$$

$$k' = k + i, \quad (14)$$

$$\hat{k}' = \hat{k} + \hat{i}, \quad (15)$$

$$\bar{\phi} = \theta\phi + (1 - \theta)\phi^*, \quad (16)$$

$$(\tau, \tau^*, \phi, \phi^*) = \Psi(\mathbf{s}), \quad (17)$$

$$\mathbf{s}' = \Upsilon(\mathbf{s}; \Psi). \quad (18)$$

The variable  $d$  denotes the dividends net of taxes (both profit and income taxes) paid by the multinational. Even if income taxes are paid by households, firms maximizes the value of these profits for households taking into account the ownership structure of the firm. The Home multinational knows that a fraction  $\theta$  of its profits belong to Home households who pay the income tax rate  $\phi$ . The remaining fraction  $1 - \theta$ , instead, belong to Foreign households and they pay the income tax rate  $\phi^*$ . Therefore, domestic profits have a value of  $(1 - \phi)(1 - \tau)\pi$  for shareholders residing in the Home country and  $(1 - \phi^*)(1 - \tau)\pi$  for shareholders residing in the Foreign country. By the same token, the profits generated abroad by the Home multinational has a value of  $(1 - \phi)(1 - \tau^*)\hat{\pi}$  for shareholders residing in the Home country and  $(1 - \phi^*)(1 - \tau^*)\hat{\pi}$  for shareholders residing in the Foreign country. The value for the multinational is then the weighted sum of these values, that is,

$$(1 - \bar{\phi}) \left[ (1 - \tau)\pi + (1 - \hat{\tau})\hat{\pi} - \varphi(\zeta)x \right],$$

where  $\bar{\phi} = \theta\phi + (1 - \theta)\phi^*$ . The weights  $\theta$  and  $1 - \theta$  are the corresponding shares of Home and Foreign owners of a multinational headquartered in the Home country.

The variable  $n$  is the net (of depreciation) investment in intangible capital while  $i$  and  $\hat{i}$  are net investments in tangible capital in Home and Foreign countries, respectively. We used net investments because depreciation has already been subtracted in the profits  $\pi$  and  $\hat{\pi}$ . The discount factor  $\tilde{\beta}$  is time varying and will be derived below from the discount factors of shareholders. A firm is atomistic and, therefore, it takes  $\tilde{\beta}$  as given. Having specified the problem recursively, we have omitted time subscripts and used the prime sign to indicate next period variables. Finally, we would like to emphasize that the profits  $\pi_t$  and  $\hat{\pi}_t$  are the maximized profits, that is, those obtained with the optimal inputs of labor and optimal tax shifting.

The first order conditions for the investment chosen by a Home multinational are

$$\tilde{\beta} \left[ 1 + (1 - \bar{\phi}') \left[ (1 - \tau') \frac{\partial \pi'}{\partial x'} + (1 - \tau^{*'}) \frac{\partial \hat{\pi}'}{\partial x'} - \varphi(\zeta') \right] \right] = 1, \quad (19)$$

$$\tilde{\beta} \left[ 1 + (1 - \bar{\phi}') (1 - \tau') \frac{\partial \pi'}{\partial k'} \right] = 1, \quad (20)$$

$$\tilde{\beta}_j \left[ 1 + (1 - \bar{\phi}') (1 - \tau^{*'}) \frac{\partial \hat{\pi}'}{\partial k'} \right] = 1. \quad (21)$$

Lower values of the discount factor  $\tilde{\beta}$  require higher marginal productivity of capital, both intangible and tangible. Higher future tax rates on profits,  $\tau'$  and  $\tau^{*'}$ , and income,  $\phi'$ , will be associated with higher marginal productivity of capital and, therefore, lower investment.

**Lemma 4.1** *If the profit tax rates chosen by the two countries are the same, that is,  $\tau = \tau^*$ , the next period share of intangible capital is  $\alpha$ .*

**Proof 4.1** *See appendix.*

This property is valid as long as the profit tax rates are the same. If they differ, the share of intangible capital is not  $\alpha$ . The symmetry of the two countries implies that in the steady state they choose the same tax rates and, therefore, the share of intangible capital is  $\alpha$ .

#### 4.1.2 Household's problem

The household's problem in the Home country is relatively simple and can be written recursively as

$$\begin{aligned} \Omega(\mathbf{s}, b; \Psi) &= \max_{c, b'} \left\{ u(c) + \beta \Omega(\mathbf{s}', b'; \Psi) \right\} \\ &\mathbf{s.t.} \\ c &= (1 - \phi)w + \theta d + (1 - \theta)d^* + T + b - pb', \\ \phi &= \Psi_\phi(\mathbf{s}), \\ \mathbf{s}' &= \Upsilon(\mathbf{s}; \Psi). \end{aligned} \quad (22)$$

In addition to wages, households receive dividends paid by Home multinationals in proportion to their share ownership,  $\theta d$ , and Foreign multinationals,  $(1 - \theta)d^*$ . They also receive government transfers,  $T$ . The variable  $b$  denotes the bond purchased in the previous period and  $b'$  the new bond purchased at price  $p$ . We assume that the interests earned on the bonds are not taxed. This assumption is not important for the results of

the paper but it is convenient analytically.<sup>1</sup> Notice that the dividends are already net of the income taxes paid by households, which explains why they do not show explicitly in the household's budget constraint.

The first order condition for the choice of the new bond returns

$$u_c(c)p = \beta u_c(c'), \quad (23)$$

which provides us with an expression to derive the bond price  $p$ . The condition says that the utility cost of purchasing one unit of bonds today,  $u_c(c)p$ , must be equal to the discounted utility value of the next period repayment, that is,  $\beta u_c(c')$ .

Since multinationals maximize the value of their shareholders, they take into consideration how dividends are valued by shareholders. In particular, one unit of dividends paid today by a Home multinational has a utility value of  $\theta u_c(c)$  for Home shareholders (since they will receive a share  $\theta$  of dividends) and  $(1 - \theta)u_c(c^*)$  for Foreign shareholders. Thus, the total value of one unit of dividends is

$$\theta u_c(c) + (1 - \theta)u_c(c^*). \quad (24)$$

As an alternative to paying the dividend today, the firm could invest that unit in new capital—let's say in domestic tangible capital—and this will generate a return in the next period of  $(1 - \bar{\phi})(1 - \tau)\partial\pi'/\partial k'$ . The return can be paid to shareholders in the next period together with the unit invested, which has a present value of

$$\beta(\theta u_c(c') + (1 - \theta)u_c(c'^*)) \left[ 1 + (1 - \bar{\phi})(1 - \tau)\frac{\partial\pi'}{\partial k'} \right]. \quad (25)$$

Utility maximization requires that the value of paying one unit of dividends today—equation (24)—must be equal to the value of reinvesting that unit and paying it the next period together with the return from the investment—equation (25). Equalizing the two terms and re-arranging we obtain

$$1 = \frac{\beta(\theta u_c(c') + (1 - \theta)u_c(c'^*))}{\theta u_c(c) + (1 - \theta)u_c(c^*)} \left[ 1 + (1 - \bar{\phi})(1 - \tau)\frac{\partial\pi'}{\partial k'} \right].$$

This shows that Home multinationals discount future payments by the factor

$$\tilde{\beta} = \frac{\beta(\theta u_c(c') + (1 - \theta)u_c(c'^*))}{\theta u_c(c) + (1 - \theta)u_c(c^*)}. \quad (26)$$

Next we want to show that the discount factor used by firms is equal to the price of the bond. The households' first order conditions in the choice of bonds, for Home and

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<sup>1</sup>Since the determination of the current tax rates depends on the taxed interests on bonds that are earned today but are based on the interest rate determined in the previous period, we would need to keep track of the interest rate as an additional state variable. Keeping track of an additional state variable would be a major complication for the numerical computation of the equilibrium.



Foreign households are, respectively,

$$u_c(c)p = \beta u_c(c'), \quad (27)$$

$$u_c(c^*)p = \beta u_c(c^{*'}). \quad (28)$$

Multiplying the first equation by  $\theta$  and the second equation by  $1 - \theta$ , summing them together and re-arranging, we obtain

$$p = \frac{\beta(\theta u_c(c') + (1 - \theta)u_c(c^{*'}))}{\theta u_c(c) + (1 - \theta)u_c(c^*)}. \quad (29)$$

Equations (26) and (29) show that  $\tilde{\beta} = p$ .

### 4.1.3 Equilibrium for given policy rules

We provide here a formal definition of a competitive equilibrium when tax rates are determined by a policy function  $\Psi$ .

**Definition 4.1** *A recursive competitive equilibrium for a given policy rule  $\Psi$  is given by: (i) aggregate functions for wages,  $w(\mathbf{s}; \Psi)$  and  $w^*(\mathbf{s}; \Psi)$ , price of bonds,  $p(\mathbf{s}; \Psi)$ , allocations of intangible expenses,  $\zeta(\mathbf{s}; \Psi)$ ,  $\hat{\zeta}(\mathbf{s}; \Psi)$ ,  $\zeta^*(\mathbf{s}; \Psi)$  and  $\hat{\zeta}^*(\mathbf{s}; \Psi)$ , investments in intangible,  $N(\mathbf{s}; \Psi)$  and  $N^*(\mathbf{s}; \Psi)$ , investment in tangible,  $I(\mathbf{s}; \Psi)$ ,  $\hat{I}(\mathbf{s}; \Psi)$ ,  $I^*(\mathbf{s}; \Psi)$  and  $\hat{I}^*(\mathbf{s}; \Psi)$ , law of motion for aggregate states,  $\Upsilon(\mathbf{s}; \Psi)$ ; (ii) firm values,  $V(\mathbf{s}, x, k, \hat{k}; \Psi)$  and  $V^*(\mathbf{s}, x^*, k^*, \hat{k}^*; \Psi)$ , firms' decision rules for allocation of intangible expenses,  $g^\zeta(\mathbf{s}, x, k, \hat{k}; \Psi)$ ,  $g^{\hat{\zeta}}(\mathbf{s}, x, k, \hat{k}; \Psi)$ ,  $g^{\zeta^*}(\mathbf{s}, x^*, k^*, \hat{k}^*; \Psi)$ ,  $g^{\hat{\zeta}^*}(\mathbf{s}, x^*, k^*, \hat{k}^*; \Psi)$ , input of labor  $g^l(\mathbf{s}, x, k, \hat{k}; \Psi)$  and  $g^{l^*}(\mathbf{s}, x^*, k^*, \hat{k}^*; \Psi)$ , intangible investment,  $g^n(\mathbf{s}, x, k, \hat{k}; \Psi)$  and  $g^{n^*}(\mathbf{s}, x^*, k^*, \hat{k}^*; \Psi)$ , tangible investment,  $g^i(\mathbf{s}, x, k, \hat{k}; \Psi)$ ,  $g^{\hat{i}}(\mathbf{s}, x, k, \hat{k}; \Psi)$ ,  $g^{i^*}(\mathbf{s}, x^*, k^*, \hat{k}^*; \Psi)$ ,  $g^{\hat{i}^*}(\mathbf{s}, x^*, k^*, \hat{k}^*; \Psi)$ ; (iii) households' values  $\Omega(\mathbf{s}, b; \Psi)$  and  $\Omega^*(\mathbf{s}, b^*; \Psi)$ , and households' decision rules for the acquisition of bonds  $g^b(\mathbf{s}, b; \Psi)$  and  $g^{b^*}(\mathbf{s}, b^*; \Psi)$ , such that: (i) the decision rules of firms and households solve their corresponding problems and  $V(\mathbf{s}, x, k, \hat{k}; \Psi)$ ,  $V^*(\mathbf{s}, x^*, k^*, \hat{k}^*; \Psi)$ ,  $\Omega(\mathbf{s}, b; \Psi)$  and  $\Omega^*(\mathbf{s}, b^*; \Psi)$  are the associated value functions; (ii) firms and households are representative, that is,*

$$\begin{aligned} g^\zeta(\mathbf{s}, X, K, \hat{K}; \Psi) &= \zeta(\mathbf{s}; \Psi), \\ g^{\hat{\zeta}}(\mathbf{s}, X, K, \hat{K}; \Psi) &= \hat{\zeta}(\mathbf{s}; \Psi), \\ g^{\zeta^*}(\mathbf{s}, X^*, K^*, \hat{K}^*; \Psi) &= \zeta^*(\mathbf{s}; \Psi), \\ g^{\hat{\zeta}^*}(\mathbf{s}, X^*, K^*, \hat{K}^*; \Psi) &= \hat{\zeta}^*(\mathbf{s}; \Psi), \\ g^l(\mathbf{s}, X, K, \hat{K}; \Psi) + g^{\hat{l}}(\mathbf{s}, X, K, \hat{K}; \Psi) &= 1, \\ g^{l^*}(\mathbf{s}, X^*, K^*, \hat{K}^*; \Psi) + g^{\hat{l}^*}(\mathbf{s}, X^*, K^*, \hat{K}^*; \Psi) &= 1, \\ g^n(\mathbf{s}, X, K, \hat{K}; \Psi) &= N(\mathbf{s}; \Psi), \\ g^{n^*}(\mathbf{s}, X^*, K^*, \hat{K}^*; \Psi) &= N^*(\mathbf{s}; \Psi), \end{aligned}$$

$$\begin{aligned}
g^i(\mathbf{s}, X, K, \hat{K}; \Psi) &= I(\mathbf{s}; \Psi), \\
\hat{g}^i(\mathbf{s}, X, K, \hat{K}; \Psi) &= \hat{I}(\mathbf{s}; \Psi), \\
g^{i*}(\mathbf{s}, X^*, K^*, \hat{K}^*; \Psi) &= I^*(\mathbf{s}; \Psi), \\
\hat{g}^{i*}(\mathbf{s}, X^*, K^*, \hat{K}^*; \Psi) &= \hat{I}^*(\mathbf{s}; \Psi), \\
g^b(\mathbf{s}, B; \Psi) + g^{b*}(\mathbf{s}, -B; \Psi) &= 0,
\end{aligned}$$

(iv) governments balance their budget every period, equations (5) and (6).

## 4.2 Determination of policies

When governments choose the current tax rates— $\tau$  and  $\phi$  in the Home country, and  $\tau^*$  and  $\phi^*$  in the Foreign country—they take as given the rule that determines future policies, that is, the function  $\Psi$ . Furthermore, each government takes as given the policy variables of the other country. Effectively, a government chooses only the profit tax rate,  $\tau$  or  $\tau^*$ , because the income tax rate,  $\phi$  or  $\phi^*$ , will be determined endogenously by the budget constraint of the governments. For the same reason, each government takes as given only the profit tax rate of the other country since the income tax rate will be determined endogenously by the government budget of the other country.

We define first the equilibrium when current policies are exogenously given and future policies are determined by  $\Psi$ . The problem solved by a multinational firm headquartered in the Home country can be written recursively as

$$\begin{aligned}
\tilde{V}(\mathbf{s}, x, k, \hat{k}, \tau, \tau^*; \Psi) &= \max_{\zeta, l, n, i, \hat{i}} \left\{ d + pV(\mathbf{s}', x', k', \hat{k}'; \Psi) \right\} & (30) \\
\mathbf{s.t.} & \\
d &= (1 - \bar{\phi}) \left[ (1 - \tau)\pi + (1 - \tau^*)\hat{\pi} \right] - n - i - \hat{i}, \\
x' &= x + n, \\
k' &= k + i, \\
\hat{k}' &= \hat{k} + \hat{i}, \\
\bar{\phi} &= \theta\phi + (1 - \theta)\phi^* \\
(\phi, \phi^*) &= \tilde{\mathcal{B}}(\mathbf{s}; \tau, \tau^*) \\
\mathbf{s}' &= \tilde{\Upsilon}(\mathbf{s}, \tau, \tau^*; \Psi),
\end{aligned}$$

The next period value function is for a given policy rule  $\Psi$  as we defined in the previous section. For the current period, instead, the value function has the current policies  $\tau, \tau^*$  as explicit arguments. As we explained above, the income tax rates,  $\phi$  and  $\phi^*$ , are determined by the budget constraints of the two governments. This is indicated in the problem by the function  $\tilde{\mathcal{B}}(\mathbf{s}; \tau, \tau^*)$ , which is a compact notation for the government budget constraints. All functions that depend on current policies  $\tau$  and  $\tau^*$  are denoted with a tilde sign to distinguish them from the analogous functions where policies are determined by the policy rule  $\Psi$ .

The problem solved by households in the Home country is

$$\begin{aligned}
\tilde{\Omega}(\mathbf{s}, b, \tau, \tau^*; \Psi) &= \max_{c, b'} \left\{ u(c) + \beta \Omega(\mathbf{s}', b'; \Psi) \right\} \\
&\mathbf{s.t.} \\
c &= (1 - \phi)w + \theta d + (1 - \theta)d^* + T + b - pb', \\
\phi &= \tilde{\mathcal{B}}_\phi(\mathbf{s}, \tau, \tau^*; \Psi), \\
\mathbf{s}' &= \tilde{\Upsilon}(\mathbf{s}, \tau, \tau^*; \Psi),
\end{aligned} \tag{31}$$

with the continuation value defined in the previous section. The definition of the equilibrium for given current policies,  $\tau$  and  $\tau^*$ , is analogous to the definition provided earlier.

We are now ready to define the problem solved by the government of the Home country. This consists in the choice of  $\tau$  to maximize the welfare of the resident households, that is, the function  $\tilde{\Omega}(\mathbf{s}, B, \tau, \tau^*; \Psi)$ . The problem solved by the Home government is

$$\max_{\tau} \tilde{\Omega}(\mathbf{s}, B, \tau, \tau^*; \Psi). \tag{32}$$

The solution is given by a function  $h(\mathbf{s}; \tau^*, \Psi)$  that returns the optimal profit tax rate  $\tau$  as a function of the profit tax rate chosen by the Foreign government  $\tau^*$  (in addition to be a function of the aggregate states). This is the response function of the Home government to the policy of the Foreign government.

The problem solved by the Foreign government is similar and can be written as

$$\max_{\tau^*} \tilde{\Omega}^*(\mathbf{s}, -B, \tau, \tau^*; \Psi). \tag{33}$$

In equilibrium, the bonds held by households in the Home country,  $B$ , must be equal to the negative of the bonds held by households in the Foreign country. This is why the objective function of the Foreign government has  $-B$  as a state variable. The solution is given by a function  $h^*(\mathbf{s}; \tau, \Psi)$  which represents the response function of the Foreign government to the policy of the Home government.

**Definition 4.2 (Nash one-step equilibrium)** *Given the states  $\mathbf{s}$  and the policy rule  $\Psi$  determining future policies, a Nash one-step equilibrium is given by tax rates  $\tau$  and  $\tau^*$  that satisfy  $\tau = h(\mathbf{s}, \tau^*; \Psi)$  and  $\tau^* = h^*(\mathbf{s}, \tau; \Psi)$ .*

We denote the solution to the Nash game for given states  $\mathbf{s}$  by the function  $(\tau, \tau^*) = \psi(\mathbf{s}; \Psi)$ . This is the equilibrium ‘current policy rule’ when the two governments expect that future policies will be determined by the policy rule  $\Psi(\mathbf{s})$ . We now have all the elements to define the equilibrium time-consistent policies.

**Definition 4.3 (Time-consistency)** *The equilibrium time-consistent policy rule satisfies  $\Psi(\mathbf{s}) = \psi(\mathbf{s}; \Psi)$ .*

In words, the policy rule  $\Psi$  is time consistent if the solution to the current policy game replicates the rule that determines future policies.

## 5 Policy coordination

For policy coordination we think of an environment in which the two governments choose common tax rates on profits, that is,  $\tau = \tau^*$ , in order to maximize the sum of the welfare of the two countries. This is still done without commitment to future policies. The objective of the coordinating governments is

$$\max_{\tau} \left\{ \tilde{\Omega}(\mathbf{s}, B, \tau, \tau; \Psi) + \tilde{\Omega}^*(\mathbf{s}, -B, \tau, \tau; \Psi) \right\}. \quad (34)$$

With symmetric countries the coordinated policies are indeterminate. This is because, with inelastic labor supply, current taxes are not distortionary. Capital is already installed so changing the taxation of capital cannot change its current allocation. Similarly, changing the taxation of income, which includes the taxation of wages, cannot change the quantity of labor used in production since the supply is inelastic. The tax rates cannot generate cross-country redistribution since they are the same. Therefore, changing the common profit tax rate  $\tau$  simply changes the composition of tax revenues without affecting production and consumption.

Because the coordinated time-consistent policy is undetermined, it is not possible to characterize the precise tax rates that would emerge in a globalized environment in which taxation is fully coordinated across countries. In reality, full coordination of fiscal policies is unlikely to be achieved. Even with highly integrated economies such as the European Union, there is not full coordination of fiscal policies. Some form of partial coordination such as a minimum taxation floor could be more likely for the future. This is what the US Treasury Secretary has been promoting.

## 6 Quantitative analysis

We now turn our attention to the main question addressed in this paper: How the increased role of intangible capital and cross-country investments affected equilibrium taxes.

To answer this question we conduct a quantitative analysis where we increase both the share of intangible capital, and the cross-country investment and ownership of multinationals. Since in the model the share of intangible capital is dictated by the parameter  $\alpha$ , the quantitative exercise compares equilibria with low value of  $\alpha$  (inducing low shares of intangible capital like in the early 1990s) to a higher values of  $\alpha$  (inducing high shares of intangible capital like in the 2000s). To capture the importance of financial globalization we compare equilibria with high values of  $\lambda$  and  $\theta$  (low shares of foreign investments and ownership like in the early 1990s) to lower values of  $\lambda$  and  $\theta$  (high shares of foreign investments and ownership like in the 2000s).

### 6.1 Calibration

We think of the baseline model as capturing the structural conditions that prevailed in the early 1990s. By then, international markets were quite integrated and the issue of

international tax competition became more relevant. Remember that our model features capital mobility which was heavily controlled before the mid-1980s.

Most components of the model are standard and, for these components, we assign the typical parameter values used in the literature. We set the discount factor to  $\beta = 0.95$ , the curvature of the utility function to  $\sigma = 2$ , the share of capital in production (sum of tangible and intangible) to  $\nu = 0.4$ , and the common depreciation rate to  $\delta = 0.06$ .

The share parameter for intangible capital is set to  $\alpha = 0.3$ . This implies a 30% share of intangible capital which was the approximate average value of the two series plotted in Figure 1 at the beginning of the 1990s (the starting point for our quantitative exercise). We then compare the early 1990s to the last year of data available where the average of the two series is about 50%.

The parameter  $\lambda$  is the share of intermediate inputs produced by domestic multinationals in the production of final goods. The remaining share  $1 - \lambda$  is produced by non-domestic multinationals. Since this parameter also determines the share of investments made by multinational firms domestically and abroad, we calibrate it by targeting the level of Foreign Direct Investments (FDI) at the beginning of the 1990s. As shown in the first panel of Figure 2, the average value of FDI as a percentage of GDP among industrialized countries at the beginning of the 1990s was about 15%. Therefore, we choose  $\lambda$  so that in the steady state the value of foreign capital is 15% the value of final output. In terms of model's notation, foreign capital is  $(1 - \lambda)x + \hat{k}$  and final output is  $y_t$ .

An issue associated with changing the values of  $\alpha$  and  $\lambda$  is that, in addition to changing the equilibrium shares of the two types of capital and their geographical allocation, they also change aggregate production and consumption. This happens even if total capital (the sum of tangible and intangible) and the profit tax rates do not change. Because of this, it would be difficult to assess the welfare implications of a change in  $\alpha$  and  $\lambda$ . To circumvent this issue, we assume that productivities in intermediate production are functions of these two parameters according to the following formulas

$$\begin{aligned} z = z^* &= \frac{\bar{z}\lambda^{\alpha\nu}}{\alpha^{\alpha\nu}(1-\alpha)^{(1-\alpha)\nu}}, \\ \hat{z} = \hat{z}^* &= \frac{\bar{z}(1-\lambda)^{\alpha\nu}}{\alpha^{\alpha\nu}(1-\alpha)^{(1-\alpha)\nu}}. \end{aligned}$$

With this specification, if the profit tax rates chosen by the two countries do not change, steady state output and consumption are independent of  $\alpha$  and  $\lambda$ . Therefore, the real effects induced by a change in  $\alpha$  or  $\lambda$  are only driven by the endogenous responses of taxes. The parameter  $\bar{z}$  acts as a re-scaling factor and we choose its value so that the steady state output in the baseline calibration is equal to 1 (normalization).

We discuss next the calibration of the parameter  $\theta$ , that is, the domestic ownership share of multinationals. To calibrate this parameter, we use data on Portfolio Equity Investment shown in the second panel of Figure 2. At the beginning of 1990s, the average Portfolio Equity Investment (PEI) held by foreigners in industrial countries was about 5% of GDP. Therefore, we choose  $\theta$  so that the steady state value of capital held by foreigners

in a multinational,  $(1 - \theta)(k + \hat{k} + x)$ , is 5 percent the value of final output,  $y_t$ . Notice that this parameter does not affect the steady state values of output and consumption if tax rates do not change. The only macroeconomic impact induced by  $\theta$  is through the response of the tax rates.

Public spending— $G$ ,  $G^*$ ,  $T$  and  $T^*$ —are exogenous in the model. We assume that they are constant in absolute value so that we can focus on the (endogenous) composition of taxes. Since their absolute values remain constant when we change  $\alpha$ ,  $\lambda$  and  $\theta$ , the output share of public spending does not change in the steady state, provided that the tax rates remain the same. Remember that, with the normalization of productivities, steady state output changes only in response to tax rates. The values of government purchases,  $G$  and  $G^*$ , and transfers,  $T$  and  $T^*$ , are chosen so that in the steady state of the baseline model government purchases and transfers are, respectively, 20% and 15% the value of final output.

We are now left with the parameter  $\chi$ , that is, the cost of tax shifting. Higher values of  $\chi$  make more costly for multinationals to shift the taxation of profits from one country to the other. This increases the incentive of governments to tax profits and, as a result, the equilibrium taxation of profits will rise. We pin down  $\chi$  by targeting an equilibrium profit tax rate of 30%, that is,  $\tau = \tau^* = 0.3$ . To match this calibration target we use an iterative procedure: we guess  $\chi$ , solve for the steady state equilibrium associated with the guess, and then we verify whether the equilibrium tax rate is  $\tau = \tau^* = 0.3$ .

The equilibrium in the baseline calibration will be compared to the equilibrium with new values of  $\alpha$ ,  $\lambda$  and  $\theta$ . These three parameters are re-calibrated to match the shares of intangible capital, and the cross-country investment and ownership at the end of the sample. In particular, in the new calibration we set  $\alpha = 0.5$  since the average share of intangible capital shown in Figure 1 at the end of the sample period is about 50%. The values of  $\lambda$  and  $\theta$  are chosen so that the stock of FDI and PEI in 2020 are, respectively, 40% and 50% the value of GDP for industrialized countries. These are the approximate numbers shown in the two panels of Figure 2. The full set of parameter values are reported in Table 1.

## 6.2 Steady state comparisons

We first compare two steady state equilibria: (i) the initial steady state associated with the baseline calibration of  $\alpha$ ,  $\lambda$  and  $\theta$ , based on data for the beginning of the 1990s; and (ii) the terminal steady state associated with the new calibration of  $\alpha$ ,  $\lambda$  and  $\theta$  based on more recent data. The results are reported in Table 2.

Following the changes in  $\alpha$ ,  $\lambda$  and  $\theta$ , the steady state tax rate on profits drops from 30% to 28.7%. The income tax rate remains almost the same (it increases only slightly). The reason the income tax rate remains almost unchanged is because output increases and, therefore, the tax base becomes larger. Remember that government expenditures are exogenously fixed. Therefore, the funding of government expenses requires a lower tax rate when the base increases. Output increases because the stock of capital rises from 2.287 to 2.332 (thanks to the lower taxation of profits).

Table 1: Parameter values.

<i>Description</i>	<i>Parameter</i>	<i>Baseline</i>	<i>New</i>
		<i>calibration</i> 1990	<i>calibration</i> 2020
Discount factor	$\beta$	0.950	
Utility curvature	$\sigma$	2.000	
Productivity	$\bar{z}$	0.718	
Capital income share	$\nu$	0.400	
Share intangible capital	$\alpha$	0.300	0.500
Share domestic production inputs	$\lambda$	0.934	0.825
Share domestic ownership of multinationals	$\theta$	0.978	0.781
Cost of tax shifting	$\chi$	0.810	
Government purchases	$G$	0.200	
Government transfers	$T$	0.150	

Table 2: Steady state variables.

	<i>Baseline</i>	<i>New</i>
	<i>calibration</i> 1990	<i>calibration</i> 2020
Profit tax rate	0.300	0.287
Income tax rate	0.346	0.346
Public purchases-output ratio	0.200	0.198
Public transfers-output ratio	0.150	0.149
Stock of capital	2.287	2.332
Output	1.000	1.008

The changes shown in Table 2 result from the combined effects of the changes in  $\alpha$ ,  $\lambda$  and  $\theta$ . To show how each of these parameters affect the equilibrium, we conduct a sensitivity analysis. Before doing so, however, we show how the choice of the current profit tax rate affects the government's objective.

Figure 3 plots the government's value for country 1 as a function of the profit tax rate and its components: current utility,  $u_t$ , continuation utility,  $\beta\Omega_{t+1}$ , and total value  $\tilde{\Omega}_t = u_t + \beta\Omega_{t+1}$ . These values are computed assuming that the state variables and the profit tax rate chosen by the other country take the steady state values. Thus, they represent deviations of country 1 from the steady state profit tax rate. Of course, if the profit tax rate changes in country 1, the equilibrium allocation will change even if the other country does not change the current tax rate. The top panels are for the case in which the government of country 1 deviates from the steady state of the baseline calibration (1990). The bottom panels are for the case in which the government of country 1 deviates from the steady state associated with the more recent calibration (2020).

Current and continuation utilities are both concave and reach their maximum at the

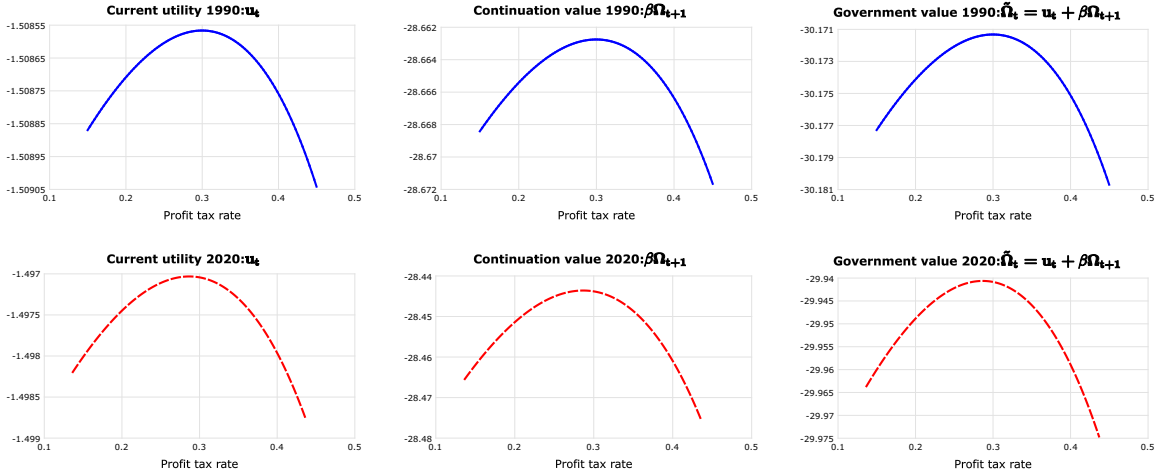


Figure 3: Government value as a function of the current profit tax rate: Deviation from the steady state.

steady state. For low profit tax rates (relative to the other country tax rate), the current utility increases while for high tax rates (also relative to the other country tax rate) it decreases. To understand why, we have to consider how an increase in the tax rate in country 1 affects tax revenues. On the one hand, the taxable profits decline since multinationals shift taxable profits abroad. This reduces tax revenues generated from the taxation of profits and country 1 collects less tax revenues from foreign earners, while domestic households will pay more taxes to the foreign government. On the other, each unit of foreign profits will pay a higher tax rate. It turns out that the second effect dominates when the initial tax rate is (relatively) low, while the first effect dominates when the initial tax rate is (relatively) high. At the pick, the two effects offset each other and there is no incentive to deviate by choosing a different tax rate.

The continuation utility follows a similar pattern. This is because, when an increase in profit tax rate raises tax revenues, the government can reduce income taxes to residents, which in turn increases disposable income. Thanks to higher disposable income, households accumulate more capital which increases next period continuation utility. When the increase in profit tax rate decreases the tax revenues, it also reduces the disposable income of residents, leading to a reduction in both current and continuation utilities.

The bottom panels plot the same variables but with the end-of-period calibration. As we can see, the functions display similar shapes as in the top panels. However, the pick is at a lower tax rate: 28.7% instead of 30%. To understand why the new calibration leads to a lower taxation of profits, we conduct a sensitivity analysis for the three parameters  $\alpha$ ,  $\lambda$ , and  $\theta$ .

We first change the share of intangible capital  $\alpha$  from 0.2 to 0.7, with increments of 0.1. We would like to reiterate that, given our specification of productivities, if the common tax rates do not change in the two countries, steady state production and consumption



will not change either. This is because intangible and tangible capital depreciate at the same rate, productivities are re-scaled when  $\alpha$  changes, and incomes generated by the two types of capital are taxed at the same rates. Thus, if total capital, output and consumption change, it is a consequence of the changes in tax rates.

The top panels of Figure 4 plot the steady state tax rates (panel (a)), as well as capital and output (panel (b)), for different shares of intangible  $\alpha$ . The increase in the share of intangible leads to a decline in the profit tax rate  $\tau$  and a slight increase in the income tax rate. The reason the income tax rate increases only slightly, despite the sizable drop in profit taxes, is because the stock of capital and, therefore, the tax base rises. In fact, panel (b) shows that total capital and output increase significantly with  $\alpha$ . Going from a share of intangible of 20% to a share of 70%, the stock of capital increases by 65 percent while output increases by 22%.

The middle panels of Figure 4 plot the sensitivity to the share of domestic inputs in final production, the parameter  $\lambda$ . In this exercise we use the more recent share of intangible,  $\alpha = 0.5$ , but the baseline value of  $\theta = 0.978$ . The parameter  $\lambda$  does not have a sizable impact on the equilibrium tax rates, which at first may be surprising. This derives from two contrasting effects. On the one hand, a higher share of foreign capital increases the incentive to tax domestic profits because a larger share of them are generated by foreign multinationals. On the other, as we decrease  $\lambda$ , the cost of tax shifting also changes. The chosen specification of this cost implies that the overall cost of deviating from the target allocation of intangible depreciation decreases as  $\lambda$  declines and gets closer to 0.5. It turns out that the quantitative importance of this second effect is not that different from the first. As a result, the equilibrium tax rates change only slightly.

The bottom panels of Figure 4 show the sensitivity to the foreign ownership of multinationals, which is determined by the parameter  $\theta$ . The foreign ownership of multinationals is important because it affects the profits earned by foreigners in the country, which in turn affects the incentive of the country to tax profits. We would like to reiterate that  $\theta$  is only the ownership of domestic multinationals, not the effective domestic ownership of capital invested in a country.<sup>2</sup>

The bottom panels of Figure 4 are constructed using  $\alpha = 0.5$  and  $\lambda = 0.825$ , that is,

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<sup>2</sup>Since multinationals invest in both countries, the effective ownership of capital invested in a country owned by foreigners is greater than  $1 - \theta$ . In the baseline calibration we imposed  $\lambda = 0.934$  and  $\theta = 0.978$ . This means that Home multinationals invest 93.4% in the Home country and 6.6% in the Foreign country. Furthermore, 97.8% of Home multinationals are owned by Home households and 2.2% by Foreign households. Since Home multinationals invest 93.4% domestically, the effective domestic ownership of Home households is  $93.4\% \times 97.8\% = 91.3\%$ . At the same time, Home households own 2.2% of Foreign multinationals that invest 93.4% of their capital in the Home country. This implies that Home households also hold  $6.6\% \times 2.2\% = 0.14\%$  of the capital invested by Foreign multinationals in the Home country. Therefore, the share of capital owned by Home households in the Home country is  $91.3\% + 0.14\% = 91.44\%$ , while the remaining 8.56% is owned by Foreign households. More generally, in a symmetric steady state, the foreign ownership of capital invested in a country is  $(1 - \lambda)\theta + \lambda(1 - \theta)$ . This implies that, provided that there is home bias— $\lambda, \theta \in (0.5, 1.0]$ —the foreign ownership of capital invested in the Home country increases either because  $\lambda$  declines or because  $\theta$  declines.

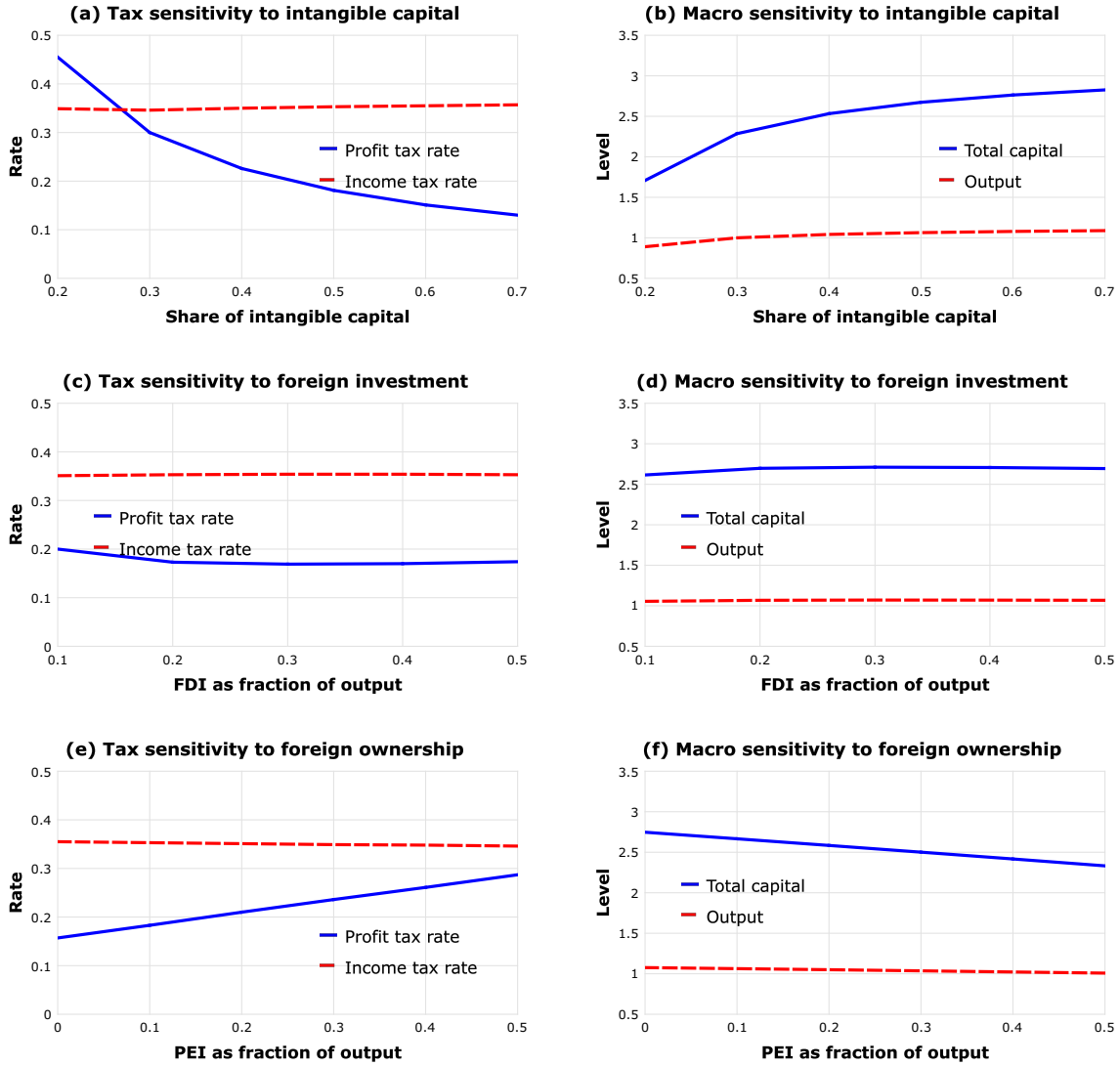


Figure 4: Steady state tax rates, capital and output for different shares of intangible capital (determined by  $\alpha$ ), foreign investments (determined by  $\lambda$ ), and foreign ownership of multinationals (determined by  $\theta$ ).

the values that target the 2020 moments. As we can see, the taxation of profits increases when a larger share of multinationals are owned by foreigners. This is because a larger share of profits earned in the country belong to foreigners, which increases the incentive of the local government to tax these profits. For example, when the value of multinationals owned by foreigners is 10% the value of domestic output, the profit tax rate is 18.3%. When the foreign ownership is 50%, the profit tax rate is 28.7%.

Overall, when we switch from the baseline calibration with  $\alpha = 0.3$ ,  $\lambda = 0.934$  and  $\theta = 0.978$  to the new calibration with  $\alpha = 0.5$ ,  $\lambda = 0.825$  and  $\theta = 0.781$ , the steady state

profit tax rate drops from 30% to 28.7%. This implies an increase in the steady state stock of capital of 2% and an increase in the steady state output of 0.8%. The change is not large but this is because the impact of the change in  $\alpha$  is counterbalanced by the change in financial globalization, especially through the change in  $\theta$ . In the next subsection we explore the welfare implications of these changes.

### 6.3 Transition dynamics and welfare

We are interested in the structural changes that took place during the last three decades, starting at the beginning of the 1990s. By then, international markets were highly integrated, at least among industrialized countries. We then assess the implications of the higher share of intangible capital and higher financial integration across countries as shown in Figures 1 and 2.

Simply focusing on steady states, the top panels of Figure 4 shows that, if the only change was the increase in the share of intangible capital from 30% to 50% (the respective values in 1990 and 2019), the profit tax rate would have dropped from 30% to 18%. This, in turn, would have generated an increase in the stock of capital of about 17%. At the same time, however, this period is characterized by a significant increase in foreign investments and foreign ownership of multinationals. Together with the increase in the stock of FDI (from 15% to 40% of output) and PEI (from 5% to 50% of output), the steady state tax rate drops from 30% to only 28.7% and the stock of capital increases only by 2%. We now show the transition dynamics that bring the economy to the new steady state.

Figure 5 shows the dynamics of tax rates, capital and output. Suppose that we start from a steady state with a share of intangible capital of  $\alpha = 0.3$ . The steady state capital is  $K + \hat{K} + X = 2.286$ . Starting from the steady state of the baseline model, the share of intangible capital changes unexpectedly from  $\alpha = 0.3$  to  $\alpha = 0.5$ , while  $\lambda$  and  $\theta$  remain constant at their baseline calibration values of 0.934 and 0.978, respectively. The transition dynamics are shown in the top two panels of Figure 5. The bottom panels plot the transition dynamics when also  $\lambda$  and  $\theta$  change to the new calibration values of 0.825 and 0.781, respectively. When only  $\alpha$  changes, the responses of taxes, capital and output are larger than the responses when all three parameters change. This is consistent with the steady state results shown in Figure 4.

We now ask whether the increased share of intangible capital and financial globalization were welfare improving. To answer this question we cannot compare steady states. Since the steady state capital in the economy with 30% intangible is lower (due to higher taxes), households' utility is likely to be lower than in the steady state with 50% intangible. But the higher capital needs to be accumulated by lowering current consumption. Therefore, to properly compute the welfare implications we need to take into account the transition shown in Figure 5.

Denote by  $\Omega(\mathbf{s}; \alpha, \lambda, \theta)$  the lifetime utility of households in the Home country for given constant values of  $\alpha, \lambda, \theta$ , and given initial states  $\mathbf{s}$ . We would like to compute the percentage change in every period consumption in the initial steady state that is necessary

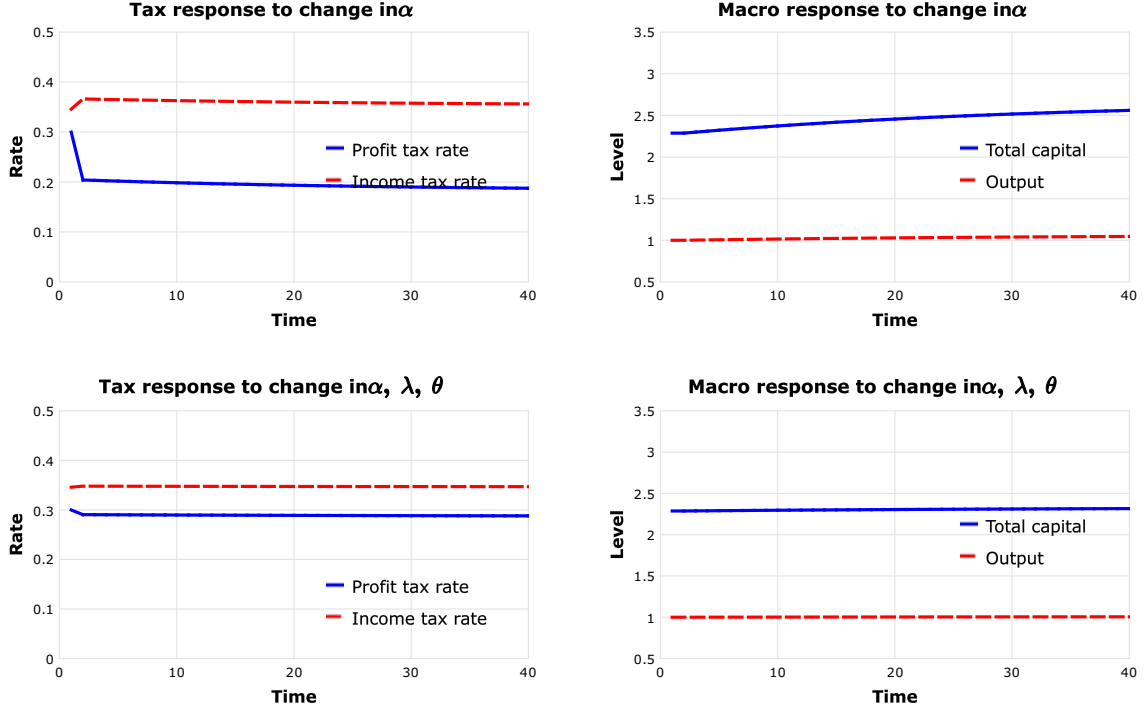


Figure 5: Dynamics of tax rates, capital and output in response to changes in  $\alpha$ ,  $\lambda$  and  $\theta$ .

to make households' utility equal to the utility in the transition equilibrium induced by the change in  $\alpha$ ,  $\lambda$  and  $\theta$ . Formally, we would like to compute the value of  $g$  that solves the equation,

$$(1 + g)^{1-\sigma} \Omega(\mathbf{s}_0; \alpha = 0.3, \lambda = 0.934, \theta = 0.978) = \Omega(\mathbf{s}_0; \alpha = 0.5, \lambda = 0.825, \theta = 0.781).$$

Here the vector  $\mathbf{s}_0 = (K_0, \hat{K}_0, X_0, K_0^*, \hat{K}_0^*, X_0^*, B_0)$  contains the states in the steady state equilibrium before the structural change.

After computing the values of  $\Omega(\mathbf{s}_0; \alpha = 0.3, \lambda = 0.934, \theta = 0.978)$  and  $\Omega(\mathbf{s}_0; \alpha = 0.5, \lambda = 0.825, \theta = 0.781)$ , we can solve the above equation for  $g$ . This represents the proportional increase in consumption that needs to be given to households living in the steady state with  $\alpha = 0.3$ ,  $\lambda = 0.934$  and  $\theta = 0.978$ , in order to make them indifferent between staying in that steady state equilibrium with the additional consumption or moving to a new economy with the same initial states but experiencing a transition.

The first panel of Figure 6 plots the welfare gains for changes in  $\alpha$  only, while  $\lambda$  and  $\theta$  remain at their baseline calibration values. The second panel plots the welfare gains induced by changes in  $\theta$ , when  $\alpha = 0.5$  and  $\lambda = 0.825$  from the beginning, that is, the new calibration values. The welfare gains increase with the share of intangible capital, but decline when the foreign ownership of multinationals increases. If we increase the value of foreign ownership as a fraction of output from 0.05 to 0.5 (keeping  $\alpha = 0.5$  and

$\lambda = 0.825$ ), the two countries experience a welfare loss of about 1% of consumption. However, if only the share of intangible capital changes from 0.3 to 0.5 while  $\lambda$  and  $\theta$  stay constant at 0.934 and 0.978, respectively, the two countries experience a welfare gain of 1% of consumption.

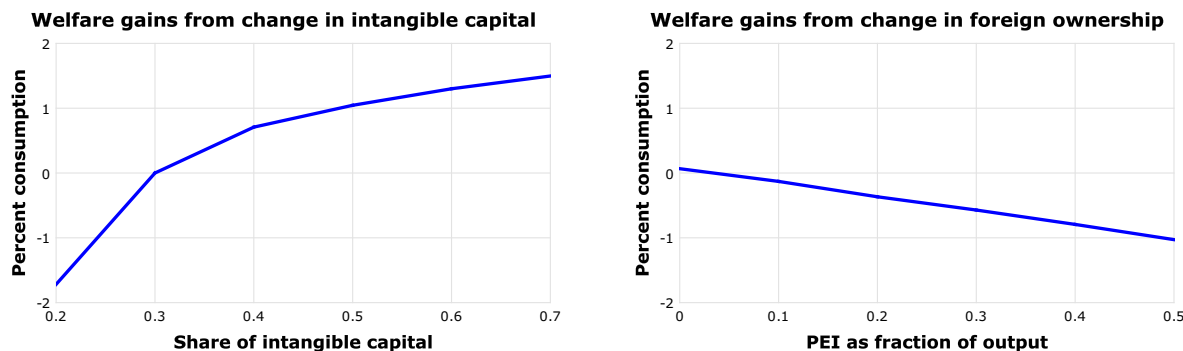


Figure 6: Welfare gains as functions of changes in  $\alpha$  and  $\theta$ .

Finally, when we combine the changes in  $\alpha$ ,  $\lambda$  and  $\theta$  from their baseline values (targeting the 1990 moments) to the new calibration values (targeting the 2020 moments), the welfare gain is 0.1% of consumption.

## 7 Inequality and taxation

The analysis conducted so far is based on a model where households are homogeneous. In that set up, the structure of taxes are chosen only on the basis of efficiency from the point of view of the local government. In reality, there is considerable heterogeneity and taxes play an important role for internal redistribution.<sup>3</sup>

If we lived in a world with homogeneous agents, it would be difficult to justify why we are concerned about low corporate taxes, besides efficiency considerations. However, the reality is that some households earn a larger share of income from capital, while other households earn a larger share of income from wages. Thus, a reduction in profit tax rates shifts the taxation burden away from the first category of households and toward the second category. The second category of households turn out to earn lower incomes on average. In addition to the direct redistributive impact of taxes, a change in their composition could have indirect effects through the general equilibrium: the change in prices could have heterogeneous impacts on the incomes of different groups of households

Extending the model with rich heterogeneity would make the characterization complex. However, it is possible to introduce some stylized heterogeneity that could capture the main redistributive channels discussed here (heterogeneous tax burdens and heterogeneous general equilibrium effects), while keeping the structure of the model tractable.

<sup>3</sup>In the model considered so far, taxes generate redistribution between Home and Foreign households if governments choose different tax rates. However, there is not internal redistribution within a country.

Suppose that in each country there are two types of agents. A measure  $\mu$  of agents have the same characteristics as the households in the representative-agent model studied so far. The remaining measure,  $1 - \mu$ , contains households that are hand-to-mouth and simply consume their wages. The first type earns both capital and labor incomes, while the second type earns only labor income. In this environment, taxes have a redistributive impact both directly and indirectly through general equilibrium effects.

The objective function of the Home government can now be written as

$$\max_{\tau} \left\{ \mu \tilde{\Omega}(\mathbf{s}, B, \tau, \tau^*; \Psi) + (1 - \mu) \tilde{U}(\mathbf{s}, \tau, \tau^*; \Psi) \right\}, \quad (35)$$

where  $\tilde{\Omega}(\mathbf{s}, B, \tau, \tau^*; \Psi)$  is the lifetime utility of households that participate in capital markets, earning both labor and capital incomes. We can derive this function by solving the previous household's problem (31). The function  $\tilde{U}(\mathbf{s}, \tau, \tau^*; \Psi)$ , instead, is the value for hand-to-mouth households, which we derive by solving the recursive functional equation

$$\begin{aligned} \tilde{U}(\mathbf{s}, \tau, \tau^*; \Psi) &= u(c) + \beta \tilde{U}(\mathbf{s}'; \Psi) \\ &\mathbf{s.t.} \\ c &= (1 - \phi)w + T, \\ \phi &= \tilde{\mathcal{B}}_{\phi}(\mathbf{s}, \tau, \tau^*; \Psi), \\ \mathbf{s}' &= \tilde{\Upsilon}(\mathbf{s}, \tau, \tau^*; \Psi), \end{aligned} \quad (36)$$

The Foreign government solves a similar problem,

$$\max_{\tau^*} \left\{ \mu \tilde{\Omega}^*(\mathbf{s}, -B, \tau, \tau^*; \Psi) + (1 - \mu) \tilde{U}^*(\mathbf{s}, \tau, \tau^*; \Psi) \right\}. \quad (37)$$

Equilibrium taxes are determined as the solution to the Nash game played by the two countries in the same way we defined it for the model with homogeneous households.

## 7.1 Equilibrium taxes with heterogeneous households

We explore the importance of heterogeneity focusing on the calibration that targets the most recent period. Thus, we set  $\alpha = 0.6$ ,  $\lambda = 0.825$  and  $\theta = 0.781$ . See last column of Table 1.

The first panel of Figure 7 plots the steady state tax rates as a function of the share of hand-to-mouth households,  $1 - \mu$ . This is a measure of inequality: When  $1 - \mu = 0$ , we go back to the representative agent model studied earlier. As we increase  $1 - \mu$ , capital incomes are earned by a smaller fraction of households. Thus, income disparity between hand-to-mouth households (with wage income only) and other households (with both wage and capital incomes) increases. The figure shows that higher inequality does not lead to large changes in equilibrium tax rates. Even when the share of hand-to-mouth households is 80% (so that capital incomes are earned only by 20% of households), the profit tax rate does not change much. In this case the per-capita pre-tax income of hand-to-mouth households is 0.6 while the per-capita pre-tax income of other households is 2.6.

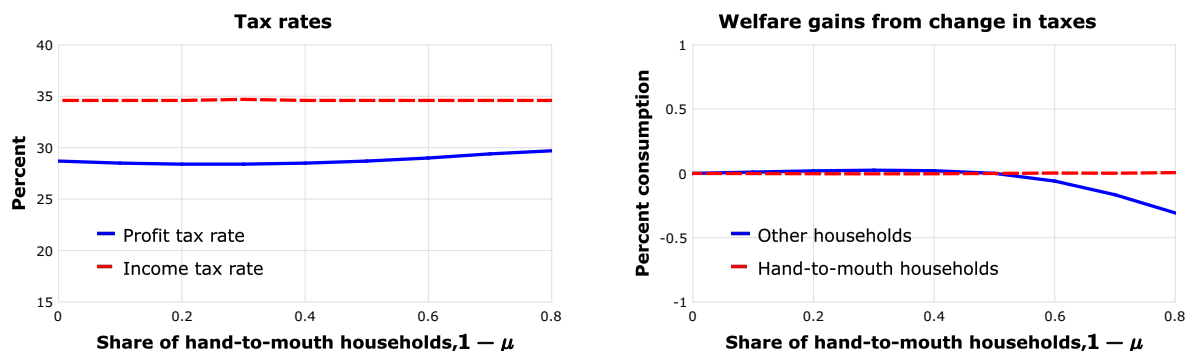


Figure 7: Taxes and welfare gains as a function of inequality  $1 - \mu$ .

The 20% of rich households earn an individual income that is 4.3 times bigger than the individual income of the remaining 80 percent of the population.

The finding that profit taxes are not very sensitive to inequality is somewhat surprising. To illustrate why, Figure 8 plots the utility values for other households (panels in first row) and hand-to-mouth households (panels in second row), when  $\mu = 0.3$ . The graphs show how current and continuation utilities for the two types of households change when the government of country 1 changes the profit tax rate. The current states and the profit tax rate of country 2 are at the steady state values with  $\mu = 0.3$ . The current utility of other households declines with a higher profit tax rate while the current utility of hand-to-mouth households is mostly increasing. At some point, however, the current utility of hand-to-mouth households starts declining because of the loss of revenues from taxing profits (tax shifting). The continuation utility is decreasing for both types of households. This is because higher profit taxes reduce the income of savers (other households) and, therefore, next period capital. Lower capital is harmful also for hand-to-mouth households since it will reduce future wages.

The last row of Figure 8 contains two graphs. The first is the government value as the weighted sum of the welfare of both types of households (other and hand-to-mouth). The maximum is reached at 28.7%. The last panel with the dashed line, instead, plots the value of the government if the size of other households was  $\mu = 1$  (no inequality). Notice that the states and the profit tax rate chosen by country 2 remain the same when we change  $\mu$ . As can be seen, in absence of inequality, the government's value in the plotted range decreases in the profit tax rate. Thus, it would choose a lower tax rate.

Although higher taxation of profits reduces the tax burden of poor households, the economy also experiences higher profit taxes in the future, which discourages capital accumulation. Lower accumulation of capital could be harmful to poor households because it reduces future wages. This is a consequence of the lack of policy commitment: because governments do not have the ability to commit to future policies and current taxes affect capital accumulation only marginally, the government chooses higher profit tax rates in every period.

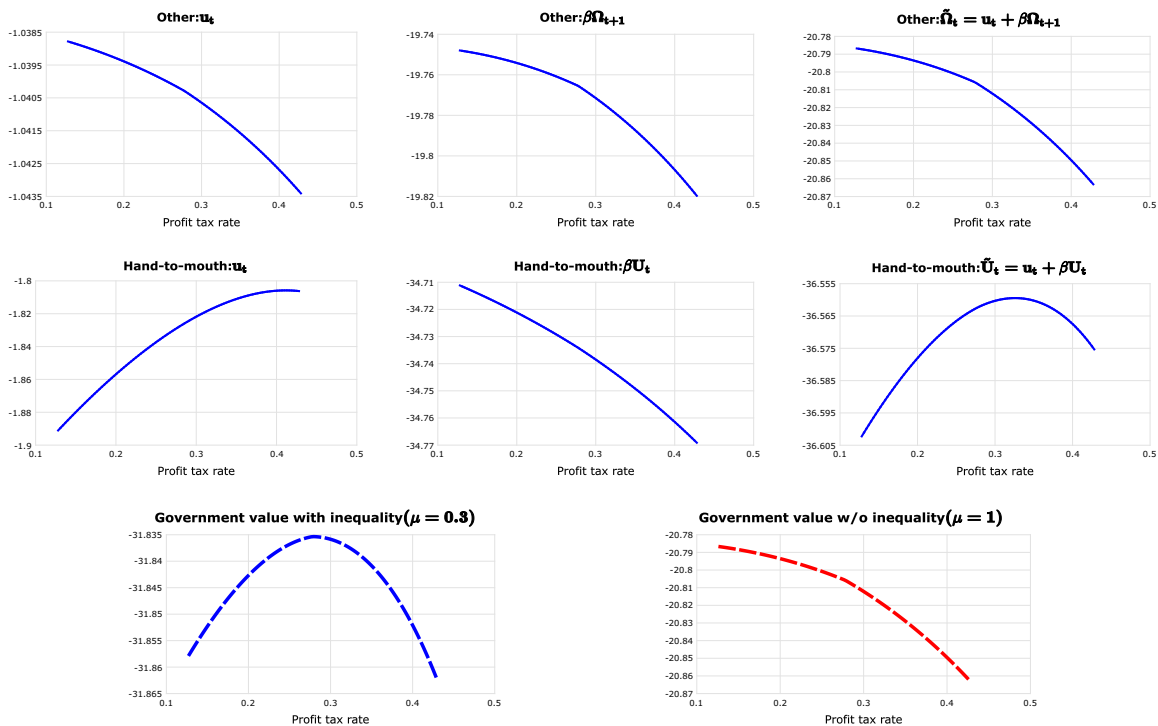


Figure 8: Households and government values as functions of the current profit tax rate when  $\mu = 0.3$ . Deviation from the steady state.

Is the higher taxation of profits induced by inequality welfare improving? On the one hand, higher profit taxes in the current period redistribute resources to agents with higher marginal utility of consumption (the poor). This should increase welfare for hand-to-mouth households. On the other, the lower accumulation of capital decreases future incomes, including wages, which is the only income earned by hand-to-mouth households. Therefore, it is not obvious whether the higher taxation of profits is necessarily welfare improving even for poor households.

The second panel of Figure 7 plots the welfare gains for different values of  $1 - \mu$  (the share of hand-to-mouth households). The welfare gains are computed by comparing two equilibria. The first is the steady state equilibrium for a particular value of  $1 - \mu$ , after imposing that the profit tax rate is set to the (endogenous) steady state value when  $1 - \mu = 0$  (representative agent model). The second is the transition equilibrium when, starting from the steady state just described, the government of the two countries choose the tax rates optimally but without coordination (Nash equilibrium policies). The welfare gains are calculated by comparing the utilities in these two equilibria, separately for hand-to-mouth households and for other households. A positive number means that the change in tax rates improves welfare. A negative number means that the endogenous change in tax rates reduces welfare.

Welfare gains are almost zero for moderate degrees of inequality. Only for large in-



equality they start to be sizable. In this case other households incur negative welfare gains (welfare losses), while hand-to-mouth households obtain a welfare gain which, compared to the losses experienced by other households, is quite small. The fact that hand-to-mouth households experience small welfare gains shows that the magnitudes of the two contrasting effects on the utility of hand-to-mouth households are similar. As already mentioned, an increase in current profit taxes is beneficial for hand-to-mouth households because it allows for lower taxation of wages. However, this also reduces capital accumulation which affects adversely their future wages.

## 7.2 Political bias and political myopia

The idea of a benevolent policy maker that weights equally all households is a frequent assumption in economic theory. In reality, however, a ruling government may weight certain groups differently from others. In this section we ask how the equilibrium outcome would change if households receive different political weights.

To address this question, we generalize the government objective to

$$\max_{\tau} \left\{ \rho \cdot \mu \cdot \tilde{\Omega}(\mathbf{s}, B, \tau, \tau^*; \Psi) + (2 - \rho) \cdot (1 - \mu) \cdot \tilde{U}(\mathbf{s}, \tau, \tau^*; \Psi) \right\}. \quad (38)$$

The new parameter  $\rho \in \{0, 2\}$  captures the differential weights used by the government in the choice of policies. When  $\rho = 1$ , the government weights equally hand-to-mouth households and other households, which is the case considered in the previous subsection. When  $\rho = 0$ , the government cares only about hand-to-mouth households while with  $\rho = 2$  the government cares only about other households.

We compare two cases. In the first case the government weights the two types of households equally, that is,  $\rho = 1$  (as before). In the second case, instead, the preferences of governments are tilted toward hand-to-mouth households (political bias). In the quantitative exercise we set  $\rho = 0.5$ . Thus, the weight assigned to hand-to-mouth households is  $1 - \rho = 1.5$ , which is three times the weight assigned to other households. The tax and welfare implications of the shift from  $\rho = 1$  to  $\rho = 0.5$  are shown in Figure 9.

The first panel plots the change in steady state tax rates induced by the change in  $\rho$ . For any positive share of hand-to-mouth households,  $1 - \mu$ , the change in profit tax rate is positive while the change in income tax rate is almost zero (very tiny decline in income tax rates). This was to be expected since hand-to-mouth households could benefit, at least in the short-term, from higher profit taxes. Then, by giving more weight to these households, the government prefers higher taxation of profits. The second panel plots the welfare gains for both types of households. We find that the shift in political weight toward hand-to-mouth households (lower  $\rho$ ) leads to sizable welfare losses for other households but relatively small gains, if any, for hand-to-mouth households.

Considering that the gains experienced by hand-to-mouth households are quite small, compared to the welfare losses experienced by other households, it may be surprising to see that governments choose to increase profit taxes. Remember that, even if governments assign more weight to hand-to-mouth households, other households are still part of the

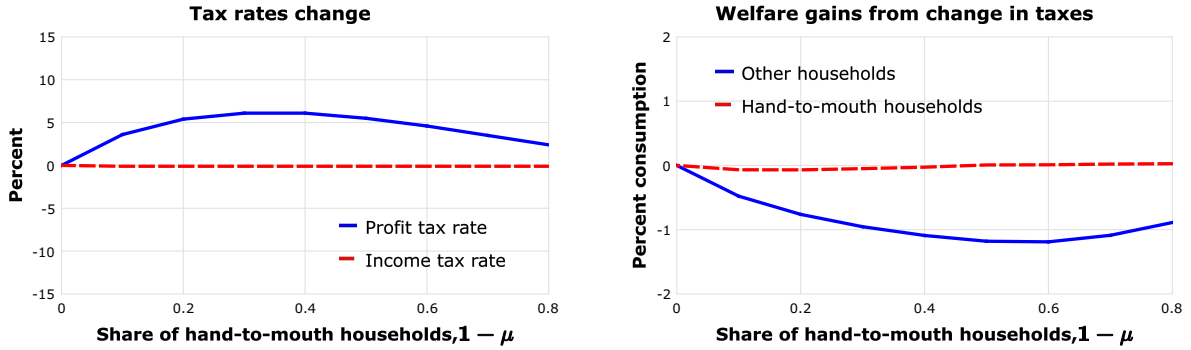


Figure 9: Change in profit tax rate and welfare gains when the government’s weight shifts toward hand-to-mouth households for different shares of hand-to-mouth households,  $1 - \mu$ .

government welfare. So why do governments choose policies that do not seem to bring benefits on average? Again, time inconsistency due to the lack of commitment is the key. The lack of commitment induces current governments to focus on the short-term effects of policies because they have limited impact on the decision of future governments. Since current policies have sizable effects on the ‘current’ utility of hand-to-mouth households, governments chooses higher taxation of profits.

The focus on the short-term effects of policies could also be the consequences of the political cycle that creates incentives for elected officials to direct their focus on short-term outcomes. According to this view, short-term results are essential for re-election. Sound policies that take longer to show their effects could be beneficial for the society as a whole. However, they are not very helpful for ruling politicians in search of re-election. This could lead to a form of policy myopia.<sup>4</sup> In our model this could further increase the taxation of profits.

To illustrate this point we assume that governments discount future outcomes more heavily than households. While the discount factor of households is  $\beta$ , the discount factor for the ruling government is  $\gamma\beta$ , with  $\gamma < 1$ . The problem solved by the government of the Home country can then be written as

$$\max_{\tau} \left\{ \mu \cdot \left[ u(\tilde{c}(\mathbf{s}, B, \tau, \tau^*; \Psi)) + \gamma\beta\Omega(\mathbf{s}, B'; \Psi) \right] + (1-\mu) \cdot \left[ u(\tilde{c}^{hm}(\mathbf{s}, \tau, \tau^*; \Psi)) + \gamma\beta U(\mathbf{s}; \Psi) \right] \right\}, \quad (39)$$

where  $\tilde{c}^{hm}(\cdot)$  is consumption for hand-to-mouth households and  $\tilde{c}(\cdot)$  is consumption for other households. The parameter  $\gamma < 1$  captures the fact that the government discounts next period values more heavily than households (policy myopia).

Figure 10 shows the change in tax rates (left panel) and welfare gains (right panel) when  $\gamma$  changes from 1 to 0.5. Policy myopia leads to higher taxation of profits and, as

<sup>4</sup>Here myopia does not mean irrationality. In fact, ruling governments behave fully rationally. It is just that the institutional environment encourages them to ‘rationally’ deviate from the socially optimal policies.

expected from the previous analysis, to welfare losses to other households. Importantly, the welfare gains for hand-to-mouth households are almost zero. The losses for other households induced by policy myopia become especially large when the fraction of hand-to-mouth households is large and, therefore, there is sizable income inequality.

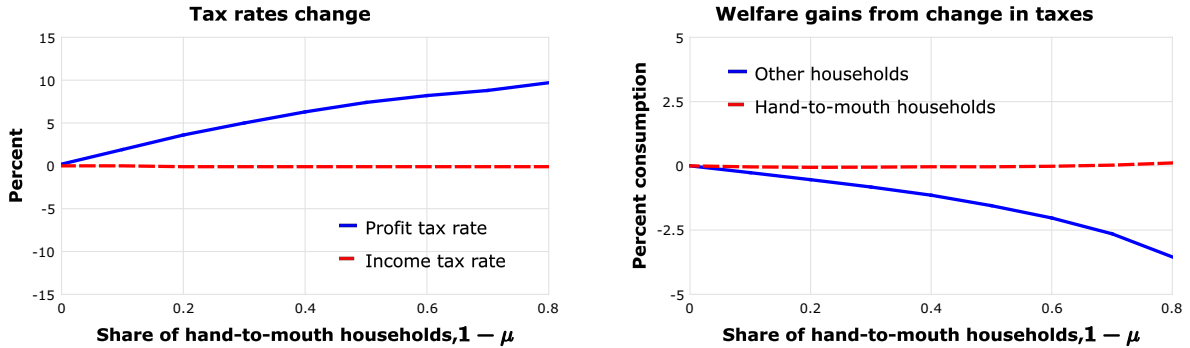


Figure 10: Change in profit tax rate and welfare gains when governments is myopic ( $\gamma = 0.5$ ), as a function of inequality  $1 - \mu$ .

## 8 Conclusion

We have studied the potential impact of two recent trends on international tax competition: (i) the growing role of intangible capital for production, and (ii) the cross-country diversification of investments. While the rise in intangible capital decreases the incentive of governments to tax profits, the rise in cross-country portfolio diversification has the opposite effect: it increases the incentive to tax profits. Given the popular view that financial globalization creates the conditions for stronger tax competition, the finding that international portfolio diversification increases the incentive to tax profits is unexpected. However, it has a simple intuition: when financial markets are more integrated, a larger share of profits earned in a country belong to foreigners, which enhances the government incentive to tax profits.

The quantitative exercise conducted with the calibrated model shows that the taxation impact of the first trend (intangible) has dominated slightly the impact of the second trend (financial globalization). Their combined effects led to a net decline in profit tax rates of 1.3 percent. The lower taxation of profits, in turn, stimulated capital accumulation and lead to a welfare gain of about 0.1 percent of consumption. These effects would be much larger if the increasing importance of intangible capital was not accompanied to the growth of financial globalization.

We have also studied a version of the model with households heterogeneous in the sources of income: some earn capital income (the rich) while others earn only wage income (the poor). In general, higher is the fraction of households for which wages is the primary source of income (the poor) and higher is the taxation of profits. This is especially true

when this type of households receive higher political weight or governments are impatient. However, the higher taxation of profits brings very limited benefits to poor households while it causes much larger losses to the rich.

# Appendix

## A Balance of Payments

Ignoring the cost of tax shifting, the following national accounting identities hold in the model:

$$\begin{aligned} Y_t &= C_t + I_t + \hat{I}_t^* + G_t + NX_t, \\ Y_t^* &= C_t^* + I_t^* + \hat{I}_t + G_t^* + NX_t^*. \end{aligned}$$

The variables  $Y_t$  and  $Y_t^*$  are gross domestic outputs in the two countries. The term  $I_t + \hat{I}_t^*$  is domestic investment in Home country (the investment made in the Home country by Home multinationals and Foreign multinationals) and  $I_t^* + \hat{I}_t$  is domestic investment in Foreign country (the investment made in the Foreign country by Foreign multinationals and Home multinationals).

The following identities also hold in the model:

$$\begin{aligned} Y_t + NFP_t &= C_t + I_t + \hat{I}_t^* + G_t + CA_t, \\ Y_t^* + NFP_t^* &= C_t^* + I_t^* + \hat{I}_t + G_t^* + CA_t^*, \end{aligned}$$

where  $NFP$  and  $NFP^*$  are Net Factor Payments in the two countries. They are defined as

$$\begin{aligned} NFP_t &= \theta \hat{\pi}_t (1 - \tau_t^*) + (1 - \theta) \pi_t^* (1 - \tau_t^*) - (1 - \theta) \pi_t (1 - \tau_t) - \theta \hat{\pi}_t^* (1 - \tau_t) + B_{t+1} - qt B_{t+1}, \\ NFP_t^* &= \theta \hat{\pi}_t^* (1 - \tau_t) + (1 - \theta) \pi_t (1 - \tau_t) - (1 - \theta) \pi_t^* (1 - \tau_t^*) - \theta \hat{\pi}_t (1 - \tau_t^*) + B_{t+1}^* - qt B_{t+1}^* \end{aligned}$$

Obviously,  $NFP_t + NFP_t^* = 0$  since  $B_{t+1} = -B_{t+1}^*$ .

Net exports can be derived from the first two equations:

$$\begin{aligned} NX_t &= Y_t - C_t - I_t - \hat{I}_t^* - G_t, \\ NX_t^* &= Y_t^* - C_t^* - I_t^* - \hat{I}_t - G_t^*. \end{aligned}$$

Finally, the current account is

$$\begin{aligned} CA_t &= NX_t + NFP_t, \\ CA_t^* &= NX_t^* + NFP_t^*. \end{aligned}$$

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