International tax competition with rising intangible capital and financial globalization

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Abstract

The last three decades has witnessed: (a) a rise in the share of intangible capital, and (b) an increase in cross-country ownership of assets (financial globalization). We study the significance of these trends for international tax competition within a two-country model, where governments choose profit and income tax rates without committing to future policies and without international coordination. Higher share of intangible capital has led to lower profit taxes, while increased financial globalization higher profit taxation with the first effect being larger. The combined effects yield a 6% reduction in profit the tax rate and 0.55% gains in welfare (accounting for the transition).

Keywords: International Tax Competition, Intangible Capital, Financial Globalization, Time Consistent Policies

JEL: E61, H25, F68

1. Introduction

A central principle in optimal taxation theory is that the tax rate on a particular source should depend on the elasticity with which that source responds to a change in the tax rate. Another principle is to tax sources over which the tax authority has no concerns. These two principles conflict in the context of the international determination of capital income tax rates where capital income earners include foreigners and where there is a concern for profit shifting in response to high profit taxes.

In this paper, we explore two major changes that could have affected governments' incentives 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 U.S. public companies from 1975 to 2019 as plotted in Eberly (2022), which uses two definitions of intangible capital from Compustat data (one includes capitalized estimates of Research and Development (R&D) expenses, while the other includes also

[⋆]We thank the attendants of the Carnegie Rochester NYU 2023 April Conference, our discussant Fabrizio Perri, our Editors George Alessandria and Michael Waugh as well as attendants at seminars at Wharton and ASU and Karen Lewis.

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capitalized estimates of Selling, General and Administrative (SG&A) expenses). 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 et al. (2022) and Crouzet et al. (2022).

The second major change 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. The left panels plot FDI and PEI as a percentage of GDP. The right panels in percentage of non-financial corporate equity. Independently of the re-scaling variable (GDP or corporate equity), the stocks of both assets and liabilities have increased substantially during the last thirty years. Since equity values have increased more than GDP over the sample period, the upward trend is smaller when we re-scale by equity. Still, even as a percentage of equity, the upward trend is quite large. 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 relevant for the taxation incentives studied in this paper. The net foreign asset positions, which for many countries are relatively small, are not as important as the gross positions.

Why are these two changes relevant for the governments' incentives to tax profit taxes? An important property of intangible 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 allocation of the cost may be irrelevant for global profits, it could be important for their taxation. In general, a multinational has an incentive to allocate larger shares of operating costs to subsidiaries located in countries with higher tax rates, provided that the multinational has the flexibility to do so. A feature of intangible capital is that it provides greater discretion on how to allocate its cost among various geographical operations. Because of this, a government that chooses to unilaterally raise the profit tax rate might end up collecting fewer tax revenues because multinationals respond by shifting taxable income to other (lower-tax) countries. This may dissuade governments from raising profit taxes and, potentially, set the conditions for a race to the bottom in international tax competition.

A major featuure of financial globalization is growing cross-country ownership of assets, and with it that a large share 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. Thus, higher cross-country ownership of assets could motivate governments to increase the taxation of capital incomes.

The above discussion emphasizes that the two trends shown in Figures 1 and 2 could have contrasting effects on the equilibrium taxation of profits: lower taxation of profits induced by the growing importance of intangible capital and higher taxation of profits induced by financial globalization. The question of what is their combined impact and whether they led to higher or lower taxation of profits is quantitative. V: [1]

To study this question we consider a two-country model with multinational firms that invest in two types of capital —tangible and intangible— and in two locations —domestic 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 (so we require time-consistency) and without policy coordination between the governments of the two countries (policy competition).

There are two forces that play an important role in the determination of the equilibrium taxation of profits. On the one hand, the lack of policy commitment could lead to high 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 anticipation of higher tax rates for the future discourages investments and leads to an equilibrium with a smaller stock of 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 total tax revenues collected by the country. Tax shifting creates a counterbalancing force to the temptation to tax capital, and might result in profit tax rates that are low (race-to-the-bottom). The size of the equilibrium taxation of profits then crucially depends on the relative importance of these two forces.

As the share of intangible capital and financial globalization increase, the relative importance of time-inconsistency and tax-shifting changes: the growing share of intangible capital makes the race-to-the-bottom more relevant because it enhances the tax-shifting ability of multinational companies while the increase in the international diversification of investments alleviates the race-to-the-bottom because governments have greater ability to tax foreigners. We explore these mechanisms quantitatively by calibrating 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 diversification observed during the last three decades affected equilibrium taxes and welfare.

We find that the increased share of intangible capital led to a significant decline in profit tax rates, while the increased cross-country diversification increased the profit tax rates. Because the impact of intangible capital was larger than the impact of diversification, the combined impacts resulted in a long run reduction in profit tax rates of 6% and. We further compute the transition (we trace the implied joint changes of tax rates, investments and consumptions that follow exogenous changes in the role of intangible capital and financial globaalization) and find that the consumption equivalent value of the average welfare gains are 0.55%. The reduction in the profit tax rate and the associated welfare gain would have been larger in absence of financial globalization, that is, no changes in cross-country asset ownership.

[1] 2017 Law changes

We also consider an extended version of the model that incorporates two types of heterogeneous households: those who solely earn labor income and those who earn both labor and capital income. 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. We find that, although inequality, political bias and political myopia all lead to higher profit tax rates, they do not bring significant welfare gains to poorer agents but they cause sizable welfare losses to wealthier agents. This begs the question of why representative governments would choose high tax rates when they are not welfare improving on average. The answer is, again, time-inconsistency: higher profit taxes do benefit poorer agents in the current period but harm them in the long run. Without commitment, governments place too much weight on current outcomes compared to future outcomes, resulting in lower generalized welfare.

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 et al. (1994), Judd (1987), Jones et al. (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 allocations. However, future taxes can discourage the accumulation of new capital, which is inefficient. Other studies re-examine the issue using richer models and show that the optimal taxation of capital could be positive also in the long-run. See, for example, Aiyagari (1995) and Golosov et al. (2003). But even if the optimal tax rate on capital were to 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. Another reason taxes on capital could be higher than what is implied by optimal taxation considerations 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 et al. (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 relevant. It is important then to extend these models in environments with multiple countries. An early contribution in this literature is Kehoe (1989) that 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 since 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 et al. (2005), Mendoza and Tesar (2003) and Quadrini (2005). A common feature of these papers is that tax competition affects the optimal choice of taxes, which in turn affects the allocation of savings. In our model, instead, the primary mechanism that discourages the taxation of capital is the discretion with which multinationals can allocate taxable income across their worldwide operations. What is central in our model is not that multinational firms can reallocate 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 done without making any changes in actual investment 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 this literature is that capital liberalization leads to lower taxation of capital, we show that this is not necessarily the case. The reason is that most contributions have considered the role of financial integration in facilitating the cross-country reallocation of capital and/or taxable income. But there is another dimension of financial globalization that has not been fully explored: 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.

Guvenen et al. (2022) studies the practices used by multinationals to shift profits abroad and the use of intangible capital to do so. Dyrda et al. (2023a) considers the possibility that multinational firms use profit shifting to reduce their tax bill when intangible capital is an important factor of production. Its goal 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 et al. (2023b), in this issue, characterizes the optimal taxation of multinationals in an environment with policy cooperation. While the analysis of their paper is *normative* in nature (the optimal taxation chosen by a global planner), our paper conducts a *positive* analysis to characterize equilibrium taxes when governments cannot coordinate their policies. Our paper is also related to the public finance literature on tax exportation (e.g. Huizinga and Nielsen (1997) and Noiset (2003)).

3. The model

There are two countries that are symmetric in technology and preferences. The first country is refered to as 'Home' the second as 'Foreign' and we use asterisks to indicate variables pertaining to the latter.

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 and the 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.

In each country, there is a measure 1 of competitive multinational firms headquartered in the country but operating in both countries: they produce intermediate goods both 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 respects. 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.

We assume that a fixed share θ of a Home multinational is owned by Home households and the remaining share $1-\theta$ is owned by Foreign households. Symmetrically, a share θ of a Foreign multinational is owned by Foreign households and the remaining share $1-\theta$ is owned by Home households. To simplify the analysis, these shares are exogenous in the model. We think of θ as being greater than 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

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

where $z, = \widehat{z}$ are productivity at home and abroad that we take to be equal. The variable x_t is the input of intangible capital which is nonrival and is used both at home and abroad. The variables k_t and $\widehat{k}_t$ are the inputs of tangible capital, while ℓ_t and $\widehat{\ell}_t$ 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

$$
\begin{aligned}
m_t^* &= F(x_t^*, k_t^*, \ell_t^*) = z\Big((x_t^*)^{\alpha} (k_t^*)^{1-\alpha}\Big)^{\nu} (\ell_t^*)^{1-\nu}, \\
\widehat{m}_t^* &= \widehat{F}(x_t^*, \widehat{k}_t^*, \widehat{\ell}_t^*) = \widehat{z}\Big((x_t^*)^{\alpha} (\widehat{k}_t^*)^{1-\alpha}\Big)^{\nu} (\widehat{\ell}_t^*)^{1-\nu}.
\end{aligned}
$$

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

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

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. Online Appendix A has the formal definition of the various components of the Balance of Payments.

Because intermediate inputs are imperfect substitutes, we 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 λ, which when greater than 0.5 displays investment home bias.

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 products, that is,

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

A key assumption is that multinationals have some discretion in the imputation of expenses associated with intangible capital. We do so by assuming that the total worldwide expenses associated with intangible capital must be equal to its actual depreciation which, for convenience, we set to the same rate as tangible capital δ. However, the multinational can choose the split between domestic and foreign operations. Denoting by ζ_t and $\widehat{\zeta}_t$ the depreciation rates chosen by the Home multinational domestically and abroad, they must satisfy $\zeta_t + \widehat{\zeta}_t = \delta$. As long as the sum of the two chosen rates is equal to δ, the Home multinational can choose different values of ζ_t and $\widehat{\zeta}_t$. For a Foreign multinational the constraint is $\zeta_t^* + \widehat{\zeta}_t^* = \delta$.

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 fined if deviating from the targeted rates without valid justification. The costs for the Home multinational in the domestic and abroad operations are, respectively,

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

The parameter λ 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 costs are zero. This will be the optimal choice when the two countries tax profits at the same rates. However, this will not be the case when the tax rates differ as we will see below. Parameter χ determines the ease with which depreciation can be shifted.

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

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

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,

$$\pi_t = q_t F(x_t, k_t, \ell_t) - w_t \ell_t - \Big[\zeta_t + \varphi(\zeta_t)\Big]x_t - \delta k_t, \tag{1}$$

$$\widehat{\pi}_t = \widehat{q}_t \widehat{F}(x_t, \widehat{k}_t, \widehat{\ell}_t) - w_t^* \widehat{\ell}_t - \Big[\widehat{\zeta}_t + \widehat{\varphi}(\widehat{\zeta}_t)\Big]x_t - \delta \widehat{k}_t, \tag{2}$$

$$\pi_t^* = q_t^* F(x_t^*, k_t^*, \ell_t^*) - w_t^* \ell_t^* - \Big[\zeta_t^* + \varphi(\zeta_t^*)\Big]x_t^* - \delta k_t^*, \tag{3}$$

$$\widehat{\pi}_t^* = \widehat{q}_t^* \widehat{F}(x_t, \widehat{k}_t^*, \widehat{\ell}_t^*) - w_t \widehat{\ell}_t^* - \Big[\widehat{\zeta}_t^* + \widehat{\varphi}(\widehat{\zeta}_t^*)\Big]x_t^* - \delta \widehat{k}_t^*. \tag{4}$$

The variable w_t is the wage in the Home country and w_t^* the wage in the Foreign country. The variables ζ_t, $\widehat{\zeta}_t$, ζ_t^*, $\widehat{\zeta}_t^*$ are the imputed unitary expenses associated with intangible capital (as described above) and δ 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 $\widehat{k}_t$. Similarly, the states of the Foreign multinational are x_t^*, k_t^* and $\widehat{k}_t^*$.

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,

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

Government:. Profits are taxed twice. They are first taxed where they are generated based on the 'source' principle: τ_t in the Home country and τ_t^* in the Foreign country. They are taxed again based on the 'residence' principle: ϕ_t by the Home country and ϕ_t^* by the Foreign country.

We refer to the source tax τ_t as 'profit' tax rate and to the residence tax ϕ_t as 'income' tax rate. The profit taxes paid by a Home multinational are

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

The first component 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

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

with the first component paid to the Home government while the second 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 its residents are

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

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

The income taxes collected by the Foreign government on the profits earned by its residents are

$$\phi_t^* \Big[\theta(1-\tau_t^*)\pi_t^* + \theta(1-\tau_t)\widehat{\pi}_t^* + (1-\theta)(1-\tau_t^*)\widehat{\pi}_t + (1-\theta)(1-\tau_t)\pi_t\Big],$$

note that this implies that net investment is made out of what is left after both taxes are paid.

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

$$\begin{aligned} G_t + T_t &= \tau_t\Big(\pi_t + \widehat{\pi}_t^*\Big) + \phi_t\Big[\theta(1-\tau_t)\pi_t + \theta(1-\tau_t^*)\widehat{\pi}_t + \\ &\qquad (1-\theta)(1-\tau_t)\widehat{\pi}_t^* + (1-\theta)(1-\tau_t^*)\pi_t^* + w_t\Big], \qquad (5) \\ G_t^* + T_t^* &= \tau_t^*\Big(\pi_t^* + \widehat{\pi}_t\Big) + \phi_t^*\Big[\theta(1-\tau_t^*)\pi_t^* + \theta(1-\tau_t)\widehat{\pi}_t^* + \\ &\qquad (1-\theta)(1-\tau_t^*)\widehat{\pi}_t + (1-\theta)(1-\tau_t)\pi_t + w_t^*\Big]. \qquad (6) \end{aligned}$$

4. Policy equilibrium

The governments of the two countries choose their policies by playing a non-cooperative game and they take into account how their choices affect equilibrium allocations. We look for Markov perfect equilibria and we take advantage of recursive methods to characterize the outcomes omitting time subscripts and using the prime sign to indicate next period variables. For this we need to establish the state of the economy. In this environment, the state is $\mathbf{s} = \{X, K, \widehat{K}, X^*, K^*, \widehat{K}^*, B\}$, this is, the representative multinationals capital holdings at the beginning of the period and the indebtedness of the Home households. Note that given the fixed nature of household's portfolios, this state vector implies the wealth of households can be obtained from this state.

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 $\Psi(\mathbf{s})$. 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 emerges in equilibrium.

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

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. Multinational'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. In the first problem given its own state $\{x, k, \widehat{k}\}$, and aggregate state $\mathbf{s}$, a firm headquartered in the Home country chooses ζ, $\widehat{\zeta}$, ℓ, and $\widehat{\ell}$ to solve

$$\begin{aligned} \max_{\zeta,\widehat{\zeta},\ell,\widehat{\ell}} \quad & \Big\{(1-\tau)\pi + (1-\tau^*)\widehat{\pi}\Big\}, \\ \text{s.t.} \quad & \zeta + \widehat{\zeta} = \delta. \end{aligned} \tag{7}$$

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. Domestic profits, π, are defined in (1); profits earned abroad, $\widehat{\pi}$, are defined in (2). The solution is characterized by the first order conditions

$$\Big[1 + \varphi_\zeta(\zeta)\Big](1-\tau) = \Big[1 + \widehat{\varphi}_\zeta(\widehat{\zeta})\Big](1-\tau^*), \tag{8}$$

$$q\ F_\ell(k, x, \ell) = w, \tag{9}$$

$$\widehat{q}\ \widehat{F}_\ell(\widehat{k}, x, \widehat{\ell}) = w^*, \tag{10}$$

where subscripts denote the relevant derivative.

Condition (8) is the optimal allocation of where to depreciate intangibles. The derivative of the cost function is $\varphi_\zeta(\zeta) = 2\chi(\zeta_t - \lambda\delta$, which implies that Condition (8) states that the deviation of ζ and $\widehat{\zeta}$ from their corresponding targets, $\lambda\delta$ and $(1-\lambda)\delta$ would be larger the larger the tax differential, where the sensitivity of ζ and $\widehat{\zeta}$ is determined by parameter χ. The shifting of the depreciation allowance introduces a mechanism for international tax competition. Conditions (9) and (10) determine the inputs of labor. They equate the marginal productivity to the wage rate in each country. The optimality conditions for a Foreign multinational are similar.

Even if higher profit taxes do not distort production in the current period, they can redistribute resources in favor of the domestic country because (partial) foreign ownership of both home and foreign multinationals means that the taxation of profits delivers revenue with no cost to the citizens for whom the government cares. These considerations imply that the government faces a trade off: increase the tax rates brings revenues from foreigners yet it reduces the tax base as multinationals shift their profits abroad.

When looking at the investment decision of multinationals we make a small notational change. We assume that multinationals themselves pay the income tax of their shareholders. This is just a notational change but it allows us to model multinationals as the decision makers of net investment and therefore we have a much simpler household problem. The problem of the multinational is

$$
\begin{aligned}
V(\mathbf{s}, x, k, \widehat{k}; \Psi) &= \max_{n,i,\widehat{i}} \left\{ d + \widetilde{R}^{-1}(\mathbf{s})\ V\left(\mathbf{s}'; x', k', \widehat{k}'; \Psi\right) \right\} && (11) \\
\text{s.t.} \qquad d &= (1-\bar{\phi})\left[(1-\tau)\pi + (1-\widehat{\tau})\widehat{\pi}\right] - n - i - \widehat{i}, && (12) \\
x' &= x + n, && (13) \\
k' &= k + i, && (14) \\
\widehat{k}' &= \widehat{k} + \widehat{i}, && (15) \\
\bar{\phi} &= \theta\phi + (1-\theta)\phi^*, && (16) \\
(\tau, \tau^*, \phi, \phi^*) &= \Psi(\mathbf{s}), && (17) \\
\mathbf{s}' &= \Upsilon(\mathbf{s}; \Psi). && (18)
\end{aligned}
$$

where $\bar{\phi} = \theta\phi + (1-\theta)\phi^*$, so variable d denotes the dividends net of income taxes . The objective of the firm is then to maximize the after tax present value of what its shareholders get on a per capita basis without country or origin bias suitably discounted by time varying $\widetilde{R}(\mathbf{s})$ (see below for its determination). Again Foreign multinationals behave symmetrically.

Variable n is net of depreciation investment in intangible capital while i and $\widehat{i}$ are net investments in tangible capital in Home and Foreign countries, respectively. Note that depreciation had already been subtracted. Finally, profits π and $\widehat{\pi}$ 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

$$\widetilde{R}^{-1}\left[1 + (1-\bar{\phi}')\left[(1-\tau')\frac{\partial \pi'}{\partial x'} + (1-\tau^{*\prime})\frac{\partial \widehat{\pi}'}{\partial x'} - \varphi(\zeta')\right]\right] = 1, \tag{19}$$

$$\widetilde{R}^{-1}\left[1 + (1-\bar{\phi}')(1-\tau')\frac{\partial \pi'}{\partial k'}\right] = 1, \tag{20}$$

$$\widetilde{R}^{-1}\left[1 + (1-\bar{\phi}')(1-\tau^{*\prime})\frac{\partial \widehat{\pi}'}{\partial \widehat{k}'}\right] = 1. \tag{21}$$

Higher values of the interest rate used by firms $\widetilde{R}$ require higher marginal productivity of capital, both intangible and tangible. Higher future tax rates on profits, τ' and $\tau^{*\prime}$, and income, ϕ', will be associated with higher marginal productivity of capital and, therefore, lower investment. A property that follows from Equations (19–21) is

Lemma 4.1. *If $\tau = \tau^*$, the next period share of intangible capital is α.*

If the profit tax rates differ in the two countries, the share of intangible capital is not α, but in symmetric steady states they will be.

4.1.2. Household's problem

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

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

Households earn wages, and receive dividends, θd paid by Home multinationals and $(1-\theta)d^*$ by Foreign multinationals. Note that consistent with our notation, dividends in the budget constraint are after income tax while wages are before tax. Households 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.[2] The intertemporal first order condition is

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

which provides us with an expression to derive the bond price p. Obviously, foreign households have the corresponding condition. 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, $\beta u_c(c')$.

The bond price has a close connection with the interest rate used by firms to discount future dividends. 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 θ of dividends) and $(1-\theta)u_c(c^*)$ for Foreign shareholders. Thus, the total value of one unit of dividends is

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

[2] Since the current tax rates depends on the taxed interests on bonds earned today but 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 significant complication for the numerical computation of the equilibrium.

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

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

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

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

This shows that Home multinationals use interest rate equal to

$$\widetilde{R} = \frac{\theta u_c(c) + (1-\theta)u_c(c^*)}{\beta\Big(\theta u_c(c') + (1-\theta)u_c(c^{*\prime})\Big)}. \tag{26}$$

But this is just $1/p$. To see this, take the households' first order conditions, multiply that of the home households by by θ and that of the foreign households second equation by $1-\theta$, add them together and re-arrange to obtain

$$p = \frac{\beta\Big(\theta u_c(c') + (1-\theta)u_c(c^{*\prime})\Big)}{\theta u_c(c) + (1-\theta)u_c(c^*)} = \frac{1}{\widetilde{R}}. \tag{27}$$

A formal definition of equilibrium for given policy rules is provided in Appendix B.

4.2. Determination of policies

When governments choose the current tax rates —τ and ϕ in the Home country, and τ^* and ϕ^* in the Foreign country— they take as given the rule that determines future policies, that is, function Ψ. Furthermore, each government takes as given the policy variables of the other country. Effectively, a government chooses only the profit tax rate, τ or τ^*, because the income tax rate, ϕ or ϕ^*, will be determined endogenously by the budget constraint of the governments. By the same token, each government takes as given only the profit tax rate of the other country, with the government budget constraint of the other country determining its income tax rate.

We define first the equilibrium when current policies are arbitrarily given and future policies are determined by Ψ. The problem solved by a multinational firm headquartered in the Home country is

$$\begin{aligned}
\widetilde{V}\Big(\mathbf{s}, x, k, \widehat{k}, \tau, \tau^*; \Psi\Big) &= \max_{\zeta, l, \widehat{\ell}, n, i, \widehat{i}} \left\{ d + pV\left(\mathbf{s}', x', k', \widehat{k}'; \Psi\right) \right\} \\
&\quad \textbf{s.t.} \\
d &= (1-\bar{\phi})\Big[(1-\tau)\pi + (1-\tau^*)\widehat{\pi}\Big] - n - i - \widehat{i}, \\
x' &= x + n, \\
k' &= k + i,
\end{aligned} \tag{28}$$

$$
\begin{aligned}
\widehat{k}' &= \widehat{k} + \widehat{i}, \\
(\phi, \phi^*) &= \widetilde{\mathcal{B}}(\mathbf{s}; \tau, \tau^*) \\
\bar{\phi} &= \theta\phi + (1-\theta)\phi^* \\
\mathbf{s}' &= \widetilde{\Upsilon}(\mathbf{s}, \tau, \tau^*; \Psi).
\end{aligned}
$$

Next period's value function is for given policy rule Ψ as defined it in the previous section. For the current period, instead, the value function has the current policies τ, τ^* as explicit arguments. Function $\widetilde{\mathcal{B}}(\mathbf{s}; \tau, \tau^*)$ is compact notation that uses the government budget constraints. All functions that depend on current policies τ and τ^* are denoted with a tilde sign to distinguish them from the analogous functions where policies are determined by the policy rule Ψ.

The problem solved by households in the Home country is

$$
\begin{aligned}
\widetilde{\Omega}(\mathbf{s}, b, \tau, \tau^*; \Psi) &= \max_{c, b'} \left\{ u(c) + \beta \; \Omega\left(\mathbf{s}', b'; \Psi\right) \right\} \qquad (29) \\
& \quad \textbf{s.t.} \\
c &= (1-\phi)w + \theta d + (1-\theta)d^* + T + b - pb', \\
\phi &= \widetilde{\mathcal{B}}^{\phi}(\mathbf{s}, \tau, \tau^*; \Psi), \\
\mathbf{s}' &= \widetilde{\Upsilon}(\mathbf{s}, \tau, \tau^*; \Psi),
\end{aligned}
$$

with the continuation value defined in the previous section. The definition of the equilibrium for given current policies, τ and τ^*, 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 τ to maximize the welfare of the representative resident households, that is, the function $\widetilde{\Omega}(\mathbf{s}, B(\mathbf{s}), \tau, \tau^*; \mathbf{\Psi})$, where $B(\mathbf{s})$ is the bonds held by the Home residents, the last component of $\mathbf{s}$. The problem solved by the Home government is

$$
\max_{\tau} \;\; \widetilde{\Omega}\Big(\mathbf{s}, B(\mathbf{s}), \tau, \tau^*; \mathbf{\Psi}\Big). \qquad (30)
$$

The solution is function $h(\mathbf{s}; \tau^*, \Psi)$ that returns the optimal profit tax rate τ as a function of the profit tax rate chosen by the Foreign government τ^* (in addition to be a function of the aggregate states). The problem solved by the Foreign government is similar using $\widetilde{\Omega}$ and $-B(\mathbf{s})$ instead of Ω and $B(\mathbf{s})$ with solution $h^*(\mathbf{s}; \tau, \Psi)$.

Definition 4.1 (Nash one-step equilibrium). *Given states* $\mathbf{s}$ *and policy rule* Ψ *determining future policies, a Nash one-step equilibrium is a pair* τ *and* τ^* *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 4.2 (Time-consistency). *The equilibrium time-consistent policy rule satisfies* $\Psi(\mathbf{s}) = \psi(\mathbf{s}; \Psi)$.

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

5. Policy Coordination

Policy coordination is the result of joint choices to determine todays' tax rates. Further, we asume that the governments weight the welfare of their residents equally. We also pose a lack of commitment to future policies. The objective of the coordinating governments is

$$\max_{\tau} \left\{ \widetilde{\Omega}\Big(\mathbf{s}, B(\mathbf{s}), \tau, \tau; \Psi\Big) + \widetilde{\Omega}^{*}\Big(\mathbf{s}, -B(\mathbf{s}), \tau, \tau; \Psi\Big) \right\}. \tag{31}$$

When both countries have the same state the overall level of taxation is determinate but the specific policies are not. This is because, with inelastic labor supply, neither taxes are distortionary and taxing foreigners is no longer a concern. Because the coordinated time-consistent policy is indeterminate, 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. Perhaps it is better to think of coordination as some form of agreement to make it more symmetrically difficult to switch profits abroad or to limit the taxation of foreigners.

6. Quantitative Analysis

We now turn to the main question in this paper: How has the increased role of intangible capital and cross-country investments affected equilibrium taxes? To answer 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 α, the quantitative exercise compares equilibria with low value of α (inducing low shares of intangible capital like in the early 1990s) to a higher value of α (inducing high shares of intangible capital like in the 2000s). To capture the importance of financial globalization we compare equilibria with high values of λ and θ (low shares of foreign investments and ownership like in the early 1990s) to lower values of λ and θ (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 had 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 follow the typical approach in the literature: an after tax rate of return of 5% (implying a discount factor $\beta = 0.95$), a curvature of the utility function of $\sigma = 2$, a share of capital in production (sum of tangible and intangible) to $\nu = 0.4$, and a common depreciation rate to $\delta = 0.06$.

We set the share of intangible capital to 30% 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) which implies $\alpha = 0.3$. We then compare the early 1990s to the last year of data available, 2019, where the average of the two series was about 50%.

The parameter λ 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. For the main exercise we target FDI (and PEI) as a percentage of GDP. Later, however, we will show how the main results change if we target FDI (and PEI) as a percentage of corporate equity. As shown in the first panel of Figure 2, the average value of FDI as a percentage of GDP among industrialized countries was about 15%. Thus, we choose λ so that in the steady state the value of capital invested abroad is 15% the value of final output (implying $\lambda = .934$. In terms of model's notation, capital invested abroad is $(1-\lambda)x + \widehat{k}$ and final output is y.

An issue associated with changing the values of α and λ 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 α and λ. To circumvent this issue, we assume that productivities in intermediate production are functions of these two parameters according to the following formulas

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

With this specification, if the profit tax rates chosen by the two countries do not change, steady state output and consumption are independent of α and λ. Therefore, the real effects induced by a change in α or λ 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).

To specify the domestic ownership share of multinationals, we use data on Portfolio Equity Investment as a percentage of GDP as shown in the bottom section 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 θ so that the steady state value of capital held by foreigners in a multinational, $(1-\theta)(k + \widehat{k} + x)$, is 5% of the value of final output, y. 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 θ 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 α, λ and θ, 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 χ, that is, the cost of tax shifting. Higher values of χ 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 χ by targeting an equilibrium profit tax rate of 30%, that is, $\tau = \tau^* = 0.3$.[3] Given our choices, this is the only parameter that requires us to solve the whole model to find its value. We use an iterative procedure: we guess χ, solve for the steady state equilibrium associated with that guess, and then we verify whether the equilibrium tax rate is $\tau = \tau^* = 0.3$.

We compare the equilibrium in the baseline calibration to the equilibrium with new values of α, λ and θ. 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 50%. The values of λ and θ are chosen so that the stock of FDI and PEI in 2020 are, respectively, 70% and 50% the value of GDP for industrialized countries. These numbers correspond to the approximate values shown in the two left panels of Figure 2. The full set of parameter values are reported in the top panel of Table 1a.

6.2. *Steady state comparisons*

The steady state allocation of the baseline calibration of α, λ and θ, based on data for the beginning of the 1990s and those of the steady state of the economy with the new calibration of α, λ and θ based on more recent data are reported in Table 1b. The profit rate that was 30% in 1990 becomes 24% after the changes, a 20% adrop. The income tax rate increases but only slightly (the larger tax base of the income tax relative to the profit taz and the higher stock of capital in the new steady state accounts for this small increase –recall that government expenditures are exogenously fixed). Output increases because the stock

[3] This is not exactly the system in the U.S. were there was an important corporate tax change in the US in 2017. The tax rate was cut from 35% to 21.5%. Also, prior to 2017 there was a requirement for US corporations to pay U.S. taxes after paying taxes abroad that made these corporations not bring back those profits. This provision was largely abolished in 2017. Also there were some changes in 2015 that difficulted profit shifting for tax purposes through the so-called "BEAT" (Base Erosion Anti-abuse Tax"). We take the 30% target as an average over most developed countries, and given our findings below, we take the 2017 corporate tax changes in the U.S. as roughly in line with the predictions of our theory.

of capital rises from 2.287 to 2.487. Recall the logic of the policy maker, it wants to tax nondistortionarily, which under its point of view includes existing, installed capital and wants to tax others, this is foreigners. The increase in intangible capital makes taxing profits distortionary because profits can be shifted abroad, while the increase in foreign ownership of assets makes taxing profits more attractive. To see this in more detail, we now conduct a sensitivity analysis for the three parameters α, λ, and θ.

We first change the share of intangible capital α from 0.2 to 0.7, with increments of 0.1 (recall that, given our specification of productivities, if the tax rates do not change in the two countries, steady state production and consumption will not change either,[4] any change in capital, output and consumption change is only a consequence of the change in tax rates.

The top panels of Figure 3 plot steady-state tax rates, capital and output for different shares of intangible α. The increase in the share of intangible leads to a decline in the profit tax rate τ and a slight increase in the income tax rate. The income tax rate increases only slightly, despite the sizable drop in profit taxes, because the stock of capital and the tax base rise. In fact, panel (b) shows that total capital and output increase significantly with α. Going from a share of intangible of 20% to a share of 70%, the stock of capital increases by 65% while output increases by 22%.

The middle panels of Figure 3 plot the sensitivity to the share of domestic inputs in final production, the parameter λ. There is not a sizable impact on the equilibrium tax rates, which at first may appear 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 these profits are generated by foreign multinationals. On the other, as we decrease λ, the cost of tax shifting also changes. The chosen specification of this cost implies that the overall cost of deviating from the targeted allocation of intangible depreciation decreases as λ 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 and, as a result, the equilibrium tax rates change only slightly.

The bottom panels of Figure 3 show the sensitivity to the foreign ownership of multinationals, parameter θ. 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 θ is only the ownership of domestic multinationals, not the effective domestic ownership of capital invested in a country.[5]

[4] This is because intangible and tangible capital depreciate at the same rate, productivities are re-scaled when α changes, and incomes generated by the two types of capital are taxed at the same rates.

[5] 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

The sensitivity to θ is constructed using $\alpha = 0.5$ and $\lambda = 0.694$, that is, 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 19.4%. When the foreign ownership is 50%, the profit tax rate is 24%.

Overall, when we switch from the baseline calibration with $\alpha = 0.3$, $\lambda = 0.934$ and $\theta = 0.978$ to the new calibration with $\alpha = 0.5$, $\lambda = 0.694$ and $\theta = 0.781$, the steady state profit tax rate drops from 30% to 24%. This implies an increase in the steady state stock of capital of 8.7% and an increase in the steady state output of 3.4%. In the next subsection we explore the welfare implications of these changes.

6.3. Transition dynamics and welfare

What happens when suddenly (starting in the initial steady state that we associate with 1990) the world changes and the increase of the role of intangibles and financial globalization occurs? Figure 4 shows the dynamics of tax rates, capital and output of such exercise. The top two panels describe the process with only the increase of the role of intangibles and the bottom panels with all changes. We see that the an increase in the role of intangiles immediatele reduces the profit tax rates and increases the income tax rates, more without financial globalization. This leads to a prolonged increase in capital and hence in output that takes many periods that is accompanied by a reduction in tax rates as the tax bases get larger and lower tax rates permit the payment of government expenses. This accumulation is almost sufficient to return the income tax rate to its initial level.

Welfare analysis also require the computation of the transition as steady-state comparisons yield not only tax differences but also capital differences and a comparison of consumption across them tells us about both outcomes and wealth levels, to the point that bad policies can look good because they are associated to more capital. Welfare analysis thus requires comparisons that share the *same* initial conditions and this requires the computation of the transitional dynamics that result from being in the steady state of the baseline economy and suddenly facing new values for parameters α, λ and θ.

To obtain a suitable welfare measure, denote by $\Omega(\mathbf{s}; \alpha, \lambda, \theta)$ the lifetime utility of households in the Home country for given constant values of α, λ, θ, 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 to make households' utility equal to the utility in the transition equilibrium induced by changes in α, λ and θ.

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 λ declines or because θ declines.

Formally, we would like to compute the value of g that solves the following equation,

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

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

The first panel of Figure 5 plots the welfare gains for changes in α only, while λ and θ remain at their baseline calibration values. The second panel plots the welfare gains induced by changes in θ, when $\alpha=0.5$ and $\lambda=0.694$, that is, the new calibration values, compared to the case in which PEI is 5% the value of output. 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 $\lambda=0.694$), the two countries experience a welfare loss of about 0.5% of consumption. However, if only the share of intangible capital changes from 0.3 to 0.5 while λ and θ stay constant at 0.934 and 0.978, respectively, the two countries experience a welfare gain of 1.3% of consumption. Finally, when we combine the changes in α, λ and θ from their baseline values (targeting the 1990 moments) to the new calibration values (targeting the 2020 moments), the welfare gain is 0.55% of consumption (also reported in Table 1c).

7. Inequality and taxation

The analysis conducted so far is based on a model where households are homogeneous. In that setup, 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.[6]

If we lived in a world with little inequality, it would be difficult to justify why we are concerned about low corporate taxes, besides efficiency considerations. In the real world, however, 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 group of households and towards the second. On average, the second group of households earn lower total incomes. In addition to the direct redistributive impact of taxes, a change in the composition of taxes could have indirect effects through general equilibrium: the change in prices could also have heterogeneous impacts on the incomes of different households. Extending the model to accommodate rich heterogeneity would make the characterization extremely 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.

[6]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 households. A measure μ of households have the same characteristics as those 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 (and, again, similarly for the Foreign) government can now be written as

$$\max_{\tau} \left\{ \mu \widetilde{\Omega}\Big(\mathbf{s}, B, \tau, \tau^*; \Psi\Big) + (1-\mu)\widetilde{U}\Big(\mathbf{s}, \tau, \tau^*; \Psi\Big) \right\}, \tag{32}$$

where $\widetilde{\Omega}(\mathbf{s}, B, \tau, \tau^*; \Psi)$ 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 problem (29). The function $\widetilde{U}(\mathbf{s}, \tau, \tau^*; \Psi)$, instead, is the lifetime utility of hand-to-mouth households, which we derive by solving the recursive functional equation

$$\begin{aligned} \widetilde{U}(\mathbf{s}, \tau, \tau^*; \Psi) &= u(c) + \beta \widetilde{U}\Big(\mathbf{s}'; \Psi\Big) \\ \text{s.t.} \qquad c &= (1-\phi)w + T, \\ \phi &= \widetilde{\mathcal{B}}_{\phi}(\mathbf{s}, \tau, \tau^*; \Psi), \\ \mathbf{s}' &= \widetilde{\Upsilon}(\mathbf{s}, \tau, \tau^*; \Psi), \end{aligned} \tag{33}$$

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 $\alpha = 0.5$, $\lambda = 0.694$ and $\theta = 0.781$.

Panel a in Figure 7 plots the steady state tax rates as a function of the share of hand-to-mouth households, $1-\mu$, which 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 pre-tax per-capita income of hand-to-mouth households is 0.6 while the pre-tax per-capita income of other households is 2.6. The 20% of rich households earn, individually, an income that is 4.3 times bigger than the income earned by the remaining 80% of the population.

The finding that profit taxes are not very sensitive to inequality is somewhat surprising. To illustrate why, Figure 6 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 lowers future wages.

The last row of Figure 6 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 25%. 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 μ. 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.

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. Because of these two effects, it is not obvious whether the higher taxation of profits is necessarily welfare improving, even for poor households.

Panel b of Figure 7 plots the welfare gains for different values of $1 - \mu$ (the share of hand-to-mouth households) which 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 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 indicates 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 inequality they start to be sizable. In this case other households incur negative welfare gains (welfare losses), while hand-to-mouth households experience 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 offset each others. 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, one that favors equalitarian outcomes because of the concavity of utility functions. Yet, a ruling government may weight certain groups more than others. We now explore the implications of such asymmetry. We generalize the government objective to

$$\max_{\tau} \quad \left\{ \rho \cdot \mu \cdot \widetilde{\Omega}\Big(\mathbf{s}, B, \tau, \tau^*; \Psi\Big) + (2-\rho) \cdot (1-\mu) \cdot \widetilde{U}\Big(\mathbf{s}, \tau, \tau^*; \Psi\Big) \right\}. \tag{34}$$

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 previously. When $\rho = 0$, the government cares only about hand-to-mouth households while with $\rho = 2$ it 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 government's preferences 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 panels c and d of Figure 7. Panel c plots the change in steady state tax rates. For any share of hand-to-mouth households, $1 - \mu$, the profit tax rate increases compared to the baseline case with $\rho = 1$. 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 a higher taxation of profits. Panel d plots the welfare gains for both types of households. We find that the shift in political weight toward hand-to-mouth households (smaller ρ) leads to sizable welfare losses for other households but it has insignificant welfare consequences for hand-to-mouth households.

Considering that the gains experienced by hand-to-mouth households are insignificant compared to the welfare losses experienced by other households, it may be surprising to see that governments choose higher profit taxes. Remember that, even if governments assign more weight to hand-to-mouth households, other households are still part of the government welfare. So why do governments choose policies that do not seem to bring benefits on average? Again, time inconsistency 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. But the market anticipates that this will be done also in the future. As a result, investments drop and both types of agent will experience welfare losses in the future.

The focus on the short-term effects of policies could also be the consequence of elected officials having a shorter horizon (a heavier discount of the future). 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 society as a whole, but they do not help ruling politicians looking for re-election. This could lead to a form of policy myopia that could further increase the taxation of profits.[7].

To explore this case we assume that governments discount the future more heavily than households, at rate $\gamma\beta$, with $\gamma < 1$. The problem solved by the government of the Home country is then

$$\max_{\tau} \left\{ \mu \cdot \left[u\Big(\tilde{c}(\mathbf{s}, B, \tau, \tau^*; \Psi)\Big) + \gamma\beta\Omega(\mathbf{s}, B'; \Psi) \right] + (1-\mu) \cdot \left[u\Big(\tilde{c}^{hm}(\mathbf{s}, \tau, \tau^*; \Psi)\Big) + \gamma\beta U(\mathbf{s}; \Psi) \right] \right\}. \quad (35)$$

The variable $\tilde{c}^{hm}(.)$ is consumption for hand-to-mouth households and $\tilde{c}(.)$ 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).

Panels e and f of Figure 7 show the change in tax rates (left) and the welfare gains (right) when γ changes from 1 to 0.5. Policy myopia leads to higher taxation of profits and, as expected from the previous analysis, to welfare losses for 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.

8. Robustness

We now conduct two robustness exercises. First we use the FDI and PEI as a percentage of corporate equity to calibrate the model. In the second we consider alternative specifications for the cost of tax shifting.

8.1. International financial holdings over equity

In Figure 2 we have shown the process of financial integration by plotting the Foreign Direct Investments and Portfolio Equity Investments as a percentage of GDP as well as a percentage of equity of non-financial corporations. Although the trend is clearly visible independently of the re-scaling variable (GDP or Equity), the upward trend is smaller when we normalize by Equity. This is because during the last three decades, the stock market valuation has increased more than GDP. Since we used the trends in FDI and PEI to calculate the model, the choice of one or the other could affect the quantitative results.

[7] Here myopia does not mean irrationality. In fact, ruling governments are fully rational. It is just that the institutional environment encourages them to 'rationally' deviate from the socially optimal policies.

For the purpose of taxation, what matters is the share of income generated domestically but paid to foreigners. To the extent that the increase in equity valuation was accompanied to an increase in the share of capital income, the use of GDP as a re-scaling factor could be more suitable. Suppose, for example, that the share of capital owned by foreigners does not change but the valuation of capital increases relatively to GDP. This implies that the ratios of FDI and PEI over capital would not change. If the higher valuation of capital is associated with higher corporate profits, a larger share of income is paid to foreigners. This will increase the incentive to tax profits.

Although there is clear evidence that the share of capital income (and profits) has increased during the last few decades, this may not be enough to explain the increase in the value of corporations. Because of this, we now show how the main quantitative results would change if we use FDI and PEI over Equity. We continue to calibrate the baseline model in the early 1990s so that FDI and PEI are, respectively, 15% and 5% the value of output. However, the target for 2020 will be, respectively, 30% and 20%. This is consistent with the trend displayed by the right panels of Figure 2 where the variables were in percentage of Equity. In the quantitative exercises conducted earlier, instead, the targets for 2020 were significantly higher: 40% and 50%, respectively. The steady state variables are reported in the third column of Table 1b. The effects are similar to the baseline.

8.2. Cost of tax shifting

The cost of tax shifting, per unit of intangible capital, has been specified as deviation of the imputed depreciation at home and abroad (ζ and $\widehat{\zeta}$) from their corresponding targets, that is,

$$\chi(\zeta - \lambda\delta)^2 \qquad \text{and} \qquad \chi(\widehat{\zeta} - (1-\lambda)\delta)^2.$$

One unattractive property of this specification is that, even if a firm produces only domestically ($\lambda = 1$), it has the ability to shift taxation abroad. One could argue that this capability should depend on the globalization of the firm's production.

One way to capture this is to assume that the cost function takes the form

$$\chi\left(\frac{\zeta - \lambda\delta}{1-\lambda}\right)^2 \qquad \text{and} \qquad \chi\left(\frac{\widehat{\zeta} - (1-\lambda)\delta}{1-\lambda}\right)^2.$$

This specification implies that the cost of tax shifting decreases in $1-\lambda$, that is, the degree international globalization in production. For a firm that invests and produces only domestically ($\lambda = 1$), the cost of tax shifting is infinitely large so that the chosen depreciations are always equal to the target.

We calibrate the model targeting the same moments for the early 1990s. In particular, we impose that in 1990 FDI and PEI, as a percentage of output, are 15% and 5% respectively. We then recalibrate λ and θ, together with α, so that FDI and PEI are 70% and 50% in the new steady state (which is representative of 2020). The steady state statistics are reported in the last column of Table 2.

As production becomes more globalized as a consequence of the reduction in the parameter λ, the cost of tax shifting also decreases. This makes more difficult for governments to increase revenues by taxing profits.

As a result, the equilibrium tax rate on profits drops to 6.1% and the steady state capital increases by 32%. The welfare gains are sizable, almost 2% of consumption.

To further illustrate the significance of the new specification of the tax shifting cost, we solve for the steady state when λ takes different values. The top panels of Figure 8 are for the baseline tax cost shifting functions and the bottom panels for the alternative considered here. As can be seen, with the new cost function, the profit tax rate declines monotonically and sizably with the share of foreign direct investments (lower λ). With the previous specification, instead, the dependence of the profit tax rate from λ was small and non-monotone.

9. 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 (financial globalization). While the rise in intangible capital decreases the incentive of governments to tax profits, the rise in cross-country portfolio diversification does not necessarily lower 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 could increase the incentive to tax profits is perhaps surprising. A closer examination, though, reveals 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. This is not different from the incentive of governments to default on sovereign debt when a larger share of the debt is held by other countries.

The quantitative exercise conducted with the calibrated model shows that the taxation impact of the first trend (growth in the intangible share of capital) has dominated the impact of the second trend (growth in globalization). Their combined effects led to a net decline in the profit tax rate of 20% (from 30% to 24%). This lower taxation of profits, in turn, stimulated capital accumulation and lead to a welfare gain of about 0.55 percent of consumption. These effects would be larger if the increasing importance of intangible capital was not accompanied by greater portfolio diversification. They would also be larger if globalization allowed for greater flexibility in the geographical allocation of taxable profits.

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 incomes (the poor). In general, the higher the fraction of households with wages as the primary source of income (the poor) the 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.

References

Aiyagari, S.R., 1995. Optimal capital income taxation with incomplete markets, borrowing constraints, and constant discounting. Journal of political Economy 103, 1158–1175.

Benhabib, J., Rustichini, A., 1997. Optimal taxes without commitment. Journal of Economic Theory 77, 231–259.

Chamley, C., 1986. Optimal taxation of capital income in general equilibrium with infinite lives. Econometrica 54, 607–22.

Chari, V.V., Christiano, L.J., Kehoe, P.J., 1994. Optimality fiscal policy in a business cycle model. Journal of Political Economy 102, 617–652.

Crouzet, N., Eberly, J.C., Eisfeldt, A.L., Papanikolaou, D., 2022. The economics of intangible capital. Journal of Economic Perspectives 36, 29–52.

Dyrda, S., Hong, G., Steinberg, J.B., 2023a. A macroeconomic perspective on taxing multinational enterprises. Unpublished manuscript, University of Toronto.

Dyrda, S., Hong, G., Steinberg, J.B., 2023b. Optimal taxation of multinational enterprises: A ramsey approach. Unpublished manuscript, University of Toronto.

Eberly, J.C., 2022. The value of intangible capital. NBER Reporter , 16–19.

Falato, A., Kadyrzhanova, D., Sim, J., Steri, R., 2022. Rising intangible capital, shrinking debt capacity, and the us corporate savings glut. The Journal of Finance 77, 2799–2852.

Golosov, M., Kocherlakota, N., Tsyvinski, A., 2003. Optimal indirect and capital taxation. The Review of Economic Studies 70, 569–587.

Guvenen, F., Mataloni Jr, R.J., Rassier, D.G., Ruhl, K.J., 2022. Offshore profit shifting and aggregate measurement: Balance of payments, foreign investment, productivity, and the labor share. American Economic Review 112, 1848–1884.

Ha, J., Sibert, A., 1997. Strategic capital taxation in large open economies with mobile capital. International Tax and Public Finance 39, 243–62.

Huizinga, H., Nielsen, S.B., 1997. Capital income and profit taxation with foreign ownership of firms. Journal of International Economics 42, 149–165.

Jones, L.E., Manuelli, R.E., Rossi, P.E., 1993. Optimal taxation in models of endogenous growth. Journal of Political Economy 101, 485–517.

Judd, K.L., 1987. The welfare cost of factor taxation in a perfect-foresight model. Journal of Political Economy 95, 675–709.

Kehoe, P.J., 1989. Cooperation among benevolent governments may be undesirable. Review of Economic Studies 56, 289–296.

Klein, P., Krusell, P., Rios-Rull, J.V., 2008. Time-consistent public policy. The Review of Economic Studies 75, 789–808.

Klein, P., Quadrini, V., Rios-Rull, J.V., 2005. Optimal time-consistent taxation with international mobility of capital. Advances in Macroeconomics 5.

Klein, P., Rios-Rull, J.V., 2003. Time-consistent optimal fiscal policy. International Economic Review 44, 1217–46.

Krusell, P., Rios-Rull, J.V., 1999. On the size of U.S. government: political economy in the neoclassical growth model. American Economic Review 89, 1156–81.

Mendoza, E., Tesar, L., 2003. A quantitative anlysis of tax competition v. tax coordination under perfect capital mobility. NBER Working Paper Series # 9746.

Noiset, L., 2003. Is it tax competition or tax exporting? Journal of Urban Economics 54, 639–647.

Quadrini, V., 2005. Policy commitment and the welfare gains from capital market liberalization. European Economic Review 49, 1927–1951.

Zhu, X., 1992. Optimal fiscal policy in a stochastic growth model. Journal of Economic Theory 58, 250–89.

Table 1: Main Results

(a) Parameter Values

Description	*Parameter*	*Baseline 1990*	*New 2020*
Discount factor	β	0.950	
Utility curvature	σ	2.000	
Productivity	$\bar{z}$	0.718	
Capital income share	ν	0.400	
Share intangible capital	α	0.300	0.500
Share domestic production inputs	λ	0.934	0.694
Share domestic ownership of multinationals	θ	0.978	0.781
Cost of tax shifting	χ	0.810	
Government purchases	G	0.200	
Government transfers	T	0.150	

(b) Steady state Outcomes

	Baseline	*2020*
Profit tax rate	0.300	0.240
Income tax rate	0.346	0.349
Public purchases-output ratio	0.200	0.193
Public transfers-output ratio	0.150	0.145
Stock of capital	2.287	2.487
Output	1.000	1.034

(c) Welfare gain.

0.55%

Table 2: Steady state variables.

	Baseline	*2020*	*2020*	*2020*
Scaling		*GDP Scaling*	*Equity Scaling*	*Alternative*
Cost Function		*Baseline*	*Baseline*	*Cost Function*
Profit tax rate	0.300	0.240	0.225	0.061
Income tax rate	0.346	0.349	0.350	0.363
Public purchases-output ratio	0.200	0.193	0.192	0.179
Public transfers-output ratio	0.150	0.145	0.144	0.134
Stock of capital	2.287	2.487	2.536	3.023
Output	1.000	1.034	1.042	1.118
Welfare gain		0.55%	0.72%	1.93%

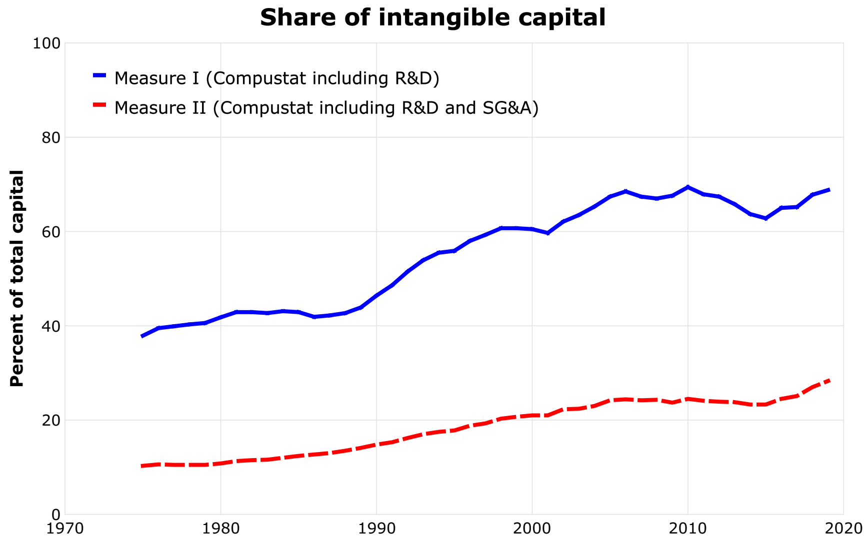

Figure 1: The growing share of intangible capital. The dashed line plots capitalized estimates of Research and Development (R&D) expenses. The continuous line plots adds capitalized estimates of Selling, General and Administrative (SG&A) expenses.

Source: Eberly (2022) based on Compustat data.

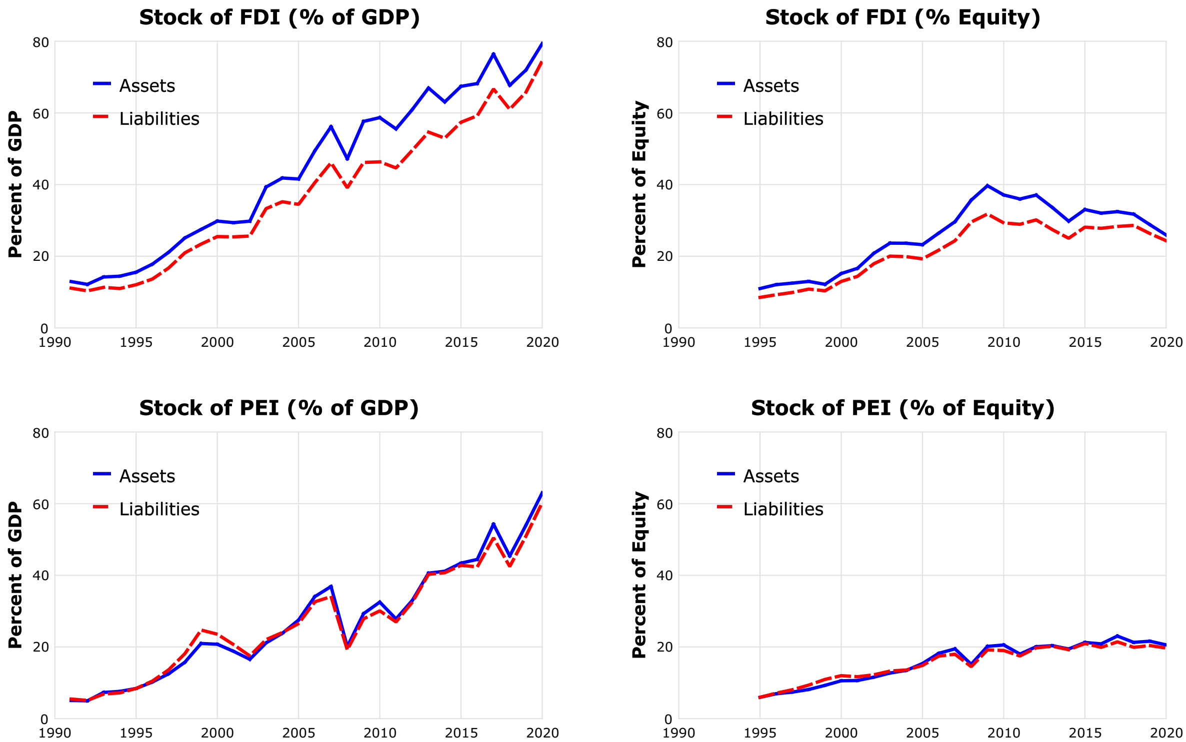

Figure 2: Stock of Foreign Direct Investments (FDI) and Portfolio Equity Investments (PEI) in industrialized countries, 1990-2020. The left panels plot the FDI and PEI in percentage of GDP. The right panels in percentage of non-financial corporate equity. Industrialized countries include: Australia, Austria, Belgium, Canada, Denmark, Finland, France, Germany, Greece, Ireland, Italy,Japan, Netherlands, New Zealand, Norway, Portugal, Spain, Sweden, Switzerland, United Kingdom, United States.

Sources: External Wealth of Nations database (Lane and Milesi-Ferretti (2018)) and OECD National Accounts Statistics.

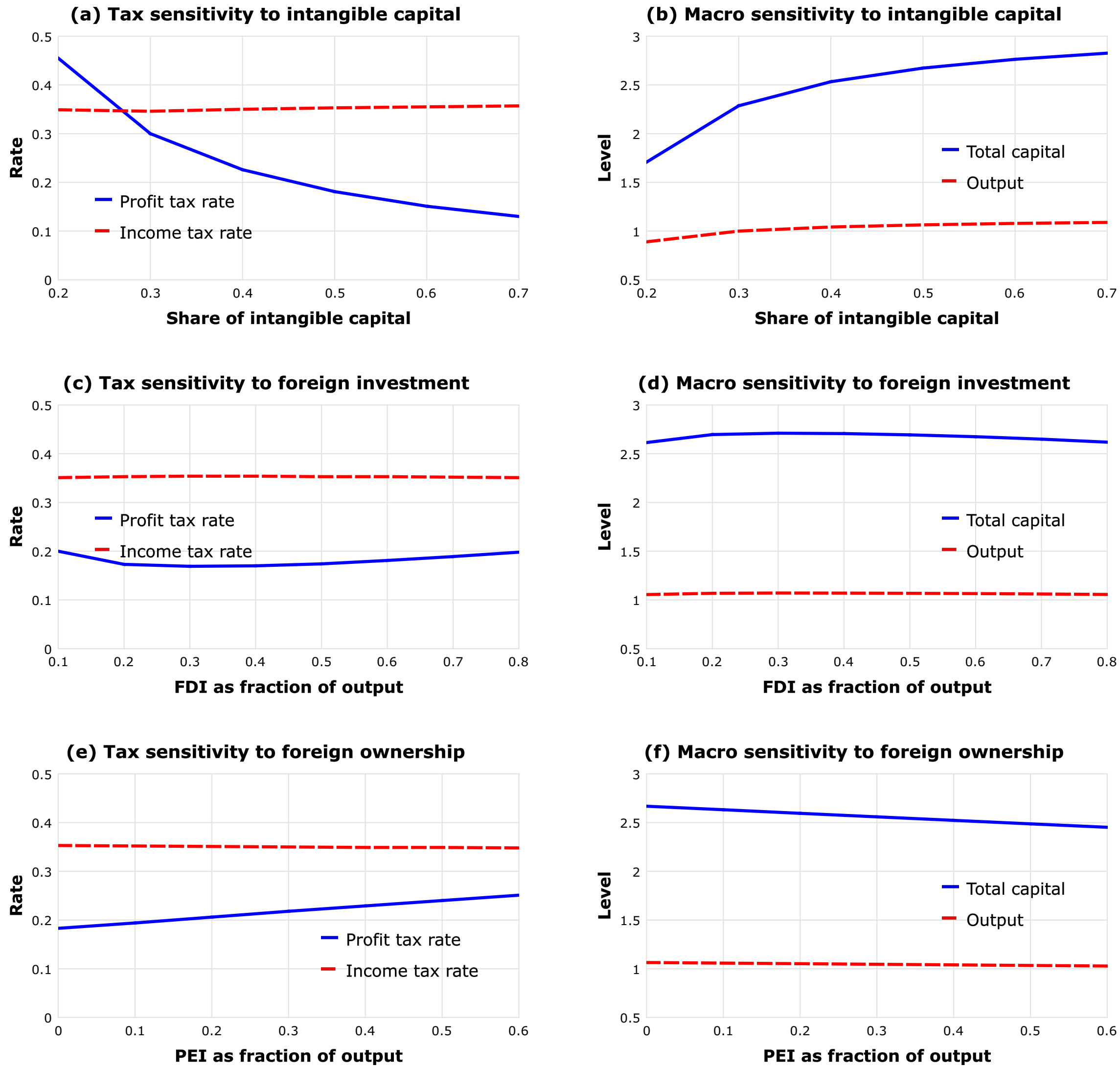

Figure 3: Steady state tax rates, capital and output for different shares of intangible capital (determined by α), foreign investments (determined by λ), and foreign ownership of multinationals (determined by θ).

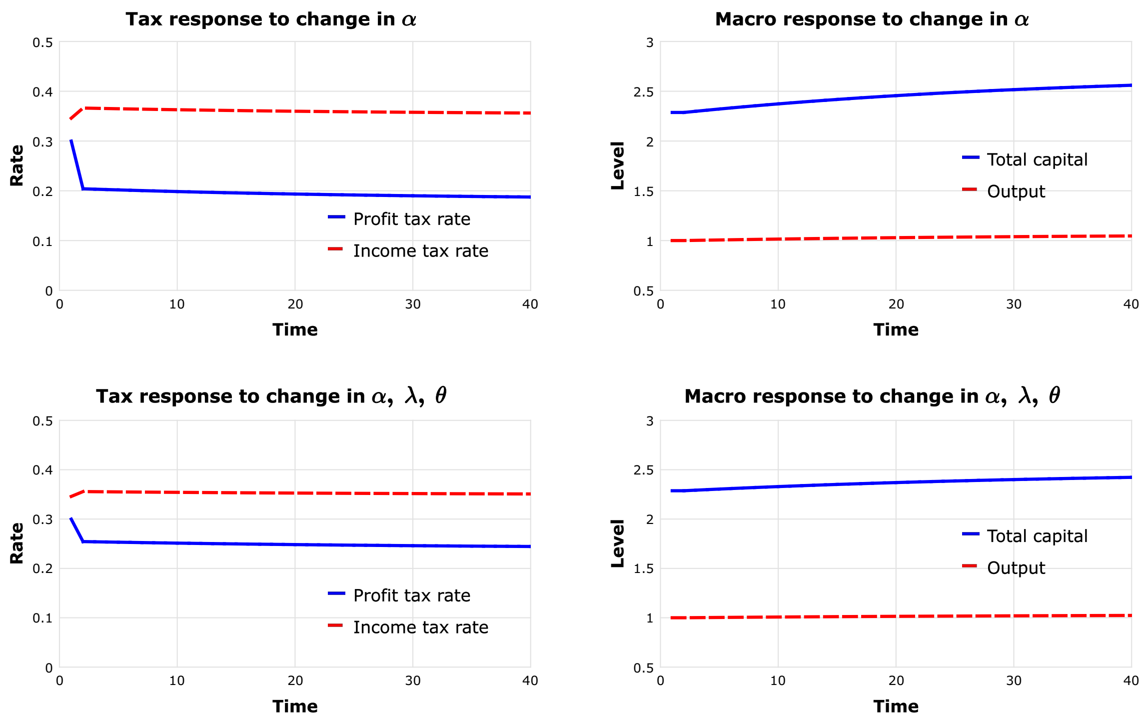

Figure 4: Dynamics of tax rates, capital and output in response to changes in α, λ and θ.

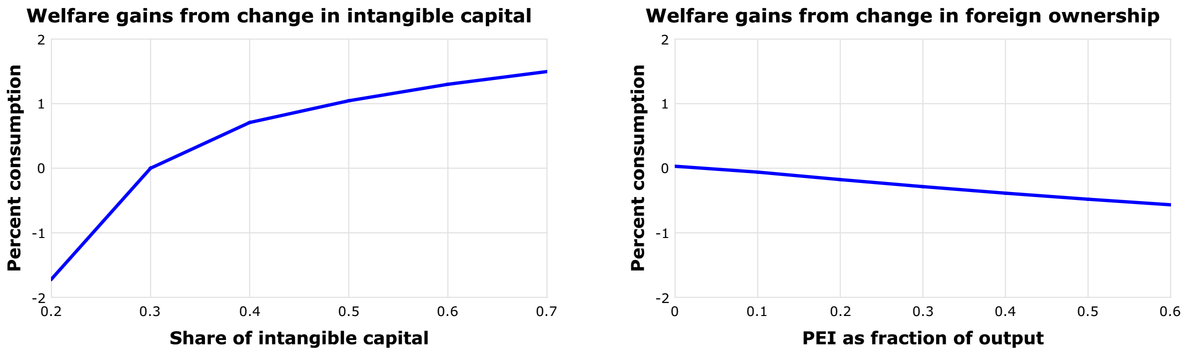

Figure 5: Welfare gains as functions of changes in the share of intangibale capital α and the share of portfolio equity investment θ.

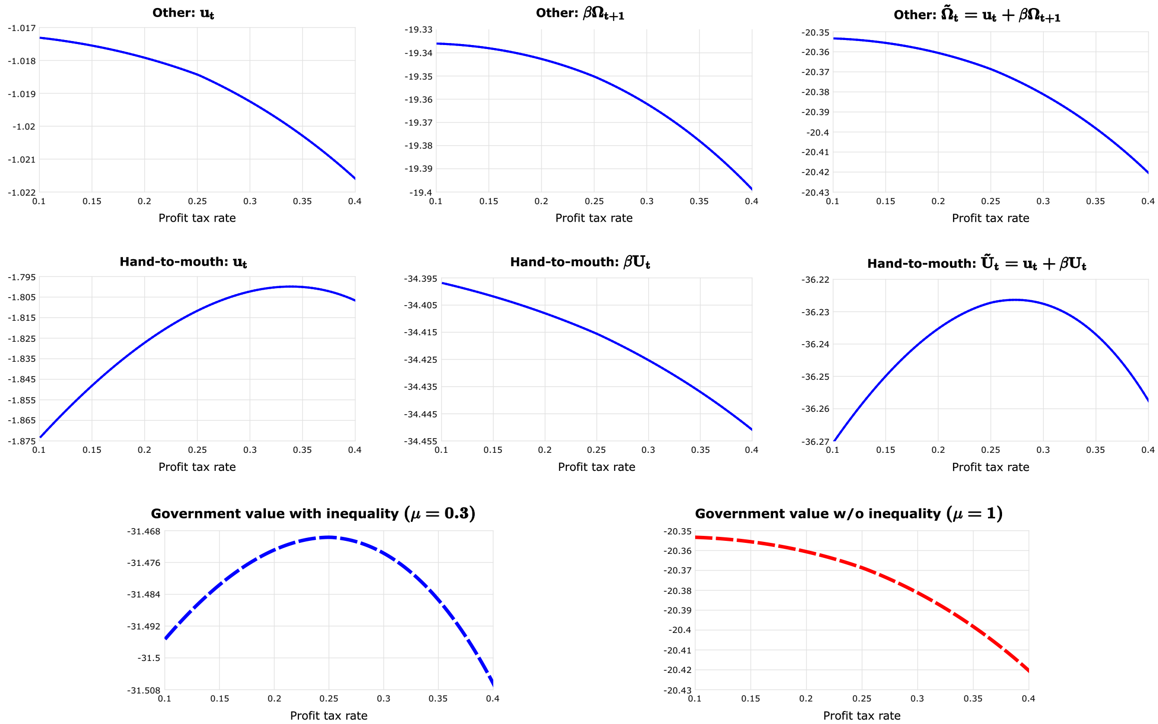

Figure 6: Households and government values as functions of the current profit tax rate when $\mu = 0.3$. Deviation from the steady state.

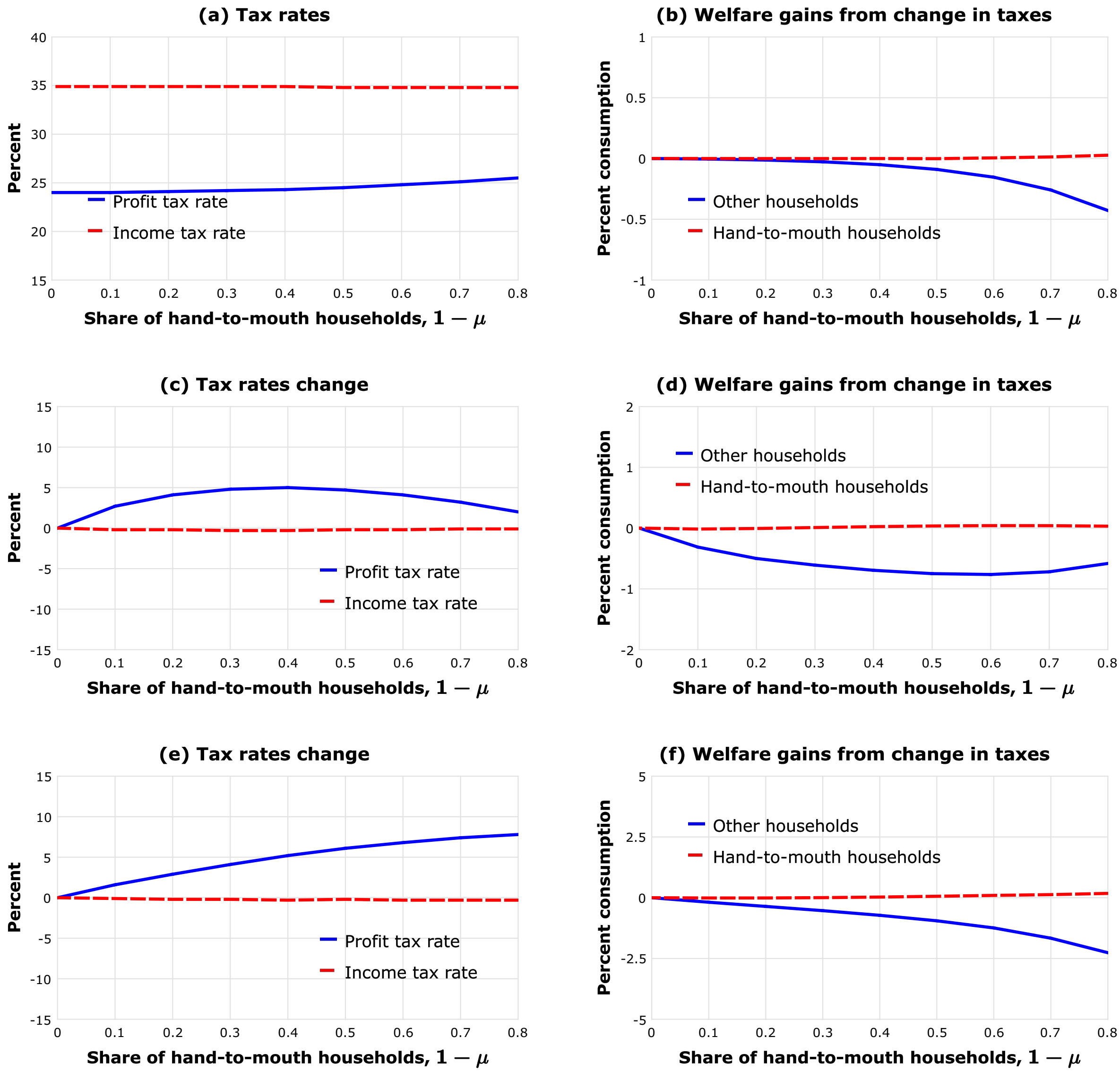

Figure 7: Tax Rates (Panel a), Welfare Gains (Panel b) as a function of the share of hand to mouth and Tax Rates Change (Panels c and e) and Welfare Gains Change (Panels d and f) for different shares of hand-to-mouth households when the government's weight shifts toward hand-to-mouth households, $\rho = 0.5$, (Panels c and d) and for when governments become myopic, $\gamma = 0.5$, (Panels e and f).

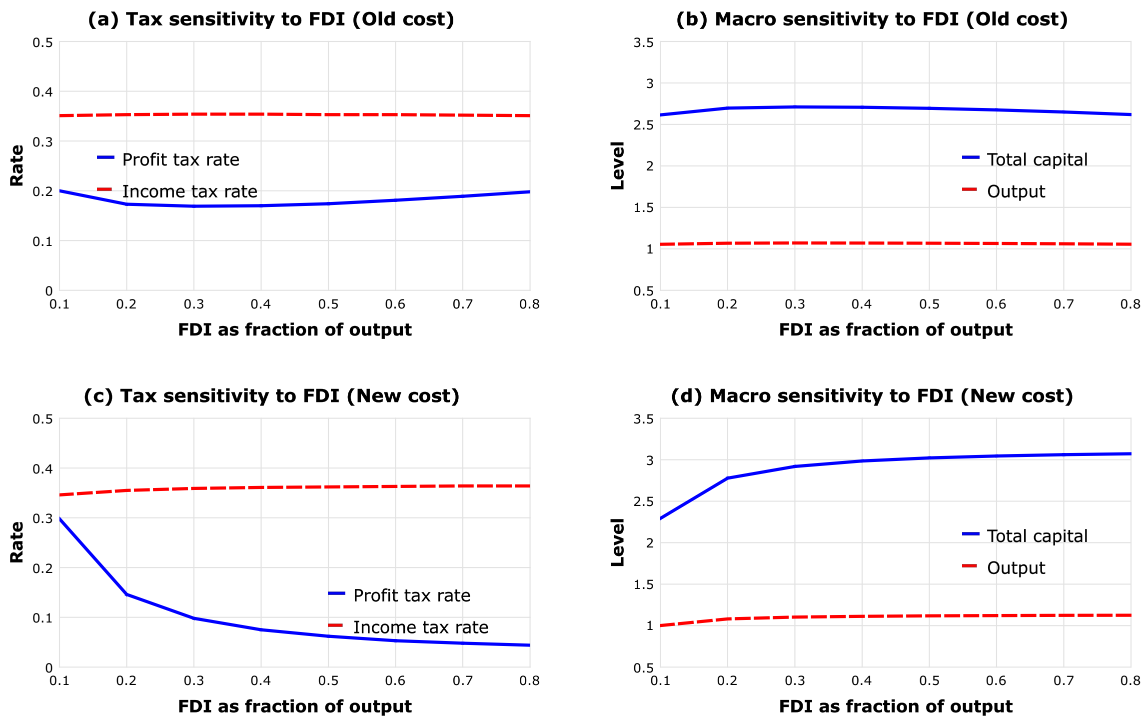

Figure 8: Steady state tax rates, capital and output for different FDI (determined by λ). The steady states are computed with $\alpha = 0.5$ and $\theta = 0.978$. The top panels are for the baseline cost function, the bottom panels are for the alternative cost function.

Appendix

Appendix A. Balance of Payments

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

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

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:

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

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

$$NFP_t = \theta\hat{\pi}_t(1-\tau_t^*) + (1-\theta)\pi_t^*(1-\tau_t^*) - (1-\theta)\pi_t(1-\tau_t) - \theta\hat{\pi}_t^*(1-\tau_t) + B_{t+1} - q_t B_{t+1},$$
$$NFP_t^* = \theta\hat{\pi}_t^*(1-\tau_t) + (1-\theta)\pi_t(1-\tau_t) - (1-\theta)\pi_t^*(1-\tau_t^*) - \theta\hat{\pi}_t(1-\tau_t^*) + B_{t+1}^* - q_t B_{t+1}^*$$

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

Net exports can be derived from the first two equations:

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

Finally, the current account is

$$CA_t = NX_t + NFP_t,$$
$$CA_t^* = NX_t^* + NFP_t^*.$$

Appendix B. Definition of equilibrium for given policy rules

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

Definition Appendix B.1. *A recursive competitive equilibrium for a given policy rule Ψ 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,

$$
\begin{aligned}
g^{\zeta}(\mathbf{s}, X, K, \hat{K}; \Psi) &= \zeta(\mathbf{s}; \Psi), \\
g^{\hat{\zeta}}(\mathbf{s}, X, K, \hat{K}; \Psi) &= \hat{\zeta}(\mathbf{s}; \Psi), \\
g^{\zeta^*}(\mathbf{s}, X^*, K^*, \hat{K}^*; \Psi) &= \zeta^*(\mathbf{s}; \Psi), \\
g^{\hat{\zeta}^*}(\mathbf{s}, X^*, K^*, \hat{K}^*; \Psi) &= \hat{\zeta}(\mathbf{s}; \Psi), \\
g^l(\mathbf{s}, X, K, \hat{K}; \Psi) + g^{\hat{l}}(\mathbf{s}, X, K, \hat{K}; \Psi) &= 1, \\
g^{l^*}(\mathbf{s}, X^*, K^*, \hat{K}^*; \Psi) + g^{\hat{l}^*}(\mathbf{s}, X^*, K^*, \hat{K}^*; \Psi) &= 1, \\
g^n(\mathbf{s}, X, K, \hat{K}; \Psi) &= N(\mathbf{s}; \Psi), \\
g^{n*}(\mathbf{s}, X^*, K^*, \hat{K}^*; \Psi) &= N^*(\mathbf{s}; \Psi), \\
g^i(\mathbf{s}, X, K, \hat{K}; \Psi) &= I(\mathbf{s}; \Psi), \\
g^{\hat{i}}(\mathbf{s}, X, K, \hat{K}; \Psi) &= \hat{I}(\mathbf{s}; \Psi), \\
g^{i^*}(\mathbf{s}, X^*, K^*, \hat{K}^*; \Psi) &= I^*(\mathbf{s}; \Psi), \\
g^{\hat{i}^*}(\mathbf{s}, X^*, K^*, \hat{K}; \Psi) &= \hat{I}^*(\mathbf{s}; \Psi), \\
g^b(\mathbf{s}, B; \Psi) + g^{b^*}(\mathbf{s}, -B; \Psi) &= 0,
\end{aligned}
$$

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

Appendix C. Computational procedure

We solve the model globally following the steps described in Section 4 to define a policy equilibrium. The fist step is to define the sufficient sets of state variables. The paper defined the equilibrium recursively using the aggregate states $\mathbf{s} = (X, K, \hat{K}, X^*, K^*, \hat{K}^*, B)$. However, taking advantage of the first order conditions of firms, we can redefine the equilibrium using only two state variables

$$
\begin{aligned}
A_t &= \theta(K_t + \hat{K}_t + X_t) + (1 - \theta)(K_t^* + \hat{K}_t^* + X_t^*) + B_t, \\
A_t^* &= \theta(K_t^* + \hat{K}_t^* + X_t^*) + (1 - \theta)(K_t + \hat{K}_t + X_t) + B_t^*.
\end{aligned}
$$

These variables represent the net wealth of the Home country and Foreign country respectively. We can then express the policy function as $\Psi(A, A^*)$. Reducing the set of state variables is possible because, once we know, A_t and A_t^*, we can determine the variables X, K, $\hat{K}$, X^*, K^*, and $\hat{K}^*$ using the first order conditions of firms for the choice of these variables in the previous period $t - 1$.

The numerical procedure starts by forming a discrete grids for the states A and A^* and then it solves for the policy equilibrium at each grid values of A and A^* in the two-dimensional grid. Even if we solve for the equilibrium over a finite number of state values (the two-dimensional grid for A and A^*), optimal decisions may return values of A and A^* in the next period that are outside the grid. In this case we interpolate bi-linearly the relevant functions, including the policy rule $\Psi(A, A^*)$ and the value functions $\Omega(A, A^*)$ and $\Omega^*(A, A^*)$. The latter are households' (and government's) values.

The solution returns a set of decision rules for any combination of A and A^* on the grid. Since these solutions solve the model globally, a transition equilibrium can be solved using these decision rules. Over the transition, of course, the states A and A^* will likely be outside the grid. In this case we simply interpolate (bi-linearly) the decision rules over the grid values of the states A and A^*.