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Abstract

We consider a world in which countries apply optimal taxes on mobile capital and savings (like in Bucovetsky and Wilson, 1991). Firms and savers may underreport income in order to avoid or evade taxation. We show that, even in the presence of underreporting, the equilibrium under tax competition may still be constrained-efficient (in the sense that there is no scope for welfare enhancing tax coordination). This is the case if the marginal social costs of underreporting savings and investment income are equal. The model demonstrates that, if source-based taxes on capital are inefficiently low, as is often assumed, taxes on savings must be inefficiently high. Constrained-efficient tax policy minimizes the social cost of underreporting. The results are robust to introducing taxes on profit or on labor income, if these types of income can be underreported as well. We conclude that commonly held assumptions on the need for coordination under tax competition need to be revised or qualified.

JEL-Codes: H250, H320, H870.

Keywords: tax competition, social welfare, tax coordination.

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1 Introduction

Efficient taxation of capital suffers from the asymmetry between boundless capital markets and national tax policies that are constrained by national borders. An abundant literature deals with the inefficiencies resulting from this asymmetry and, by now, there seems to be a consensus that it requires multilateral tax coordination to deal with these inefficiencies. However, in an early theoretical contribution, Bucovetsky and Wilson (1991) have shown that, if both savings and investment can be taxed, tax competition may be efficient in the sense that the net externality from tax policy is zero.[2] Then, a coordinated change in tax rates cannot achieve a welfare improvement. This argument is often dismissed by pointing to the large degree of evasion of residence-based taxes on savings income. As a representative account of this view, consider the beginning of the introduction in Huizinga and Nielsen (2008):

> "Over time countries have found it increasingly difficult to enforce residence-based capital income taxes, as international financial integration offers ample opportunities to avoid such taxation. Continued erosion of residence-based taxation would imply that in the end only source-based capital income taxes remain." (p. 1183)

While these authors explicitly take the absence of residence-based taxes into account and thoroughly examine its consequences,[3] many theoretical studies of source-based tax competition discard the role of savings taxes simply by referring to tax evasion of residence-based capital taxes and then assume that only source-based taxes are available.

Recent developments may warrant revisiting this argument (apart from the obvious fact that residence-based taxes are still levied almost everywhere). First, there is, by now, a huge literature that demonstrates the empirical importance of avoidance of source-based taxes (surveyed by, among others, Heckemeyer and Overesch 2017, Riedel 2018, Beer et al. 2020).[4]

[2] Eggert and Haufler (1999) as well as Eggert and Genser (2001) replicate the Bucovetsky and Wilson (1991) finding and link it to the production efficiency theorem (Diamond and Mirrlees 1971).

[3] The idea that income shifting shapes the properties of optimal tax systems is considerably older, though. See e.g. Gordon and MacKie-Mason (1995) and Gordon and Slemrod (2000).

[4] Heckemeyer and Overesch (2017) provide a meta-study of 27 profit-shifting studies and report a semi-elasticity of subsidiary profits with respect to tax rate of -0.8. Beer et

The overall effect on the allocation of tax base is huge; e.g. according to recent estimates, more than \$600bn are shifted to tax havens (Tørsløv et al., 2021, Table 3). Second, while evasion of savings taxes is still a substantial problem,[5] some progress has been made in the international enforcement of residence-based taxes on saving returns: e.g. the (automatic) international exchange of information[6], FATCA[7], and reductions in bank secrecy[8], though their level of effectiveness is subject to debate (Sheppard 2009).[9] The literature thus seems to suggest that both kinds of taxes are subject to extensive avoidance and evasion activities. Therefore, instead of just assuming that one tax instruments is unavailable due to excessive evasion, it is preferable to investigate optimal policy and tax competition when both instruments are only imperfectly enforced.

In this paper, we reconsider optimal tax policy with two tax instruments, i.e. savings and investment taxes, when both taxes can be avoided or evaded. Avoidance differs from evasion by being a legal activity. Since the legality of actions does not play a central role in our model, we refer to these activities as *underreporting income* (which may take legal forms, e.g. with profit shifting, and illegal ones, e.g. misreporting income). We do, however, differentiate between different cost types of underreporting. Following Chetty (2009), we distinguish between underreporting with a *social cost* (by using valuable resources), and underreporting with only a *private cost* (e.g. expected fines) but no social cost (as fines are revenue from the government's perspective).

First, we find that, even with underreporting of both tax bases, the tax competition equilibrium can be constrained-efficient. To be precise, if the marginal social cost of underreporting is equal for both types of income in equilibrium, the net externality is zero and the classical Bucovetsky-Wilson

al. (2020) present another meta-study of 37 profit shifting studies and find a semi-elasticity of -1 and, for more recent years, even close to -1.5.

[5] Johannesen and Zucman (2014) provide evidence that tax evaders shift deposits to tax havens not covered by a treaty with their home country, thereby benefiting the least compliant havens.

[6] See e.g. Bilicka and Fuest (2014).

[7] See e.g. Johannesen et al. (2018).

[8] See e.g. Johannesen and Zucman (2014).

[9] The empirical evidence shows that there is still an enormous amount of wealth located in tax havens (Zucman 2013, 2014, Alstadsæter et al. 2018, 2019). Hanlon et al. (2015) is a rare example of a study that allows for measuring tax effects on evasion of taxes on interest income. Using data on US investors, these authors find that "a 1% increase in the top U.S. ordinary tax rate results in an approximate 2.1% to 2.8% increase in inbound [foreign portfolio investment] from tax havens relative to nonhavens" (p. 259). The resulting revenue loss is in the range between \$8 to \$27 billion.

(1991) result is restored. Second, if the marginal social cost of underreporting investment income is larger than that of underreporting savings income, source-based investment taxes are inefficiently high in the sense that a coordinated decrease of these taxes and an associated increase of savings taxes would increase welfare. Third, we show that, with underreporting, one of the two taxes will usually be too high, while the other is too low. This finding is informative for the debate on tax coordination, which sometimes seems to assume that both taxes should be increased in coordination. Fourth, we show that, while the optimal tax *structure* under coordination is undetermined (only the total tax wedge matters) in the absence of underreporting, it is unique if at least one of the two tax bases can be underreported. Fifth, with additional taxes on (endogenously chosen) labor income,[10] all three tax types are used in equilibrium, if labor income is underreported as well. In the absence of (socially costly) underreporting of labor income, the optimal tax system only uses taxes on labor and savings income.

Our paper is, to the best of our knowledge, the first to analyze tax competition with two or more instruments while explicitly accounting for avoidance and evasion of taxes. A special case of this setting is considered in Huizinga and Nielsen (2008) who consider – see the quote above – cases in which the savings tax is available and cases in which it is not (the latter assumption is motivated by evasion). These authors show that a loss of the savings tax instrument may lead to an increase in welfare because, with international cross-ownership of firms, the tax wedge on capital may be inefficiently high. In this paper, we allow for (partial) evasion and avoidance of all involved tax bases. The model is then used to explore the welfare properties of tax competition. It also allows for policy analysis, e.g. an assessment of the prospects for business tax coordination in times when savings taxes are better enforced (e.g. through abolishment of bank secrecy, shut-down of tax havens etc.).

The next section describes the model, Section 3 investigates the equilibrium tax policy, and Section 4 analyzes its welfare properties and optimal government intervention. Section 5 adds endogenous labor to the model, and an Appendix explores the role of profit taxes. Section 6 concludes.

[10] In the Appendix, we explore the use of profit taxes instead of labor taxes. If profit income can be underreported, all three taxes are used in the Nash equilibrium. Again, second best tax policy minimizes the social cost of underreporting income from savings and investment. If there is no (socially costly) underreporting of profit income, the optimal tax system only uses profit taxes.

2 The model

The model augments the framework used in Bucovetsky and Wilson (1991) by introducing tax avoidance and evasion opportunities.

2.1 Setup

Consider a two-period model with n identical countries. The index on countries is suppressed unless misunderstandings arise. For simplicity, we assume that n is large, so each country is a price-taker in international capital markets. The basic insights, however, carry over to the case where n is small.

In each country, there is a representative household, who receives utility from private consumption in the first period, x^1, and the second period, x^2, and from a local public good, g, which is consumed in period 2. Utility is given by

$$u = u\left(x^1, x^2, g\right), \tag{1}$$

with $u_{x^1} > 0 > u_{x^1x^1}$, $u_{x^2} > 0 = u_{x^2x^2}$ and $u_g > 0 > u_{gg}$. To simplify, we assume that utility is separable in its arguments and linear in x^2, implying that savings depend only on the after-tax return, i.e. there are no income effects on savings demand.

The household is endowed with income e, which may be consumed in period 1 (x^1) or saved (S):

$$x^1 = e - S. \tag{2}$$

In period 2, the household receives savings plus interest and dividends Π from firm ownership. Gross interest income is given by ρS where ρ denotes the interest rate, determined on the world capital market. The government levies taxes on savings at the rate m.

The household may engage in activities that reduce the tax base for m below S. As we discuss in the introduction, these activities may involve illegal tax evasion as well as legal tax avoidance, and will be referred to as "underreporting" of different types of income. Following Chetty (2009), we distinguish between two types of underreporting costs: a *resource cost*, c, which is a social loss, and an *expected fine*, z, which is only a private cost because it implies an equivalent income in other parts of the economy, specifically, the government.[11]

[11] Chetty (2009) also interprets the private cost as an expected fine but ignores risk aversion by assuming risk neutral taxpayers. We similarly ignore issues involving risk aversion.

Letting a denote the amount of underreporting on a dollar of savings, the base for the savings is given by $S(1-a)$. Let $c^s(a)$ denote the resource cost of underreporting per dollar of savings. Next, let $z^s(a,m)$ denote the expected fine. We assume that $c^s(0) = z^s(0,m) = 0$; $c^s_a(0) = z^s_a(0,m) = 0$; $c^s_a(a) > 0$ and $z^s_a(a,m) > 0$ for $a > 0$ as well as $c^s_{aa}(a) < 0$ and $z^s_{aa}(a,m) < 0$. Furthermore, we assume that $a > z^s_m(a,m) > 0$ which makes sure that the government cannot reduce the net revenue loss due to underreporting, $ma - z^s(a,m)$, by levying a higher tax rate.

The household's second-period budget constraint is

$$x^2 = \Pi + S(\rho - m(1-a) - c^s(a) - z^s(a,m)). \tag{3}$$

In each country, there is a representative firm, which is fully owned by the domestic household. The firm has a production technology, $F(K)$, with $F'(K) > 0$ and $F''(K) < 0$, using capital K as the variable input. Capital can be rented in the world capital market at an interest rate of ρ. The government levies a unit tax τ on capital use K. The firm may underreport capital use, so that tax revenue is given by $\tau(1-b)K$. Underreporting b is chosen by the firm and again involves a resource cost and an expected fine, $c^k(b)$ and $z^k(b,\tau)$, respectively. The cost and the fine satisfy assumptions similar to those for our savings tax: $c^k(0) = z^k(0,\tau) = 0$; $c^k_b(0) = z^k_b(0,\tau) = 0$; $c^k_b(b) > 0$ and $z^k_b(b,\tau) > 0$ for $b > 0$ as well as $c^k_{bb}(b) < 0$ and $z^k_{bb}(b,\tau) < 0$; furthermore, $b > z^k_\tau(b,\tau) > 0$.

Firm profits are given by

$$\Pi = F(K) - (\rho + \tau(1-b) + c^k(b) + z^k(b,\tau))K. \tag{4}$$

While real world tax systems set taxes on interest income and profit income (allowing for debt cost deductions, etc.), our model features unit taxes on savings S and investment K. These tax assumptions allow us make comparison with the standard tax competition literature, starting with Zodrow and Mieszkowski (1986) and Wilson (1986).[12]

The government's budget constraint is given by

$$g = (m(1-a) + z^s(a,m))S + (\tau(1-b) + z^k(b,\tau))K. \tag{5}$$

[12] Note also that a tax on profits would either be perfectly neutral (provided that the tax base is Π) or a combination of a tax on pure profit and a tax on investment. If a neutral tax is available, there is no point in levying distorting taxes on savings and capital and a country could immunize itself from tax competition (Sinn 1990). However, even if a tax on pure profit is available, a tax on capital may still be optimal, if pure profit cannot be costlessly identified, see Keen and Piekkola (1997) and Haufler and Schjelderup (2000). See the Appendix for an augmented model with a profit tax.

The presence of $z^s(a,m)$ and $z^k(b,\tau)$ in the government budget constraint reflects the assumption that these are private costs but not social costs, since they just represent a redistribution of funds from the private sector to the public sector.

2.2 Utility and profit maximization

Each country's representative household takes the government's policy choices of m, τ and g as given and chooses x^1, x^2, K, a and b in order to maximize utility. The representative household's maximization problem is

$$\max_{x^1,x^2,a,K,b} u\left(x^1,x^2,g\right) \tag{6}$$

subject to (2), (3), (4) and (5).

The first-order conditions are:

$$\begin{aligned}
\frac{u_{x^2}(.)}{u_{x^1}(.)} &= \frac{1}{\rho - m(1-a) - c^s(a) - z^s(a,m)}; && (7)\\
c^s_a(a) + z^s_a(a,m) &= m; && (8)\\
F'(K) &= \rho + \tau(1-b) + c^k(b) + z^k(b,\tau); && (9)\\
c^k_b(b) + z^k_b(b,\tau) &= \tau. && (10)
\end{aligned}$$

Conditions (8) and (10) imply that a can be expressed as a function $a(m)$, and b as $b(\tau)$. Going forward, it is convenient to work with the following *effective unit tax rates*, inclusive of underreporting costs:

$$\begin{aligned}
M(m) &= m(1-a(m)) + z^s(a(m),m) + c^s(a(m)); && (11)\\
T(\tau) &= \tau(1-b(\tau)) + z^k(b(\tau),\tau) + c^k(b(\tau)). && (12)
\end{aligned}$$

Due to the assumptions made above ($z^s_m < a$ and $z^k_\tau < b$), the effective unit tax rates are strictly monotonic functions of the tax rates m and τ, respectively, i.e. $M'(m) > 0$ and $T'(\tau) > 0$ everywhere. We can therefore treat M and T as control variables, since each M corresponds to a unique level of m, and each T corresponds to a unique level of τ. Accordingly, we consider the savings and investment functions, $S(\rho - M)$ and $K(\rho + T)$, defined by conditions (7) through (10). Equivalently, we express $a(m)$ as $a(M)$ and $b(\tau)$ as $b(T)$.[13] Similarly, the cost function $c^s(a(m))$ may be

[13] To be precise, we express $a(m)$ as $a(m(M))$ where $m(M) = M^{-1}(m)$. The first derivative of $a(M)$ is then given by $a'(m)\,m'(M)$ where $m'(M)$ is strictly positive. The same applies to $b(T)$ and $b(\tau)$.

written as $c^s(M)$ and $c^k(b(\tau))$ as $c^k(T)$. Finally, the government budget constraint may be rewritten,

$$g = (M - c^s(M))S(\rho - M) + (T - c^k(T))K(\rho + T). \quad (13)$$

It will be useful to work with the indirect utility function, which gives the household's maximized utility as a function of taxes, the public good level, and interest rate: $v(M, T, g, \rho)$. The derivatives are obtained by using the envelope theorem:

$$\begin{aligned} v_M &= -u_{x^2}S \text{ and } v_T = -u_{x^2}K; \\ v_\rho &= u_{x^2}(S - K) \text{ and } v_g = u_g. \end{aligned}$$

2.3 Capital market

In capital market equilibrium, aggregate capital demand for all of the n identical countries is equal to aggregate savings supply. Under symmetry, this implies that each individual country' savings equals its capital demand:

$$S(\rho - M) = K(\rho + T). \quad (14)$$

This requirement implicitly defines the interest rate as a function of the common equilibrium effective tax rates: $\rho(M, T)$. A coordinated tax change (with identical rate changes in each country) would affect the interest rate as follows:

$$\frac{\partial \rho}{\partial M} = \frac{\epsilon_S}{\epsilon_S + \epsilon_K} > 0; \quad (15)$$

$$\frac{\partial \rho}{\partial T} = -\frac{\epsilon_K}{\epsilon_S + \epsilon_K} < 0; \quad (16)$$

where $\epsilon_S = S'/S$ and $\epsilon_K = -K'/K$ are semi-elasticities for savings and capital, measured positively.

3 Equilibrium tax policy

Governments are assumed to be benevolent in the sense that they care only for their representative household's well-being. Thus, each government's optimization problem may be written as follows:

$$\max_{M,\, T} v(M, T, g, \rho), \quad (17)$$

subject to the government budget constraint (13). Since countries are price-takers, the interest rate ρ is taken as given. Using the derivatives of the indirect utility function, we obtain the following first-order conditions:

$$\frac{u_g}{u_{x^2}} = \frac{1}{1 - c_M^s - (M - c^s)\epsilon_S}; \tag{18}$$

$$\frac{u_g}{u_{x^2}} = \frac{1}{1 - c_T^k - (T - c^k)\,\epsilon_K}. \tag{19}$$

As usual, an optimum is achieved only when the marginal cost of the public good does not depend on the method of financing. This invariance condition may be written as follows:

$$(M - c^s(M))\,\epsilon_S - \left(T - c^k(T)\right)\epsilon_K = c_T^k - c_M^s. \tag{20}$$

The above condition characterizes the optimal tax mix under tax competition. For purpose of comparison, consider the case where there is no underreporting. Then, the above rule boils down to $M\epsilon_S = T\epsilon_K$ or $M/T = \epsilon_K/\epsilon_S$ which is a kind of inverse elasticity rule.

Lemma 1 *(Bucovetsky and Wilson 1991) Both tax rates are positive: $m > 0$ and $t > 0$.*

Proof. If $m = 0$, then $M = 0$. Since $c^s(0) = 0$ and $c_M^s(0) = 0$, the above equation (20) cannot hold for $T > 0$, which is necessary to satisfy the government budget constraint. The same argument can be made for $t = 0$. ■

Thus, in the tax competition equilibrium, countries levy both taxes at non-zero rates.

4 Welfare properties

Before we discuss the welfare properties of the tax competition equilibrium, we define the notion of efficiency as a benchmark measure. *Unconstrained* efficiency would have households save according to $u_{x^2}/u_{x^1} = \frac{1}{\rho}$, and reduce underreporting to zero. Firms would invest according to $F'(K) = \rho$ and, again, set underreporting to zero. Public good provision would satisfy $\frac{u_g}{u_{x^2}} = 1$.

In this paper, we assume that lump-sum taxes and other more sophisticated tax instruments are unavailable. Instead, governments have access only to the taxes m and τ, as defined above. Under these circumstances, we can define *constrained efficiency* as follows:

Definition 1 *An equilibrium under tax competition is characterized by constrained efficiency if no representative household's utility can be improved by changing the individual countries' choices of tax rates without making another representative household's utility decrease.*

Assume now that there is a symmetric equilibrium in which all countries set their tax rates according to (18) and (19). In line with the above definition of constrained efficiency, we ask whether the equilibrium is constrained-efficient. In the uncoordinated equilibrium, each country sets its tax rate such that its own household's utility cannot be increased. Therefore, inefficiencies from uncoordinated tax rate setting can be measured by the effect of changes in other countries' tax rates, i.e. by the size of the cross-border externalities. These externalities occur only through changes in ρ, since there are no other cross-border linkages between countries.

Under symmetry, each country's gross interest income equals its interest cost, $\rho S = \rho K$. Therefore, a rise in ρ increases interest income by the same amount as it increases the firm's interest payments and, thus, reduces its profits. However, a change in ρ may affect tax revenue and, therefore, g, depending on the relative tax rates on savings and investment. In other words, a change in ρ may create a *fiscal externality.* For the following proposition, a tax is described as inefficiently high (low) if welfare could be increased by raising (lowering) every country's level of this tax from its equilibrium value.

Proposition 1 *Assume that there is a symmetric Nash equilibrium in tax competition. With respect to the notion of constrained efficiency (as defined above), the following holds:*
(i) If $c_T^k - c_M^s < 0$, savings taxes are inefficiently high and investment taxes are inefficiently low.
(ii) If $c_T^k - c_M^s = 0$, the tax competition equilibrium is efficient (as in Bucovetsky and Wilson, 1991).
(iii) If $c_T^k - c_M^s > 0$, savings taxes are inefficiently low and investment taxes are inefficiently high.

Proof. Starting from the Nash equilibrium, consider a small increase in M (T) in all countries. Having optimized over its own tax rates, an individual country is only affected through the change in the world market interest rate, with $d\rho/dM > 0$ and $d\rho/dT < 0$. The resulting change in utility is $\frac{du}{d\rho} = u_g\left[(M - c^s)\,\epsilon_S S - \left(T - c^k\right)\epsilon_K K\right]$. Using (20) and the symmetry assumption $S = K$, the externality is given by

$$\frac{du}{d\rho} = u_g(c^k_T - c^s_M)S. \tag{21}$$

This implies that the sign of the welfare effect of a rise in the interest rate is the sign of $c^k_T - c^s_M$. ■

The efficiency of the mix of taxes when $c^k_T = c^s_M$ can be explained intuitively. Eq. (20) tells us that, in the uncoordinated equilibrium, the tax rates are set such that

$$\frac{M - c^s}{T - c^k} = \frac{\epsilon_K}{\epsilon_S} \quad \text{if } c^k_T = c^s_M. \tag{22}$$

Thus, the effective savings tax rate net of resource cost equals $\frac{\epsilon_K}{\epsilon_S}$ times the effective investment tax rate net of resource cost, which is basically an inverse elasticity rule. In other words, if ρ is raised while holding taxes fixed, this rule implies that S rises and K falls by amounts that keep total tax payments unchanged. So whereas changes in all countries taxes still affect ρ, there is no fiscal externality from a change in ρ.

In the case of $c^s_M \neq c^k_T$, the intuition is a bit more difficult to understand. With uncoordinated tax rate setting, each individual country accounts for the resource cost of underreporting (and its marginal changes due to variations in the tax rates). That is, ceteris paribus, a higher marginal cost, c^s_M or c^k_T, implies lower optimal tax rates, M and T.[14] For purpose of illustration, assume that $c^s_M > c^k_T$. Starting from the uncoordinated Nash equilibrium, a small increase in all countries' M increases the interest rate which, as a consequence, affects other countries as follows: savings are increased, but capital stocks are reduced. Since all countries have responded to high marginal resource cost of underreporting, c^s_M, by setting relatively small effective tax rates on savings (net of resource cost), this externality is *negative.*

Corollary 1 *There is no simultaneous undertaxation of savings and investment. If both taxes, m and t, are chosen optimally, the resulting equilibrium is either constrained-efficient or one of the two tax instruments is chosen at an inefficiently high rate and the other an an inefficiently low rate.*

[14] For instance, the first order condition with respect to M can be expressed as $\frac{u_g - u_{x2}}{u_g} = c^a_M + (M - c^a)\epsilon_S$. It follows that each country fully accounts for (marginal changes in) the real cost of underreporting.

This corollary may seem surprising, since it contradicts the intuitive argument that, because savings cannot be properly taxed (and are therefore undertaxed), we need source-based taxes that are, due to tax competition, inefficiently low. The corollary shows that, if source-based taxes are inefficiently low, then taxes on savings are *overtaxed* (from a global point of view). However, if savings taxes are indeed undertaxed, then source-based taxes are inefficiently *high*.

How would a benevolent central planner (who, by definition, accounts for all externalities) set tax rates? In other words, how does optimal (i.e. second-best) tax policy look like? The central planner's optimization problem may be understood as maximizing the representative household's utility by setting taxes rates M and T while accounting for changes in the interest rate ρ and the symmetry condition $S(\rho - M) = K(\rho + T)$.[15] The latter requires $\frac{d\rho}{dM} = \frac{\epsilon_S}{\epsilon_S+\epsilon_K}$ and $\frac{d\rho}{dT} = -\frac{\epsilon_K}{\epsilon_S+\epsilon_K}$. Note that, accounting for interest rate effects and the symmetry condition, both tax instruments have the same marginal impacts on saving and investment, i.e. $\frac{dS}{dM} = \frac{dK}{dM}$ and $\frac{dS}{dT} = \frac{dK}{dT}$, and only the total tax wedge $M + T$ matters.[16]

The central planner's optimization problem is thus

$$\max_{M,\ T} v(M, T, g, \rho) \tag{23}$$

subject to the symmetry condition and the government budget constraint.

The first-order conditions for M and T can be written as follows:

$$\frac{u_g}{u_{x^2}} = \frac{1}{1 - c_M^s - (M - c^s + T - c^k)\frac{\epsilon_K\epsilon_S}{\epsilon_S+\epsilon_K}}; \tag{24}$$

$$\frac{u_g}{u_{x^2}} = \frac{1}{1 - c_T^k - (M - c^s + T - c^k)\frac{\epsilon_K\epsilon_S}{\epsilon_S+\epsilon_K}}. \tag{25}$$

Note first that, in the absence of underreporting opportunities, (24) and (25) are identical. The identity reflects the irrelevance of the tax structure (i.e. the tax wedge division) for a given level of $M+T$. This is a special case of the *liability side equivalence theorem*, under which the incidence of a tax does not depend on whether the tax is collected from suppliers or demanders. However, as emphasized by Slemrod (2008) and shown by Kopczuk et al. (2016), the irrelevance proposition does not generally apply to cases with

[15] This is equivalent to maximizing the utility levels of all representative households in all countries, accounting for the equilibrium on the world capital market.

[16] To be precise, $\frac{dS}{dM}\frac{1}{S} = \left(-S' + S'\frac{\epsilon_S}{\epsilon_S+\epsilon_K}\right)\frac{1}{S} = -\frac{\epsilon_S\epsilon_K}{\epsilon_S+\epsilon_K}$ and $\frac{dK}{dT}\frac{1}{K} = -\frac{\epsilon_S\epsilon_K}{\epsilon_S+\epsilon_K}$.

evasion and avoidance activities, since these activities may differ between the two sides of the market.

In the case considered here, the two market sides differ in underreporting activities if c_M^s and c_T^k differ. Note that, in the two optimality conditions above, only the first terms in squared brackets differ, i.e. the marginal resource costs of underreporting, c_M^s and c_T^k. All other terms are affected equally by changes in M and T. Thus, the central planner optimizes by choosing the individual values of M and T to minimize $c^s(M) + c^k(T)$.

We state this result as follows:

Proposition 2 *Under coordination, the optimal choices of M and T minimize the resource cost of underreporting, $c^s(M) + c^k(T)$, given the chosen $M+T$. This is achieved when the marginal resource costs of underreporting are equalized, $c_M^s = c_T^k$.*

For instance, when $c_M^s > c_T^k$ in equilibrium, a coordinated move from savings taxation towards source–based taxation of capital reduces the welfare loss due to underreporting and increase welfare. This cost minimization property of the coordinate tax system implies:

Corollary 2 *If only one type of income tax has a non-zero marginal resource cost of underreporting, coordinated tax setting implies a zero tax on this kind of income.*

It is important to understand that it is not underreporting in general that drives the optimality of exempting one type of income from tax. For purpose of illustration, assume that savings income is heavily evaded at a private cost ($z^s > 0$), but no social cost ($c^s = 0$ everywhere), whereas some investment income is underreported at a resource cost. Lemma 1 implies that both tax rates are strictly positive. Prop. 1 implies that, due to $c_T^k > c_M^s = 0$, savings taxes are too low and investment taxes are too high. The above corollary implies that investment taxes should actually be zero.

Given that tax competition leads to simultaneous over- and undertaxation when $c_T^k \neq c_M^s$, it is no longer clear whether public good provision is below the constrained-efficient level. (It cannot be efficient in the first-best sense, because distortionary taxes on saving and investment are being used to finance it.) So is the level of public good provision in the uncoordinated Nash equilibrium higher or lower than in the case where the benevolent planner maximizes welfare (with a limited set of instruments)?

Let $C(M+T)$ denote the minimized resource cost of underreporting for a given level of $M+T$. Then the marginal resource cost is $C'(M+T)$, and the central planner's first-order condition for public good provision is

$$\frac{u_g}{u_{x_2}} = \frac{1}{1 - C' - (M + T - C)\frac{\epsilon_K \epsilon_S}{\epsilon_S + \epsilon_K}}. \tag{26}$$

For comparison, we may express a country's corresponding first-order condition under uncoordinated tax setting as follows:

$$\frac{u_g}{u_{x_2}} = \frac{1}{1 - c^s_M \frac{\epsilon_K}{\epsilon_K + \epsilon_S} - c^k_T \frac{\epsilon_s}{\epsilon_K + \epsilon_S} - (M + T - c^s - c^k)\frac{\epsilon_K \epsilon_S}{\epsilon_S + \epsilon_K}}. \tag{27}$$

Which of the two conditions implies a higher level of public good provision? If public good provision under coordinated tax rate setting is supposed to be higher than under uncoordinated tax rate setting, the left-hand side of (26) must be larger than the right-hand side when (27) holds.

Unfortunately, we are unable to derive unambiguous results for the general model considered here. We may, however, argue that the central planner's public good provision is higher under certain conditions that do not seem implausible. Raising the same revenue as in the Nash equilibrium, requires a lower level of $M+T$ (since $C < c^s + c^k$). Provided that $\frac{\epsilon_K \epsilon_S}{\epsilon_S + \epsilon_K}$ increases in $M+T$, it follows that the third term in the denominator in (26) is smaller than the same term in (27). Given this, it is sufficient to assume that the weighted average of marginal resource cost, $c^s_M \frac{\epsilon_K}{\epsilon_K + \epsilon_S} + c^k_T \frac{\epsilon_s}{\epsilon_K + \epsilon_S}$, is smaller than the marginal minimized resource cost, C'. In this case, the right hand side of (26) side is unambiguously smaller than its counterpart in (27). At the same time, the left hand side of (26) does not change, because u_g stays constant (same revenue assumption) and u_{x^2} as well (due to the linearity assumption).

5 Integrating labor taxes

In the above model, only part of the household's pre-tax income is taxed. To be specific, the residual income $F(K) - (\rho + T)K$ remains untaxed. This raises the question whether the above results depend on the assumption of untaxed residual income.

In the Appendix, we present a version of the model in which residual income is interpreted as profit income. Each government levies a proportional tax on residual income. We show that, if there is no (resource cost of) profit underreporting, profit taxes are effectively lump-sum taxes. Then, the optimal tax system consists of only a profit tax, and tax rates on capital and savings are zero. However, with costly underreporting of profit income, all three taxes are used in the Nash equilibrium. We also show that Propositions 1 and 2, as well as Corollaries 1 and 2, apply.

In what follows, we interpret the residual income as labor income. We assume that labor (L) and capital are used for production and that the production function, $F(K, L)$, exhibits constant returns to scale, implying that firm profits are zero in equilibrium. The representative household's pre-tax labor income is wL, with w denoting the wage rate. The household chooses labor supply and consumption in each period to maximize utility, given by

$$u(x_1, x_2, L, g), \tag{28}$$

with $u_L < 0$ reflecting the disutility from work. The government levies a unit tax θ on labor supply.[17] In parallel to the taxes on investment and savings, the household may underreport a fraction h of her labor income at a resource cost of $c^l(h)$ and an expected fine of $z^l(h, \theta)$. We define $\Theta \equiv \theta(1-h) + c^l(h) + z^l(h, \theta)$ as the effective tax rate on labor.

The underreporting of payroll taxes is usually assumed to be close to zero, due to tax withholding. However, taxes on both payroll and labor income may be avoided by providing fringe benefits to workers. Moreover, some labor compensation may be paid out in ways that circumvents labor taxation (such as stock options[18]). Finally, the labor input here may also include entrepreneural labor and underreporting of labor income in particular industries, which in a more general model might be those that employ undocumented workers.

The budget constraints are now given by

$$\begin{aligned} x^1 &= e - S; & (29)\\ x^2 &= \Pi + (w - \Theta) L + (\rho - M) S; & (30)\\ \Pi &= F(K, L) - wL - (\rho + T)K; & (31) \end{aligned}$$

and the first-order conditions are $\frac{u_{x^2}(.)}{u_{x^1}(.)} = \frac{1}{\rho - M}$, $c_a^s(a) + z_a^s(a, m) = m$, $\frac{-u_L(.)}{u_{x^2}(.)} = w - \Theta$, $c_h^l(h) + z_h^l(h, \theta) = \theta$, $F_K(K, L) = \rho + T$, $F_L(K, L) = w$, and $c_b^k(b) + z_b^k(b, \tau) = \tau$. We assume that utility is separable in labor. With utility being linear in x_2, as assumed above, there are no income effects on labor supply.

[17] For simplicity, we work with a unit tax rate on labor input, rather than an ad valorem tax rate.

[18] For simplicity, we ignore spillovers to other tax bases, though.

The assumption of constant returns to scale allows expressing the capital demand per unit of labor, $k = K/L$, as a function of only the cost of capital, $k(\rho + T)$. In equilibrium, the wage adjusts to yield zero profits for a given stock of capital, $k\,(\rho + T)$. Thus, the wage can be expressed as a decreasing function of $\rho + T$, with $\frac{dw}{d(\rho+T)} = -k$. Note that the wage does not depend on Θ. Consequently, labor supply only depends on the after-tax wage, $L = L\,(w - \Theta)$. However, total capital demand now depends on both $\rho + T$ and the after-tax wage: $K = k(\rho + T)L\,(w - \Theta)$.

We can then write the government budget constraint as follows:

$$g = \left[\Theta - c^l + (T - c^k)k\right] L + (M - c^s)\,S. \tag{32}$$

As before, utility maximization yields an indirect utility function, but now it includes Θ as an argument: $v\,(M, T, \Theta, g, \rho)$, with $v_\Theta = -u_{x^2}L$.

The government's optimization problem is now

$$\max_{M,\ T,\ \Theta} v\,(M, T, \Theta, g, \rho) \tag{33}$$

subject to the budget constraint above. Each government takes the interest rate ρ as given (small open economy assumption), i.e. neglects the effect of its policy choices on ρ.

Let $\epsilon_L = L'/L$ denote the net wage semi-elasticity of labor supply and $\epsilon_k = -k'/k$ the net return semi-elasticity of capital demand per unit of labor. Note that the net return semi-elasticity of capital demand can be expressed as $\epsilon_K = \epsilon_k + k\epsilon_L$. The first-order conditions for Θ and T can be expressed as follows:

$$\frac{u_g}{u_{x_2}} = \frac{1}{1 - c^l_\Theta - [\Theta - c^l + (T - c^k)k]\,\epsilon_L}; \tag{34}$$

$$\frac{u_g}{u_{x_2}} = \frac{1}{1 - c^k_T - (T - c^k)\epsilon_k - [\Theta - c^l + (T - c^k)k]\,\epsilon_L}. \tag{35}$$

Recall that the wage rate does not depend on Θ, but decreases in T (which is why the labor semi-elasticity appears in (35)).

The optimality condition for the savings tax remains the same:

$$\frac{u_g}{u_{x^2}} = \frac{1}{1 - c^s_M - (M - c^s)\epsilon_S}. \tag{36}$$

Using these three conditions, we now prove:

Proposition 3 *In the uncoordinated Nash equilibrium,*
(i) labor and savings taxes are always used,
(ii) source-based capital taxes are used only if $c^l_\Theta > 0$, i.e. if there is underreporting of labor income involving a marginal resource cost.

Proof. (i) Suppose that $M \leq 0$. Then (36) implies $\frac{u_g}{u_{x^2}} \leq 1$, in which case (34) can hold only if $\Theta - c^l + \left(T - c^k\right) k \leq 0$, which violates the government budget constraint. Next, suppose that $\Theta \leq 0$. Since $M > 0$, we must have $T > 0$ for both (36) and (34) to hold, which violates (35). Thus, $\Theta > 0$. (ii) If $c^l_\Theta = 0$, (35) can only hold with equality if $T = 0$. In contrast, if $c^l_\Theta > 0$, (34) and (35) imply $T > 0$. ■

The proposition that a zero tax on investment is optimal when labor can be costlessly taxed has been derived by Gordon (1986). Moreover, the zero source-based tax on capital is an implication of the Diamond and Mirrlees (1971) theorem on aggregate production efficiency, applied to an open economy. The production efficiency theorem, adapted to the setting considered here, says that the allocation of investment between home and abroad should not be distorted by taxes, when optimal commodity taxation is available. Optimal commodity taxation is available with taxes on labor income and second-period consumption. Adding resource costs of underreporting, however, restores the desirability of investment taxation.

In the Nash equilibrium, conditions (34), (35) and (36) hold with equality. Comparing the former two shows that $c^l_\Theta = c^k_T + (T - c^k)\epsilon_k$ in equilibrium. This implies the following Corollary:

Corollary 3 *In the uncoordinated Nash equilibrium, the marginal resource cost of underreporting labor income is higher than the marginal resource cost of underreporting investment income.*

Before we turn to coordinated tax changes, we briefly describe the world market for capital. In a capital market equilibrium, aggregate capital demand for all of the n identical countries has to be equal to aggregate savings supply. Under symmetry, this implies that each individual country's savings equals its capital demand:

$$S\left(\rho - M\right) = k(\rho + T)L\left(w(\rho + T) - \Theta\right). \tag{37}$$

This requirement implicitly defines the interest rate as a function of the common equilibrium effective tax rates: $\rho(\Theta, M, T)$. A coordinated tax change (with identical tax rate changes in each country) would affect the interest rate as follows: $\frac{\partial\rho}{\partial M} = \frac{\epsilon_S}{\epsilon_S+\epsilon_K} > 0$, $\frac{\partial\rho}{\partial T} = -\frac{\epsilon_K}{\epsilon_S+\epsilon_K} < 0$ and $\frac{\partial\rho}{\partial\Theta} = -\frac{\epsilon_L}{\epsilon_S+\epsilon_K} < 0$, where we use $\epsilon_K = \epsilon_k + k\epsilon_L$. Note here that a rise in ρ not only impacts savings and the capital-labor ratio, but also lowers the labor supply by reducing the market-clearing wage rate. The semi-elasticity ϵ_L accounts for this latter effect.

Starting from the uncoordinated Nash equilibrium, coordinated tax changes of τ, m or θ affect an individual country only via the interest rate:

$$\frac{du}{d\rho} = u_g \left[(M - c^s)\,\epsilon_S - (T - c^k)\epsilon_K - \left(\Theta - c^l\right)\epsilon_L \right] S. \tag{38}$$

Although the presence of labor supply effects makes this condition differ from our previous condition for the utility change, our optimality conditions for the tax rates again give

$$\frac{du}{d\rho} = u_g \left[c_T^k - c_M^s \right] S. \tag{39}$$

Proposition 4 *(i) If labor income cannot be underreported or if the marginal resource cost of underreporting is zero, $c_\Theta^l = 0$, the opportunity to underreport savings income at a marginal resource cost, $c_M^s > 0$, implies that savings taxes are too high.*
(ii) If there is costly underreporting of labor income, $c_\Theta^l > 0$, Prop. 1 applies.

Proof. (i) Without (a resource cost of) underreporting of labor income, the optimal source-based tax on investment, τ, is zero, as shown above. Therefore, $\frac{du}{d\rho} = u_g\left[-c_M^s\right] S < 0$. A coordinated decrease in savings taxes reduces the world market interest rate and therefore increases welfare. Part (ii) follows from inspection of eq. (39). ■

We may further state the following.

Corollary 4 *Whenever investment taxes are too high, labor taxes are too high as well, and vice versa.*

Proof. By Prop. 1, investment taxes are too high when $c_T^k - c_M^s > 0$, i.e. a coordinated increase in T decreases welfare by reducing the interest rate (due to $\frac{du}{d\rho} > 0$). Since a coordinated increase in labor taxes changes the interest rate in the same direction as a coordinated increase in T, labor taxes are inefficiently high if $c_T^k - c_M^s > 0$. ■

Now, consider the central planner's choice of tax rates. Again, the planner maximizes household utility by accounting for interest rate effects and the symmetry condition. Both labor supply $L = L(w(\rho + T) - \Theta)$ and capital demand $K = k(\rho + T)L(w(\rho + T) - \Theta)$ depend on the interest rate ρ.

The following Proposition can be derived from inspection of the three optimality conditions given in the Appendix.

Proposition 5 *Second-best tax policy equalizes the marginal resource cost of underreporting savings and investment income, i.e.*

$$c_T^k = c_M^s. \tag{40}$$

As a side remark, consider the case in which source-based taxes on capital are not available, i.e. $T = 0$. Comparing optimality conditions (34) and (36) shows that, in the uncoordinated Nash equilibrium, each country sets taxes such that

$$c_\Theta^l - c_M^s = (M - c^s)\,\epsilon_S - \left(\Theta - c^l\right)\epsilon_L. \tag{41}$$

A small increase in the interest rate affects the representative household's utility as follows: $\frac{du}{d\rho} = u_g\left[(M - c^s)\,\epsilon_S - \left(\Theta - c^l\right)\epsilon_L\right]S$. It follows that, if $c_\Theta^l = c_M^s$, uncoordinated tax rate setting attains the second best (this includes the case of zero resource cost for both tax instruments). This, however, will only hold by chance. In most cases, either the tax on savings or the tax on labor is too high (with the other one being too low).

6 Discussion and concluding remarks

The above analysis shows that, even in the presence of tax avoidance and evasion, uncoordinated tax setting under competition may be constrained-efficient. This, however, will be rather an exception than the rule. In general, the tax competition equilibrium with two tax instruments and evasion will be characterized by an inefficient tax structure, with one tax being inefficiently low and the other being inefficiently high.

Our analysis calls into question the implicit assumption of many contributions to the tax competition literature that the analysis may be restricted to source taxes, because residence based capital taxes are subject to evasion. We consider both avoidance and evasion in residence taxation and source taxation. Except for extreme cases, both taxes will be used with strictly positive rates. As mentioned above, our analysis also qualifies the intuitive claim that both residence-based and source-based capital taxes are too low. We demonstrate that the equilibrium is either constrained-efficient or one of the tax rates will be unambiguously too high. So ironically, if source taxes are supposed to be inefficiently low, as is commonly held in the tax competition literature, this can only be if residence taxes are too high.

Actually, a case can be made for investment taxes being inefficiently high and saving taxes being inefficiently low. An important method of underreporting by savers involves the illegal use of tax havens to evade income taxation. Since tax evasion is severely punished, the private cost of underreporting may be important (at least if it takes the form of fines). In contrast, multinationals typically use tax havens to engage in tax avoidance activities. The latter may involve substantial resource costs, used to design and execute complicated tax planning strategies. These resources represent a social cost. In case where the marginal social cost of underreporting is higher for the tax on investment, Prop. 1 justifies a case for assuming that savings taxes are inefficiently low and investment taxes are inefficiently high.

Appendix

Residual income as profit income

In this Appendix, we briefly explore the properties of tax competition when the residual income $F(K) - (\rho + T)K$ is interpreted as profit income. Profit income is assumed to be taxed at an effective rate of $V = v(1-\gamma) + z^{\pi}(v,\gamma) + c^{\pi}(\gamma)$ where v is the nominal tax rate, γ the fraction of profit that remains unreported and z^{π} and c^{π} are the private and social cost of underreporting, respectively.

The household's first-period budget constraint remains the same, and the second period budget constraint is $x_2 = S(\rho - M) + \Pi$ with

$$\Pi = (F(K) - (\rho + T)K)(1 - V).$$

The government's budget constraint is

$$g = (M - c^s(M))S + (T - c^k(T))K + (V - c^{\pi}(V))(F(K) - (\rho + T)K).$$

The first-order conditions with respect to M, T and V can be expressed as

$$\begin{aligned}
\frac{u_g}{u_{x^2}} &= \frac{1}{1 - c_M^s - (M - c^s)\epsilon_S}; \\
\frac{u_g}{u_{x^2}} &= \frac{1}{1 + \frac{c^{\pi}}{1-V} - \frac{c_T^k}{1-V} - \frac{(T-c^k)\epsilon_K}{1-V}}; \\
\frac{u_g}{u_{x^2}} &= \frac{1}{1 - c_V^{\pi}}.
\end{aligned}$$

In the Nash equilibrium, we must therefore have $(M-c^s)\epsilon_S+c^s_M = \frac{(T-c^k)\epsilon_K-c^\pi+c^k_T}{1-V}$. The following lemma follows from the above three optimality conditions:

Lemma 2 *(i) If the marginal resource cost of underreporting profit income is zero, the equilibrium taxes on capital and savings are zero.*
(ii) If the marginal resource cost of underreporting profit income is strictly positive, all three taxes are used.

Proof. (i) If $c^\pi_V(V) = 0$, the optimality condition for V implies $\frac{u_g}{u_{x^2}} = 1$. This, in turn, implies $T = M = 0$. (ii) The proof proceeds in parallel to the proof of Lemma 1. ■

We now turn to the question of whether decentralized tax rate setting is efficient. As before, tax policy may have externalities across countries only via the interest rate channel. A change in the interest rate affect household utility in the following way:

$$\frac{du}{d\rho} = -\left(u_g - u_{x_2}\right) VS + u_g\left[c^\pi + \left(M - c^s\right)\epsilon_S - \left(T - c^k\right)\epsilon_K\right] S.$$

Combining the first-order conditions for M and T yields:

$$-\left(u_g - u_{x^2}\right) V + u_g c^\pi = u_g\left[c^k_T + (T - c^k)\epsilon_K\right] - u_g\left(c^s_M + (M - c^s)\epsilon_S\right),$$

Using this expression, the effect of the interest rate on utility reduces to

$$\frac{du}{d\rho} = u_g\left(c^k_T - c^s_M\right) S.$$

Proposition 6 *In the presence of profit taxes that can be underreported at a marginal resource cost, Prop. 1 applies.*

Now, consider the tax rate choices of a central planner (who has the same limited set of tax instruments as the individual governments). The central planner's optimization problem is

$$\max_{M,T,V} v\left(M, T, V, g, \rho\right)$$

The first-order conditions with respect to M, T and V are

$$
\begin{aligned}
\frac{u_g}{u_{x^2}} &= \frac{1 - V\frac{d\rho}{dM}}{1 - (V - c^\pi)\frac{d\rho}{dM} - c^s_M - (M - c^s + T - c^k)\frac{\epsilon_K\epsilon_S}{\epsilon_S+\epsilon_K}}; \\
\frac{u_g}{u_{x^2}} &= \frac{1 - V\left(1 + \frac{d\rho}{dT}\right)}{1 - (V - c^\pi)\left(1 + \frac{d\rho}{dT}\right) - c^k_T - (M - c^s + T - c^k)\frac{\epsilon_K\epsilon_S}{\epsilon_S+\epsilon_K}}; \\
\frac{u_g}{u_{x^2}} &= \frac{1}{1 - c^\pi_V}.
\end{aligned}
$$

With $\frac{d\rho}{dM} = 1 + \frac{d\rho}{dT}$, the two first optimality conditions are equal except for the marginal resource cost of underreporting. That is, again, the central planner minimizes the resource cost of underreporting by choosing

$$c^k_T = c^s_M.$$

We summarize this in the following Proposition.

Proposition 7 *In the presence of profit taxes that can be underreported at a marginal resource cost, Prop. 2 and Corollary 2 apply.*

Optimality conditions for Prop. 5

This Appendix provides the optimality conditions necessary to derive Prop. 5. The first-order conditions for the optimization problem described in the text can be expressed as

$$
\begin{aligned}
\frac{u_g}{u_{x_2}} &= \frac{1}{1 - c^l_\Theta + (\Theta - c^l)\frac{dL}{d\Theta}\frac{1}{L} + [T - c^k + M - c^s]\frac{dK}{d\Theta}\frac{1}{L}}; \\
\frac{u_g}{u_{x_2}} &= \frac{1}{1 - c^k_T + (\Theta - c^l)\frac{dL}{dT}\frac{1}{K} + [T - c^k + M - c^s]\frac{dK}{dT}\frac{1}{K}}; \\
\frac{u_g}{u_{x_2}} &= \frac{1}{1 - c^s_M + (\Theta - c^l)\frac{dL}{dM}\frac{1}{K} + [T - c^k + M - c^s]\frac{dK}{dM}\frac{1}{K}}.
\end{aligned}
$$

With $\frac{dK}{d\Theta} = -kL\epsilon_L\frac{\epsilon_S}{\epsilon_S+\epsilon_k+k\epsilon_L}$, $\frac{dK}{dT} = \frac{dK}{dM} = -kL(k\epsilon_L + \epsilon_k)\frac{\epsilon_S}{\epsilon_S+\epsilon_k+k\epsilon_L}$, $\frac{dL}{d\Theta} = -L'\frac{\epsilon_S+\epsilon_k}{\epsilon_S+\epsilon_k+k\epsilon_L}$ and $\frac{dL}{dT} = \frac{dL}{dM} = -kL'\frac{\epsilon_S}{\epsilon_S+\epsilon_k+k\epsilon_L}$, it follows that the denominators of the second and third optimality conditions are identical except for c^k_T and c^s_M, respectively. That is, second-best tax policy equates the marginal resource cost of underreporting for both taxes.

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