Granting Market Countries the Right to Tax Profit without Physical Nexus

by

Wolfram F. Richter

TU Dortmund University, CESifo Munich, and IZA Bonn

January 2022

This version: June 2022

Abstract: Almost 140 countries have accepted the OECD invitation to reform the taxation of multinational enterprises (MNEs). One of two reform pillars aims at granting market countries the right to tax supernormal ("residual") profit without requiring physical nexus. This paper examines the method of implementation proposed by the OECD and compares it with various discarded options. It concludes that intercountry tax equity and allocative efficiency speak against the OECD proposal to use a sales-based formula for allocating an MNE's group profit. Simply splitting each market country's residual profit contribution by an MNE-independent key is to be preferred. An even more fundamental argument in favor of residual profit splitting (RPS) is practicability of negotiation. RPS is implementable within the well-established tradition of separate entity assessment. By contrast, the OECD proposal calls for steps toward unitary taxation, which could still prove to be a daunting hurdle in the international search for consensus.

JEL Classification: H25, M48, F23

Keywords: BEPS Project; Pillar One; residual profit allocation/splitting; tax withholding; destination-based cash flow taxation

Address: Wolfram F. Richter, TU Dortmund University, Department of Economics, 44221 Dortmund, Germany; Wolfram.Richter@tu-dortmund.de, https://orcid.org/0000-0002-5080-1215.*

* This article builds on a series of papers written by the same author. Those that have appeared in peer-reviewed journals are cited where appropriate. Two other short papers that address relevant aspects without being published

1. Introduction

Current law does not provide for a right to tax corporate profit without physical nexus and sales activities alone create no nexus. The term *market country* has come to be used for countries where a multinational enterprise (MNE) earns revenue from remote sales. From the perspective of such a country, remote sales are imports. The notion of granting countries a shared right to tax profit earned on imports is contrary to current law, but not new in the literature. Avi-Yonah et al. (2009)'s proposal to apportion an MNE's residual profit according to the group's relative sales in each country is an early example and one that has gained prominence with the OECD's declared objective of combatting base erosion and profit splitting (BEPS), where particular emphasis is given to the tax challenges arising from the digitalization of the economy. The OECD (2021) has brought together 137 countries to draft reform proposals and the results are grouped into two "pillars". Pillar One seeks to expand the taxing rights of market countries while Pillar Two is designed to ensure a minimum taxation of large MNEs. The present paper deals with Pillar One and its plan to grant market countries a revenue-based right to tax a share of MNEs' group profit. This proposal is compared with several other prominent but discarded options, including the following:

(i) to allow market countries to levy a withholding tax on automated digital services as provided by the new Article 12B of the United Nations Model Tax Convention (UN MTC),
(ii) to allocate residual profit by income (Devereux et al., 2021a),
(iii) to split the residual profit contributed by a market country using an MNE-independent key (Richter, 2021a), and
(iv) to replace the current corporate tax system by a destination-based cash flow tax (Auerbach and Devereux, 2018).

The present model-based comparison of all these options will be guided by three objectives, namely intercountry tax equity, allocative efficiency, and practicality of negotiation. The first of these, intercountry tax equity, is an important objective because this is precisely what Pillar One aims to achieve. Allocative efficiency should also be an aim, although it is rarely the focus of multinational negotiations. Moreover, academic discussion of this topic is complicated by

in peer-reviewed journals are the following: Reforming International Taxation: A Critique of the OECD Plans and a Counterproposal, 2021, Tax Notes International 102, Viewpoint, June 28, 1823-1828. Taxing the Residual Profit of Multinational Enterprises: A Critique of Formulaic Apportionment and a Proposal, 2021, EconPol Policy Brief 35.

the fact that the production efficiency theorem is not applicable. By assumption, pure profits are not completely taxed away and this precludes the application of the theorem. Finally, practicality of negotiation is a necessary criterion because it is not enough to declare political goals without considering how they are to be achieved. Rather, a form of implementation must be found that will allow the disparate interests of the negotiating countries to be reconciled. It is doubtful whether the OECD's two-pillar approach sufficiently meets this requirement, as will be briefly explained.

The Pillar-One proposal assumes unitary taxation of MNEs' (residual) profit. However, unitary taxation, also known as formula apportionment (FA), requires the world to agree on jointly applicable rules for profit tax assessment. The problem is that there is no international agreement that could serve as a practical model.[1] Common rules for assessing taxable profit are found only in certain countries, such as the United States, Germany, and Canada. However, it makes a considerable difference whether complex sets of rules such as those governing corporate income taxation are implemented domestically or internationally. A cautionary example is provided by the EU, which over the last 20 years has failed to agree on common rules for determining taxable profit. It thus seems highly unlikely that more disparate countries will eventually agree on common rules. So far, there are only declarations of intent. Doubts about the viability of such political declarations is the major reason why this paper discards all reform proposals that assume unitary taxation. Instead, it will give preference to proposals that build on the practice of separate entity accounting and that require an agreed profit determination only by those countries that have directly contributed to the generation of that profit. In practice, this often amounts to a bilateral agreement and is a condition not fulfilled by tax regimes relying on the formulaic apportionment of an MNE's group profit. The only tax regimes discussed in this paper which meet this requirement are tax withholding, residual profit splitting (RPS), and destination-based cash flow taxation (DBCFT). In the end, this article argues in favor of RPS.

The model-based analysis in this paper will be limited to the effects that the competing tax systems have on the remote supply of digital services. However, this is done with a view to the broader question of which system seems best suited to expanding or even replacing the current system of international corporate taxation.

[1] The OECD (2021) proposes to determine profit or loss by reference to financial accounting income "with a small number of adjustments". Detailed rules are to be implemented through a multinational convention.

The outline of the paper is as follows: After section 2 has briefly summarized the relevant literature, section 3 introduces a simple two-country model to discuss reform proposals that assume unitary taxation. Section 3.1 deals with Pillar One and section 3.2 with residual profit allocation (RPA) by revenue or income. It is shown that all these tax systems have unclear efficiency effects and fail to meet the criterion of intercountry tax equity. Section 4 looks at tax withholding, which, it is later argued, can at best be part of a reform. It is certainly not the solution to the problems raised by digitalization. Section 5 examines RPS in three parts. Section 5.1 deals with the general case and section 5.2 with the specifics of quasi-linear demand; section 5.3 adds guidance on implementing RPS. Section 6 covers DBCFT, arguing that this proposal is not conducive to achieving the objective of Pillar One. Section 7 summarizes and draws conclusions. Technical derivations can be found in section 8 (Appendix).

2. Related literature

Pillar One has been initiated by the OECD/G20 as a multilateral answer to the global spread of taxes on digital services. For an overview and systematization of the different forms such taxes can take, see Bunn et al. (2020). Following Brander and Spencer (1984), Richter (2021b) interprets the global spread as an attempt by importing countries to extract rent income earned by the monopolized supply of digital services.

As mentioned above, Pillar One builds on the proposal of Avi-Yonah et al. (2009) to apportion an MNE's residual profit according to the group's relative sales in each country. Sales-based apportionment belongs to the broader family of FA designed to apportion an MNE's group profit to countries according to local sales, payroll, and capital. The European Commission (2011) has used such a broader formula when proposing the adoption of a common corporate tax base by the EU. An early analysis of the advantages and shortcomings of FA was provided by Mintz and Weiner (2003). De Mooij et al. (2021) investigate its worldwide application. RPA by income is a variant of FA recently proposed by Devereux et al. (2021a).

Most countries levy withholding taxes on outgoing payments for interest, dividends, and royalties. As part of the drive to achieve the Single Market, the EU has banned taxes on interest and dividends withheld at source. With Article 12B UN MTC, the United Nations has recently taken the opposite approach. The new article expands source countries' right to impose a withholding tax on outgoing payments arising from automated digital services (ADS). Unlike

the Pillar One proposal, Article 12B only applies to the digital economy and does not stipulate any revenue thresholds. Collier et al. (2021) compare Pillar One, Article 12B, and RPA by income and evaluate these three proposals from the perspectives of (i) efficiency, (ii) ease of administration, (iii) tax avoidance, and (iv) incentive compatibility. They identify strengths and weaknesses in all three options. Fuest et al. (2013) and Finke et al. (2014) discuss the use of withholding taxes on interest and royalty payments as an option for limiting base erosion and profit shifting by MNEs. Intercountry tax equity and allocative efficiency are not considered in their studies.

As the result of axiomatizing the OECD guideline to align profit taxation with value creation, Richter (2021a) developed the idea of RPS. It stands for a tax system characterized by the following properties: (i) The system builds on separate entity accounting. (ii) Payments made between affiliated companies for the non-rival use of excludable rights and services - non-rival rights and services for short - are no longer recognized tax items.[2] (iii) A company-independent key is used to apportion the residual profit earned in country S among S and all those countries hosting affiliated companies that developed non-rival rights and services used in S by an affiliated company or sold in S to third parties. Suggestions made by the OECD under the term "modified residual profit split method" had pointed in that direction (OECD, 2019, p. 12). However, they neither questioned the tax recognition of payments in connection with the non-rival use of rights and services nor considered the possibility of apportioning a tax base using a company-independent key.

Auerbach and Devereux (2018) proposed DBCFT as an alternative to the conventional form of corporate income taxation. One could well think that the proposal was conceived to grant market countries the right to tax profit even without physical nexus. However, this is not the case; the proposal is motivated by efficiency-related considerations rather than by those of intercountry tax equity. In particular, the DBCFT aims at not distorting the choice of location for entrepreneurial activities. Because of the prominent attention the proposal has received, it is included in the model-based comparison that follows.

The model used is extremely stylized. It builds on Richter (2021b) and distinguishes between the quantity and quality of an (excludable) non-rival service remotely supplied by a monopolist. Quality is the output of targeted investment and not the result of an explicitly modelled network

[2] Examples for the exclusion of the right of use are patentable knowhow, trademarks, copyrights, software codes, automated digital services and the like.

externality. Cui and Hashimzade (2019) and Ogawa (2021) are examples of the latter modelling approach.

3. Unitary taxation

Tax effects are analyzed in a model of two countries called Home and Abroad, with Abroad being a market country. The focus is on a monopolist producing a non-rival service in Home and selling it to both countries. Sales to Abroad are remote sales from Home and are made without relying on a permanent establishment in Abroad. Quantities are produced at zero marginal cost. They are denoted by X, x when sold to Home and Abroad, respectively. Quality is denoted by Q and its cost of production, $C(Q)$, is positive, increasing, and strictly convex. $P(X,Q)$ is average revenue from Home and $p(x,Q)$ is average revenue earned from Abroad. By assumption, $P_X, p_x < 0$. Whenever subscripts are used in connection with functions, they indicate (partial) derivatives.

3.1 Pillar One

The key idea of Pillar One is that a share σ of an MNE's residual profit ("Amount A") is allocated to market countries according to relative sales. Each individual country is then allowed to impose its own tax rate on its allocated share of Amount A. A stylized model of this tax regime is the following.

$\Pi^b \equiv PX + px - C(Q)$ is profit before tax. If $C(Q)$ is interpreted as imputed cost, it makes sense to assume normal ("routine") profit as part of cost and to interpret Π^b as supernormal ("residual") profit. As the marginal cost of quantity is zero by assumption, marginal revenue is marginal profit. Let $T, t \in (0,1)$ denote the profit tax rates applied by Home and Abroad, respectively. The tax revenues collected by Abroad and Home then are

$$g = t\frac{px}{PX+px}\sigma\Pi^b \text{ and } G = \left[T\frac{PX}{PX+px}\sigma + (1-\sigma)T\right]\Pi^b = T[1-\frac{px}{PX+px}\sigma]\Pi^b, \quad (1)$$

respectively. The monopolist maximizes profit after tax,

$$\Pi^a \equiv [1 - T - \sigma\frac{px}{PX+px}(t-T)]\Pi^b \quad (2)$$

in X, x, Q. The behavioral implications are the same as if the monopolist maximizes

$$\Pi = \Pi(X, x, Q; \theta) \equiv \frac{\Pi^a}{1-T} = PX - C(Q) + (1 - \theta\rho)px \tag{3}$$

where $\rho = \rho(X, x, Q) \equiv \frac{\Pi^b}{PX+px}$ denotes the profit-to-sales ratio and $\theta = \theta(T, t; \sigma) \equiv \sigma\frac{t-T}{1-T}$ an indicator of effective tax distortion. The latter is zero if the profit tax rates T and t are equal. A positive θ indicates distortionary taxation and a negative θ distortionary subsidization.

The objective function (3) features a monopolist charging country-specific prices. Excludability of the service's use is the basis for monopoly pricing. Without exerting market power, the cost of quality cannot be covered. Differentiating between $P(X, Q)$ and $p(x, Q)$ assumes that price discrimination by country is a technologically feasible and profit-maximizing strategy. Google Ads may serve as a prominent example. The platform traffic from non-paying users determines the quality of the service and the volumes of advertisements placed the quantities. Price discrimination is achieved through auctioning.

The first-order conditions (FOCs) associated with the maximization of profit Π are

$$(P + XP_X)[1 - \theta px\frac{\partial\rho}{\partial(PX)}] = 0 = (p + xp_x)[1 - \theta\rho - \theta px\frac{\partial\rho}{\partial(px)}] \text{ and} \tag{4}$$

$$XP_Q + (1 - \theta\rho)xp_Q + \theta px\frac{\partial\rho}{\partial Q} = C_Q\ . \tag{5}$$

Conditions (4) refer to quantities and require marginal revenues to equal zero marginal cost with respect to each country. Condition (5) refers to quality and requires the sum of marginal revenues to equal the marginal cost of quality. Because of the obvious complexity of the FOCs, the focus will be on the two special cases where the partial derivatives of ρ can largely be ignored. The first case is treated in this section and analyzes a monopolist's optimal reaction to marginal θ when θ is zero and ρ endogenous. The second case will be analyzed in the section on RPS and assumes arbitrary values of θ but constant ρ.

Ogawa (2021) points out that Pillar One has dubious efficiency effects. In the model under consideration, this is reflected in the unclear effect that a marginal change in θ has on global efficiency and the monopolist's optimal choices. To show this, we denote profit maximizing choices by $\bar{X}, \bar{x}, \bar{Q}$ and global efficiency by $W \equiv \int_0^{\bar{X}} PdX + \int_0^{\bar{x}} pdx - C(\bar{Q})$. As shown in Appendix A, the derivatives of $\bar{X}, \bar{x}, \bar{Q}$ and W, evaluated at $\theta = 0 \Leftrightarrow T = t$, are multiples of

$$\Pi_{Q\theta} = \rho\frac{P\bar{X}\cdot p\bar{x}}{P\bar{X}+p\bar{x}}\left[\frac{P_Q}{P} - \frac{p_Q}{p}\right]. \tag{6}$$

This equation reveals that the signs of the derivatives of $\bar{X}, \bar{x}, \bar{Q}$ and W depend on differences in demand elasticities of Home and Abroad. More precisely, the effects of taxation depend on the sign of the elasticity difference of the (inverse) service demands in Home and Abroad (evaluated at the monopolist's optimal choices).

Remark 1: The effects of taxation on the monopolist's optimal choices and on global efficiency are ambiguous. Their signs depend on differences in country-specific demand elasticities.

Such dependence on country-specific behavior makes it difficult to argue in favor of Pillar One. Even in the special case of equal demand elasticities, the effect on efficiency is unfavorable. If $P_Q/P = p_Q/p$, equality in tax rates, $T = t$, is not a Nash equilibrium. Abroad would benefit from marginally raising t above T. Because $dY/d\theta = 0$ for $Y \equiv \bar{X}, \bar{x}, \bar{Q}$ at $\theta = 0$, the marginal increase of t would cause no loss of consumer rent in Abroad but only gain from increased tax revenue. The inefficiency of monopoly pricing would be reinforced by distortionary taxation.

There is yet another reason to question Pillar One and this refers to the OECD guideline to align profit taxation with value creation, which Richter (2021a) argues aims at intercountry tax equity. It is precisely this objective which Pillar One does not meet. To show this, let us assume that the monopolist is able to increase sales to Home while keeping cost and sales to Abroad constant. In that case, the MNE's profit-to-sales ratio increases, $\frac{\partial \rho}{\partial (PX)} = \frac{C}{(PX+px)^2} > 0$, which induces a proportional increase of the tax base allocated to Abroad,

$$b \equiv \frac{px}{PX+px}\sigma\Pi^b = \sigma\rho \cdot px. \tag{7}$$

This runs counter to the objective of aligning profit taxation with value creation because marginal value is created in Home and yet the tax base of Abroad increases.

Remark 2: Pillar One does not meet the OECD guideline to align profit taxation with value creation.

3.2 Residual profit allocation (RPA)

The term RPA subsumes taxation schemes, which rely on separating an MNE's total profit into a "routine" and a "residual" part. The literature distinguishes between schemes according to

how that separation is implemented and the formula used to apportion residual profit among all the countries in which the MNE is active. As the present model does not differentiate between payments and imputed values questions of separation cannot be analyzed in a meaningful way. Therefore, the analysis will focus on the effects that two prominent proposals of apportionment have for efficiency and intercountry tax equity. One is by Avi-Yonah et al. (2009), who propose a sales-based apportionment of profit, and the other is by Devereux et al. (2021a), who propose an income-based apportionment of non-allocable costs. They call their scheme RPA by income, where income means residual gross income (RGI) defined as third-party revenues less allocable costs. However, as allocable costs are zero in the present model, the two methods of apportionment have equivalent effects. Home and Abroad would collect $G = T\frac{PX}{PX+px}\Pi^b$ and $g = t\frac{px}{PX+px}\Pi^b$, respectively. This is as if one were to set the parameter σ in eq. (1) at one. Eq. (3) would also remain unchanged, except that σ would have to be set at one in the definition of θ. Since Remarks 1 and 2 hold for all positive values of σ, we obtain Proposition 1. Clearly, the equivalence of RPA by sales and income no longer holds if allocable costs fail to vanish.

$Proposition$ 1: In this paper's model, RPA by sales and RPA by income

(i) are behaviorally equivalent schemes of taxation and equivalent to Pillar One when setting $\sigma = 1$;

(ii) have ambiguous effects on the monopolist's optimal choices and global efficiency and

(iii) fail to meet the OECD guideline to align profit taxation with value creation.

4. Tax withholding

Let $w \in (0, t]$ denote a withholding tax levied by Abroad on outflowing payments and let σ denote the rate by which the withholding tax is (partially) credited by Home. Abroad' tax revenue is $g = wpx$ and Home's tax revenue is $G = T[PX + px - C(Q)] - \sigma wpx$. Given such a system, the monopolist will maximize,

$$\Pi^a \equiv (1 - T)[PX + px - C(Q)] - (1 - \sigma)wpx, \tag{8}$$

which is equivalent to maximizing

$$\Pi = \Pi(X, x, Q; \theta) \equiv \frac{\Pi^a}{1-T} = PX - C(Q) + (1-\omega)px \tag{9}$$

where $\omega \equiv \frac{1-\sigma}{1-T} w$ denotes the *effective* withholding tax rate. The FOCs are

$$P + XP_X = 0 = p + xp_x \,, \tag{10}$$

$$XP_Q + (1-\omega)xp_Q = C_Q. \tag{11}$$

As before, profit maximizing variables are denoted by $\bar{X}, \bar{x}, \bar{Q}$. Profit before tax decreases in ω,

$$\frac{d}{d\omega}\, \Pi(\bar{X}, \bar{x}, \bar{Q}; \omega) = -p(\bar{x}, \bar{Q})\bar{x} = \bar{x}^2 p_x < 0. \tag{12}$$

This follows from an application of the envelope theorem and the assumption that demand is decreasing in quantity. The second-order conditions associated with maximization (9) combined with the assumption of $p_Q > 0$ imply

$$\frac{d\bar{Q}}{d\omega} < 0, \text{ while } \frac{d\bar{x}}{d\omega}, \frac{d\bar{X}}{d\omega} \leq 0 \text{ holds only if } p_Q + \bar{x}p_{xQ}, P_Q + \bar{X}P_{XQ} \geq 0 \tag{13}$$

holds additionally (see Appendix B). Hence, optimal quality decreases when the effective tax rate, ω, imposed on Abroad's profit contribution, $\pi \equiv px$, increases. The effect on quantity is less clear and the assumption that marginal revenues, $p + \bar{x}p_x, P + \bar{X}P_X$, weakly increase in Q is not innocuous. In the example of quasi-linear demand discussed further below it does not hold.

Home's social surplus is

$$S = CR + \Pi^a + G = CR + \Pi^b - wpx = CR + \Pi + (\omega - w)\pi \tag{14}$$

with $CR \equiv \int_0^{\bar{X}} PdX - \bar{X}P(\bar{X}, \bar{Q})$ denoting Home's consumer rent. Defining cr analogously, Abroad's surplus is

$$s = cr + g = cr + w\pi \,. \tag{15}$$

Without policy coordination, Home and Abroad will both seek to tax the monopolist's profit. In the case of Home, this is obvious. After all, the efficiency-preserving taxation of pure profit beckons. But Abroad also has an incentive to tax imports, thus jeopardizing tax efficiency (Brander and Spencer, 1984). The clashing incentives of Home and Abroad can only be overcome through policy coordination. In line with Article 12 B of the UN MTC, we assume

that Home and Abroad agree to set w jointly. However, this does not rule out double taxation. The Draft Commentary refers to Article 23 and expresses the expectation that the countries involved will "reduce or eliminate" double taxation by providing for exemption or crediting. The present section analyzes (partial) crediting modelled by σ when taking tax rates w, T, t as given. We wish to show that full crediting, $\sigma = 1$, is most likely to be Home's optimal choice if w is sufficiently small.

For $\sigma < 1$, maximizing Home's social surplus over σ requires optimizing over ω. By equations (14) and (12) this is equivalent to maximizing $CR - w\pi$ over ω. Since not only $CR(\bar{X}, \bar{Q})$ but also $\pi(\bar{x}, \bar{Q})$ tend to be concave, an interior solution cannot be expected to exist for ω. To obtain a better insight into the optimization problem, we consider the example of quasi-linear demand defined by $P \equiv AQ^{\alpha} - BQX$, $p \equiv aQ^{\alpha} - bQx$ and $\omega \geq 0$, $1 > \alpha > \frac{1}{2}$. (The elasticity parameter α is assumed to exceed ½ to ensure positivity of $p_Q(\bar{x}, Q)$ and $P_Q(\bar{X}, Q)$.). Proof of the following remark is to be found in Appendix C:

Remark 3: Given quasi-linear demand, it is optimal for Home to grant full crediting if

$$\mu \equiv \frac{1}{2}\frac{A\bar{X}}{a\bar{x}} = \frac{1}{2}\frac{A^2/B}{a^2/b} > w. \tag{16}$$

Let us interpret the parameter μ as an indicator of relative market size. Eq. (16) then suggests that full crediting is optimal if the withholding tax rate is sufficiently low and/or Home's market sufficiently large in comparison to Abroad's. This is because crediting eliminates the costs of tax distortion, on the one hand, but is costly for Home in terms of lost tax revenue, on the other. If w is sufficiently low, the second effect is small and the first dominant.

In the general case of non-linear demand, optimality of full crediting requires $dS/d\omega = dCR/d\omega - wd\pi/d\omega < 0$ at $\omega \geq 0$. Let us assume positivity of p_Q as before. By equations (10) and (13), $\mathrm{d}\pi/d\omega = \bar{x}p_Q d\bar{Q}/d\omega < 0$. Hence, $dS/d\omega < 0$ is only obtained at $\omega \geq 0$ if $w > 0$ is sufficiently small and $dCR/d\omega$ negative at $\omega \geq 0$.

Proposition 2: (i) It is optimal for Home to grant full crediting and to eliminate any distortive effect of taxation if w is sufficiently small and $dCR/d\omega$ negative at $\omega \geq 0$; (ii) $dCR/d\omega$ is negative at $\omega \geq 0$ if P_Q is decreasing in X and $P_Q + \bar{X}P_{QX} \geq 0$.

See Appendix D for a proof of part (ii). Note that $P_Q + \bar{X}P_{QX} \geq 0$ cannot be taken for granted. As mentioned, $P_Q + \bar{X}P_{QX} = -(1-\alpha)A\bar{Q}^{\alpha-1}$ is negative for quasi-linear demand. In the case of non-linear demand, the ratio of $dCR/d\omega$ and $d\pi/d\omega$ takes the role of the relative market size, μ.

The absence of tax distortion does not imply efficiency. Nor does it ensure a second-best policy. The production efficiency theorem does not apply, as pure profit is not completely taxed away. The monopolist must retain the ability to make sufficient profit to cover its costs and, to this end, exerts market power and charges positive prices even though marginal costs are zero.

Article 23 does not prescribe crediting, but leaves tax exemption as a possible alternative. If the two countries agreed on exemption, the monopolist would not be liable to profit taxation in Home on the profit contribution earned in Abroad. The only tax on π would be the one imposed by Abroad at rate w. Note that tax exemption amounts to partial crediting at rate $\sigma = w/T$. It could only be optimal for Home if tax rates were equal, $w = T$.

5. Residual profit splitting (RPS)

Like RPA, RPS is based on the separation of an MNE's profit into a "normal" and a "residual" part. The questions raised by separation are briefly discussed in section 5.3. Here, we focus on the formula used by RPS to apportion taxable profit and we simply speak of profit splitting. Under profit splitting, σpx is taxed by Abroad and $T[PX - C] + T(1-\sigma)px$ by Home where $\sigma \in (0,1)$ is called the splitting parameter. As shown by Richter (2021a) with reference to Shapley value theory, considerations of intercountry tax equity suggest choosing a positive value of σ that is not greater than 50 percent. Under profit splitting, profit earned on sales to Abroad is taxed at the weighted average rate $\tau \equiv (1-\sigma)T + \sigma t$ and profit splitting can thus be interpreted as partial exemption. Only the share σ of Abroad's profit contribution is exempt and not the whole contribution, as exemption normally implies.

Under profit splitting, the monopolist maximizes

$$\Pi^a \equiv (1-T)[PX - C(Q)] + [1 - (1-\sigma)T - \sigma t]px, \tag{17}$$

which is equivalent to maximizing

$$\Pi = \Pi(X, x, Q; \theta) \equiv \frac{\Pi^a}{1-T} = PX - C(Q) + (1-\theta)px \tag{18}$$

with $\theta = \sigma\frac{t-T}{1-T}$. Obviously, eq. (18) equals eq. (3) and eq. (9) when setting $\rho = 1$ and $\omega = \theta$, respectively. Therefore, the FOCs associated with the maximization of eq. (18) do not differ from those for equations (10) and (11) if ω is replaced with θ. The same holds for equations (12) and (13).

Let us assume that Home and Abroad agree on a specific value for the splitting parameter σ, though not on values for T, t. Rather, the countries set their own tax rates, taking σ as given. Obviously, rate differences are a source of tax distortion but, as explained above, elimination of distortion cannot be a policy goal. In the present model, an efficiency-oriented policy should instead favor an allocation of taxing rights, which helps to mitigate the inefficiency of monopoly pricing. We shall show that profit splitting has the potential to do so.

5.1 Non-cooperative choices of tax rates

Governments are assumed to take monopoly pricing as given and to choose tax rates by maximizing the social surplus accruing to their own country. Profit splitting is assumed throughout. Home's social surplus is

$$S = CR + \Pi^a + G = CR + \Pi + (\theta - \sigma t)\pi \tag{19}$$

where $\pi = p(\bar{x}, \bar{Q})\bar{x}$ is profit earned before tax on sales to Abroad. As $\frac{\partial\theta}{\partial T} = -\sigma\frac{1-t}{(1-T)^2} < 0$, maximization of social surplus in T is equivalent to minimization in θ. The FOC is

$$0 = \frac{dS}{d\theta} = \frac{d}{d\theta}CR + \frac{d\Pi}{d\theta} + \pi + (\theta - \sigma t)\frac{d\pi}{d\theta} = \frac{d}{d\theta}CR - \sigma\frac{1-t}{1-T}T\frac{d\pi}{d\theta}.^3 \tag{20}$$

The condition reveals that Home faces a trade-off between two effects when optimizing over θ. One is the change in its consumer rent and the other the change in profit lost. There are two sources of profit loss. One is tax revenue collected by Abroad, shown in pure form if tax rates are equal, in which case $\theta - \sigma t = -\sigma t = -\sigma T$ holds. The change in tax revenue collected by Abroad equals $\sigma t\pi_\theta$ if $T = t$. The other source of profit lost is tax inefficiency, shown in pure form if $t = 0$, in which case $\theta - \sigma t = \theta = -\sigma\frac{T}{1-T}$ holds. The monopolist's optimal choice of quality is distorted if $T > 0 = t$. The term $\sigma\frac{T}{1-T}\pi_\theta$ captures the change in Home's welfare

[3] The second-order conditions (SOCs) are assumed to be fulfilled when Home and Abroad optimize.

resulting from inefficient taxation. Home's tax planner has to trade the change in CR off against the change in the profit that is lost for Home. The existence of an interior solution of T requires negativity of $dCR/d\theta$, which is ensured under conditions stated in Proposition 2 (ii).

The social surplus of Abroad, s, is the sum of consumer rent, cr, and tax revenue, $\sigma t\pi$. The FOC of maximizing s in tax rate t yields

$$0 = \frac{d}{dt}s = \left[\frac{d}{d\theta}cr + \sigma t\frac{d\pi}{d\theta}\right]\frac{d\theta}{dt} + \sigma\pi = \left[\frac{d}{d\theta}cr + \sigma t\frac{d\pi}{d\theta}\right]\frac{\sigma}{1-T} + \sigma\pi. \qquad (21)$$

The last term on the right-hand side of eq. (21) is the marginal increase in Abroad's tax revenue if the tax base is constant. The increase is clearly positive. The existence of an interior solution for $t \in (0,1)$ therefore requires negativity of the sum of the terms in square brackets. Such negativity holds if $dcr/d\theta$ is negative. We call a pair of tax rates (T^N, t^N) a *Nash equilibrium* if the rates are solutions of the system of FOCs (20) and (21).

Proposition 3: (i) If p_Q is positive and the derivatives of CR, cr w.r.t. θ are negative, a Nash equilibrium exists with $T^N \in (0,1)$.

(ii) If $\tilde{\mu} \equiv \frac{dCR/d\theta}{d\pi/d\theta} > \sigma$, then $T^N > t^N$.

The proof is given in Appendix E. The intuition for part (ii) is the following. Home could equate T to $t < 1$, in which case taxation would be non-distortionary. By setting T marginally above the level of t, the production of quality is effectively subsidized, which is beneficial for global efficiency. It remains to show that the marginal decrease in consumer rent, $dCR/d\theta$, is smaller than the marginal decrease in the amount of profit which is lost for Home, $\sigma T \cdot d\pi/d\theta$. Under the stated assumptions, this is ensured as $\tilde{\mu} > \sigma > \sigma T \Longrightarrow dCR/d\theta < \sigma T \cdot d\pi/d\theta$.

In section 4 we mentioned that the case of quasi-linear demand suggests interpreting $\tilde{\mu}$ as an indicator of relative market size. Therefore, the assumption of Proposition 3 (ii), $\tilde{\mu} > \sigma$, requires the market of Home to be sufficiently large. This is not unrealistic. It makes sense to assume that the monopolist is domiciled in a sufficiently large country. More critical is the assumption that the policy of Abroad has a noticeable effect on equilibrium quality. If Abroad stands alone against Home, this is plausible. If, on the other hand, Home serves many small countries, the

effect of each individual country's policy could be vanishing. In that case, it would be more likely that a market country would raise the tax rate t to one hundred percent (Richter, 2021b).

5.2 The case of quasi-linear demand

Assuming quasi-linear demand, $P \equiv AQ^{\alpha} - BQX, p \equiv aQ^{\alpha} - bQx$, $1 > \alpha > \frac{1}{2}$, and solving the monopolist's FOC for $\bar{X}$ yields $\bar{X} = \frac{1}{2B} A\bar{Q}^{\alpha-1} > 0$. Willingness to pay for marginal quality, $P_Q(\bar{X}, \bar{Q}) = \left(\alpha - \frac{1}{2}\right) A\bar{Q}^{\alpha-1}$ is positive which, by replacing ω with θ in eq. (13), implies $d\bar{Q}/d\theta < 0$. As already mentioned, non-negativity of $P_Q + \bar{X}P_{QX} = -(1-\alpha)A\bar{Q}^{\alpha-1}$ cannot be proven. Rather, the sign is negative, which, again by eq. (13), implies $d\bar{X}/d\theta > 0$. Still, for quasi-linear demand, $CR, cr,$ and π are decreasing functions of θ (see Appendix C). In particular, $dcr/d\theta = \frac{1}{2} d\pi/d\theta$ is obtained.

For quasi-linear demand, Home's FOC (20) takes the form

$$\sigma \frac{1-t}{1-T} T = \mu, \tag{20'}$$

where the parameter μ is the indicator of relative market size (see eq. (16)). Equally, Abroad's FOC (21) takes the form

$$\frac{1-T}{\frac{1}{2}+\sigma t} = -\frac{1}{\pi} \frac{d\pi}{d\theta} > 0. \tag{21'}$$

The right-hand side of eq. (21') depends on $\bar{Q}$ and thus on C_Q. The determination of the Nash equilibrium, (T^N, t^N), is considerably simplified when setting $C_Q \equiv \gamma Q^{\gamma-1}, \gamma \geq 2$. In this case, eq. (21') can be rewritten as the following eq. (22), as shown in Appendix F:

$$\frac{1-T}{\frac{1}{2}+\sigma t} = \frac{2\alpha-1}{(\gamma+1-2\alpha)(2\mu+1-\theta)}. \tag{22}$$

The pair of tax rates, (T^N, t^N), is a Nash equilibrium if it is a solution of the system of equations (20') and (22). By Proposition 3, a pair exists with t^N being smaller than $T^N \in (0,1)$. The value of $\theta^N \equiv \sigma \frac{t^N - T^N}{1-T^N}$ is therefore negative and the production of quality, $\bar{Q}$, is effectively subsidized in equilibrium. However, a decrease of quantities, $\bar{X}, \bar{x}$, cannot be ruled out. Therefore, while one would conjecture an increase in global efficiency, this is not obvious. Appendix G analyzes

this question for quasi-linear demand in more detail. It is shown that θ^N is not smaller than $-\mu-\frac{1}{2}$ and that $W \equiv \int_0^{\bar{X}} PdX + \int_0^{\bar{x}} pdx - C(\bar{Q})$ decreases in θ for all $\theta \geq -\mu-\frac{1}{2}$. Hence, W evaluated at θ^N must exceed W at $\theta = 0$.

Proposition 4: For quasi-linear demand, $\gamma \geq 2$ and $\mu \geq \sigma$, the negative effect which monopoly pricing has on global efficiency is mitigated by taxation.

It is equally shown in Appendix G that T^N increases in μ and decreases in σ. This makes sense. The larger Home's market share is, the higher Home's optimal tax rate will be. Market power thus translates into tax power. Tax power, on the other hand, is reduced when the share of profit, σ, earned in, and taxed by, Abroad increases. In contrast to the effects of μ and σ on T^N, those on t^N are ambiguous in sign. Hence, it is not clear whether t^N increases or decreases if μ or σ increase. Under the stated assumptions, part (ii) of Proposition 3 only tells us that t^N is necessarily smaller than T^N. Finally, it should not go unmentioned that effective subsidization ensures that the monopolist makes profit after tax and not a loss. This follows from eq. (18).

5.3 Implementing RPS

If the marginal costs of remote sales vanish, as assumed in the model-based analysis, RPS can be implemented straightforwardly through a combination of withholding taxation and partial exemption. Abroad would need to be entitled to withhold $t\sigma px$ while Home would be required to exempt σpx. The existence of positive allocable costs complicates matters, as they would have to be exempted from taxation. Administratively, the simplest way to do this would be to deduct costs at standardized rates. If the result were not deemed satisfactory by tax authorities, a detailed assessment would be necessary to determine the residual profit contribution, as is the case when the source country hosts a permanent establishment.

Under current law, international profit taxation is based on separate entity accounting (SEA) and RPS is not designed to challenge this. SEA requires arm's length pricing of transactions carried out by a permanent establishment with affiliated companies. Ideal transfer prices are uncontrolled, as found under perfect market conditions. Since market prices reflect marginal

costs, SEA poses problems whenever imputed (marginal) costs are zero, as is the case when intangible assets are used. Current tax law leaves wide scope for pricing intangible assets, which invites profit-shifting activities (Grubert, 2003; Karkinsky and Riedel, 2012). [4] Unitary taxation is an attempt to remove the incentive to misprice intangible assets and their use. Under unitary taxation, intra-group payments have no effect on group profit and profit shifting generates no tax benefit. However, the policy price is high, since the tax assessment of all costs and income must be coordinated internationally. RPS is less demanding, as it accepts SEA and arm's length pricing whenever imputed (marginal) costs are positive. Imputed costs will be positive if the production factors to be priced are rival in use, such as land, labor, and capital. In contrast, the imputed cost of the non-rival use of rights and services is zero. In cases of zero imputed costs, RPS not only obviates the need for pricing, it no longer recognizes intra-group payments for tax purposes. The profit obtained by deducting from revenues only the imputed costs for the rival use of production factors is residual by definition.[5] Under RPS, a company-independent key is used to apportion the residual profit earned in source country S among S and all those countries hosting affiliated companies that developed non-rival rights and services used in S by an affiliated company or sold in S to third parties (Richter, 2021a).

If RPS were implemented internationally, profit-shifting activities would be limited to rival production factors. Particular focus would be on the financing of investments with debt and equity and on intentional departures from arm's length pricing, such as with accelerated depreciation. Whether such loopholes should be closed is primarily a political question. As a rule, they only allow the shifting of normal profits or the deferral of tax payments and it could therefore be argued that they need not be the focus of international tax policy. However, if the practice of shifting profit through financing decisions were to be stopped, this goal could best be reached by limiting the right to tax the returns from rival production factors to those countries that incur the opportunity cost of supply. To a great extent, this is in line with current practice, with land taxed at source, labor taxed in the supplier's country of residence, and interest taxed in the lender's country of residence. The main discrepancy concerns equity. Under current law, the return on equity is taxed where business is carried out and not where the supplier of capital

[4] According to Grubert (2003), income derived from R&D based intangibles accounts for about half of the income shifted from high-tax to low-tax countries.

[5] Because of differential methods of determination, residual profit under RPS is not residual profit under RPA. In both cases residual profit is what remains when deducting normal profit from the profit determined by SEA. However, Pillar One and Devereux et al. (2021a) determine normal profit by common transfer pricing techniques, e.g. as a markup on (certain) expenses. In contrast, RPS sets normal profit equal with accounting profit determined as the difference between imputed costs and payments for the inputs that are rival in use.

is resident. This would need to be changed to stop the financing of investment being used to shift profits.

6. Destination-based cash flow taxation (DBCFT)

DBCFT has two components. The "cash flow" taxes the surplus of revenues over expenditures as they accrue. The "destination-based" element introduces border adjustments: exports are untaxed, while imports are taxed (Devereux et al., 2021b). In the simple model used in this paper, net profit after DBCFT equals $\Pi^a \equiv (1-T)[PX - C(Q)] + (1-t)px$. Obviously, this is eq. (17) at $\sigma = 1$. This means that DBCFT is equivalent to the degenerate version of profit splitting, where profit earned from monopolized export is only taxed by the importing countries. This might seem particularly advantageous for market countries, but the picture looks different when their exports are included in the analysis. Then it becomes clear that tax revenues from imports must be netted with wage subsidies paid for exports. If these export goods are only produced with labor and if Abroad maintains an equilibrium in trade, then Abroad needs all the revenue collected from taxing imports to subsidize the labor cost of exports. In other words, Abroad does not effectively participate in the taxation of the profit contributed when Home's monopolist expands sales to Abroad. This is very different from profit splitting. The explanation is that the DBCFT is effectively a tax imposed on residents' lump-sum income (Frenkel et al., 1991, Chap. 4; Auerbach and Devereux, 2018). It has the merit that the distortions created by profit taxation are eliminated. Its drawback is that it fails to achieve the objective of Pillar One: market countries will derive no particular net benefit from the right to tax imports. The price they have to pay is to subsidize exports.

Proposition 5: The DBCFT

(i) grants market countries the right to tax imports at the price of subsidizing exports;

(ii) eliminates any distortions from profit taxation;

(iii) does not meet Pillar One's objective.

7. Summary and conclusions

It is widely recognized that the current taxation of MNEs is in need of reform in order to cope with the challenges raised by the digitalization of the economy. The OECD has brought almost 140 countries together to draft proposals grouped into two pillars. This paper deals with those made under Pillar One. The agreed policy objective of granting market countries the right to tax contributed profit at source is taken as given. However, the proposed method of implementation is questioned. The method assumes unitary taxation and a multinational agreement on jointly applicable rules for determining group profit. With no example of such an agreement yet available in the international sphere, it is doubtful that the necessary rules of determination will be agreed upon within a reasonable time. Additional arguments against Pillar One are that the proposed implementation, firstly, does not really meet the OECD guideline to align profit taxation with value creation and, secondly, has unclear efficiency effects. This paper uses the same arguments to dismiss residual profit allocation (RPA) by sales or income, which are two related options for reform proposed in the literature (Proposition 1).

From the three remaining reform options discussed in this paper, DBCFT is dismissed because it fails to meet Pillar One's policy objective (Proposition 5). Under it, market countries do not effectively participate in the taxation of the monopoly profits that MNEs earn from the supply of non-rival services, since they are expected simultaneously to subsidize the labor cost of exports. An appealing feature of DBCFT is that, if internationally adopted, the taxation of profit would not be distortionary. However, this is a debatable advantage as non-distortionary profit taxation is not necessarily second best efficient when private profits are not completely taxed away.

The same reservation applies to tax withholding (Article 12B UN MTC) combined with full tax crediting. Non-distortionary international profit taxation will not necessarily enhance global efficiency. Despite this, tax withholding has some attractive features. First, it allows profit taxation to be aligned with value creation in the axiomatic sense of Richter (2021a). Secondly, its introduction can be made the subject of bilateral agreements. There is no need to wait for a multinational accord on common rules for determining group profit. Yet there are drawbacks, too. First, a withholding tax is problematic if it is levied on costs. This would have to be taken into account if, unlike Article 12B, a withholding tax were also to be levied on payments to which allocable costs can be attributed. It would then be necessary to consider deducting those costs from the withholding tax base – either through assessment or through negotiated standardized rates. However, netting would compromise the administrative simplicity, which

generally speaks in favor of withholding taxation. Secondly, it must be seen that a withholding tax levied only on imported non-rival services can easily be avoided by establishing nexus. This is particularly relevant for market countries with high withholding and profit tax rates. In such cases, an MNE can establish a permanent establishment in the market country and siphon off profit contributions through royalties paid to an affiliated company located in a low-tax country. Therefore, withholding taxation cannot be the full answer to the challenges of the digital economy; it is at best a partial solution and needs to be complemented by a fundamental reform of the taxation of license fees and, more generally, of income from intangible assets.

By contrast, residual profit splitting (RPS) offers a comprehensive solution to the challenges of digitalization. It involves two major changes: Firstly, payments made between affiliated companies for the non-rival use of excludable rights and services are no longer recognized items in taxation. Secondly, a company-independent key is used to apportion residual profit earned in source country S among S and all those countries hosting affiliated companies that developed non-rival rights and services used in S by an affiliated company or sold in S to third parties. If only two countries are involved, this means that the profit contribution that an MNE earns by expanding operations into a market country is simply split between that country and the MNE's home country. Drawing on Shapley's theory of value, Richter (2021a) shows that RPS can be justified axiomatically and the axioms can be interpreted in terms of the OECD guideline to align profit taxation with value creation. Moreover, RPS has a number of additional appealing features. Firstly, informational requirements for implementing RPS are low. There is no need to assess an MNE's group profit or the tax value of intangible assets that are non-rival in use. Secondly, the non-recognition for tax purposes of payments made between affiliated companies for the non-rival use of rights and services eliminates a key instrument of profit-shifting activities by MNEs. Thirdly, RPS enhances resilience to tax competition for the location of research and development. This is because average tax rates replace the role of tax rate differentials in location decisions (Richter, 2021b). Fourthly and finally, RPS has the potential to enhance global efficiency. More precisely, this paper has shown for a two-country model that the negative effect which monopoly pricing has on global efficiency is mitigated by the effective subsidization of international profit taxation. This result is obtained when demand is quasi-linear, the profit tax of the market country has a negative effect on the quality of the imported service, and the country hosting the monopolist is sufficiently large in relative terms (Proposition 4).

While these are promising results, they are, of course, derived from a highly stylized model, which fails, for example, to take into account distortionary capital taxation. The assumptions that the remote supply of services is monopolized and that the market country's profit tax has a negative effect on the quality of the imported service are also undoubtedly simplistic. Future research will need to ascertain how robust the results are to model generalizations. Policy makers should bear this in mind and draw their conclusions with due caution.

8. Appendices

A) The derivatives $\frac{dY}{d\theta}\Big|_{\theta=0}$ are obtained for $Y \equiv \bar{X}, \bar{x}, \bar{Q}, W$ by solving the following system of equations

$$\begin{bmatrix} 2P_X + \bar{X}P_{XX} & 0 & P_Q + \bar{X}P_{QX} \\ 0 & 2p_x + \bar{x}p_{xx} & p_Q + \bar{x}p_{xQ} \\ P_Q + \bar{X}P_{QX} & p_Q + \bar{x}p_{xQ} & \bar{X}P_{QQ} + \bar{x}p_{QQ} - C_{QQ} \end{bmatrix} \begin{bmatrix} \frac{d\bar{X}}{d\theta} \\ \frac{d\bar{x}}{d\theta} \\ \frac{d\bar{Q}}{d\theta} \end{bmatrix} = \begin{bmatrix} 0 \\ 0 \\ -\frac{\partial^2 \Pi}{\partial Q \partial \theta}\Big|_{\theta=0} \end{bmatrix} \tag{A.1}$$

with

$$-\frac{\partial^2 \Pi}{\partial Q \partial \theta}\Big|_{\theta=0} = \rho \bar{x} p_Q - p\bar{x}\frac{\partial \rho}{\partial Q} = \rho \bar{x} p_Q - p\bar{x}\left[\frac{C_Q}{P\bar{X}+p\bar{x}} - C(Q)\frac{P_Q\bar{X}+p_Q\bar{x}}{(P\bar{X}+p\bar{x})^2}\right] \tag{A.2}$$

$$= \rho \bar{x} p_Q - p\bar{x}\left[\frac{P_Q\bar{X}+p_Q\bar{x}}{P\bar{X}+p\bar{x}} - (1-\rho)\frac{P_Q\bar{X}+p_Q\bar{x}}{P\bar{X}+p\bar{x}}\right] = \rho \bar{x} p_Q - \rho p\bar{x}\frac{P_Q\bar{X}+p_Q\bar{x}}{P\bar{X}+p\bar{x}}$$

$$= \rho \frac{P\bar{X}\cdot p\bar{x}}{P\bar{X}+p\bar{x}}\left[\frac{p_Q}{p} - \frac{P_Q}{P}\right] \equiv -\Pi_{Q\theta}\ . \tag{A.3}$$

By Cramer's rule, $\frac{dY}{d\theta}\Big|_{\theta=0}$ is a multiple of $\Pi_{Q\theta}$ for $Y = \bar{X}, \bar{x}, \bar{Q}$. *A fortiori*, $\frac{dW}{d\theta}\Big|_{\theta=0}$ is a multiple of $\Pi_{Q\theta}$ from which Remark 1 follows. □

B) The derivatives $Y_\omega \equiv \frac{dY}{d\omega}$ with $Y = \bar{X}, \bar{x}, \bar{Q}$ are obtained by solving the following system of equations

$$\begin{bmatrix} 2P_X + \bar{X}P_{XX} & 0 & P_Q + \bar{X}P_{QX} \\ 0 & 2p_x + \bar{x}p_{xx} & p_Q + \bar{x}p_{xQ} \\ P_Q + \bar{X}P_{QX} & (1-\omega)(p_Q + \bar{x}p_{xQ}) & \bar{X}P_{QQ} + (1-\omega)\bar{x}p_{QQ} - C_{QQ} \end{bmatrix} \begin{bmatrix} \bar{X}_\omega \\ \bar{x}_\omega \\ \bar{Q}_\omega \end{bmatrix} = \begin{bmatrix} 0 \\ 0 \\ \bar{x}p_Q \end{bmatrix}. \tag{B.1}$$

The second-order conditions imply negativity of $2P_X + \bar{X}P_{XX}$, $2p_x + \bar{x}p_{xx}$, and the determinant of the Hessian matrix D. Referring to Cramer's rule and assuming $p_Q > 0$ we obtain,

$$\frac{d\bar{Q}}{d\omega} = \bar{x}p_Q[2P_X + \bar{X}P_{XX}][2p_x + \bar{x}p_{xx}]/D < 0\,, \tag{B.2}$$

$$\frac{d\bar{X}}{d\omega} = -\bar{x}p_Q\left[P_Q + \bar{X}P_{QX}\right][2p_x + \bar{x}p_{xx}]/D \leq 0 \iff P_Q + \bar{X}P_{QX} \geq 0, \tag{B.3}$$

For reasons of symmetry, $d\bar{x}/d\omega \leq 0 \iff p_Q + \bar{x}p_{Qx} \geq 0$.□

C) If demand is quasi-linear, $P = AQ^{\alpha} - BQX$, $p = aQ^{\alpha} - bQx$, with $1 > \alpha > 1/2$, then

(i) $$\bar{X} = \frac{A}{2B}Q^{\alpha-1},\ \bar{x} = \frac{a}{2b}Q^{\alpha-1} \tag{C.1}$$

(ii) $$\pi = \bar{x}p = \frac{1}{4b}a^2\bar{Q}^{2\alpha-1} \tag{C.2}$$

(iii) $$CR = \int_0^{\bar{X}} PdX - \bar{X}P(\bar{X},\bar{Q}) = \left[A\bar{Q}^{\alpha}\bar{X} - \frac{1}{2}B\bar{Q}\bar{X}^2\right] - \bar{X}[A\bar{Q}^{\alpha} - B\bar{Q}\bar{X}]$$

$$= \frac{1}{2}B\bar{Q}\bar{X}^2 = \frac{1}{8B}A^2\bar{Q}^{2\alpha-1}. \tag{C.3}$$

Obviously, $CR - w\pi$ is increasing in $\bar{Q}$ if $\frac{1}{8B}A^2 > \frac{w}{4b}a^2$ from which Remark 3 follows. For later reference, we note that the derivative $\frac{dY}{d\bar{Q}}$ is positive and $Y(\bar{Q}(\omega))$ therefore decreasing in ω for $Y = CR, cr, \pi$. □

D) Proposition 2 (ii) requires to show

$$0 > \frac{d}{d\omega}CR = \left[\int_0^{\bar{X}} P_Q dX - \bar{X}P_Q\right]\bar{Q}_{\omega} - \bar{X}P_X\bar{X}_{\omega}\,. \tag{D.1}$$

After dividing this inequality through by $\bar{Q}_{\omega} < 0$ and reducing the inequality is equivalent to

$$0 < \int_0^{\bar{X}} P_Q dX - \bar{X}P_Q + \frac{P_Q + \bar{X}P_{QX}}{2P_X + \bar{X}P_{XX}}\bar{X}P_X. \tag{D.2}$$

By assumption and second-order condition, the last term on the right-hand side (RHS) is non-negative. As P_Q is decreasing in X, $\int_0^{\bar{X}} P_Q dX > \bar{X}P_Q$. Hence, inequality (D.1) holds.□

E) To show the existence of a Nash equilibrium (T^N, t^N) it is necessary to find a solution of the system of Home's and Abroad's FOCs (20) and (21), respectively. Rewriting eq. (20) yields

$$(\sigma-\theta)T=\sigma\frac{1-t}{1-T}T=\tilde{\mu}=\frac{dCR/d\theta}{d\pi/d\theta}>0. \tag{E.1}$$

The RHS of eq. (E.1) is constant in θ, t, T. Therefore, $t \to 1$ and $\theta \to const$ if $T \to 1$. Solving eq. (E.1) for σtT, and inserting in eq. (21) yields

$$(1-T)\tilde{\mu}=T\left[\sigma+\frac{dcr/d\theta}{d\pi/d\theta}\right]+T(1-T)\frac{\pi}{d\pi/d\theta} \tag{E.2}$$

For $T \to 1$, the LHS and the last term on the RHS tend to zero. The bracketed expression on the RHS tends to a positive constant. Therefore, eq. (E.2) holds with " $<$ " for large values of $T < 1$. For $T \to 0$, the LHS tends to a positive constant. On the RHS, the product of T and the bracketed expression tend to zero. As the last term on the RHS is negative for small values of $T > 0$, eq. (E.2) holds with " $>$ " for small values of $T > 0$. By the intermediate value theorem, some $T^N \in (0,1)$ must exist with $LHS = RHS$. This proves Proposition 3 (i). If $\tilde{\mu} > \sigma$, eq. (E.2) implies $\theta < 0$ in equilibrium. Therefore, $T > t$, which proves (ii). □

F) Assume $C_Q \equiv \gamma Q^{\gamma-1}, \gamma \geq 2$. By equations (29), $\bar{X}P_Q = (\alpha-\frac{1}{2})\frac{A^2}{2B}\bar{Q}^{2(\alpha-1)}$. For quasi-linear demand and ω replaced with θ, eq. (11) can be written as

$$\left(\alpha-\frac{1}{2}\right)\frac{1}{2}\left[\frac{A^2}{B}+(1-\theta)\frac{a^2}{b}\right]\bar{Q}^{2(\alpha-1)}=\gamma\bar{Q}^{\gamma-1} \tag{F.1}$$

which implies $\frac{d\bar{Q}}{d\theta}=-\frac{\bar{Q}}{[2\mu+1-\theta](\gamma+1-2\alpha)}$ and

$$-\frac{1}{\pi}\frac{d\pi}{d\theta}=-\frac{1}{\pi}\frac{d\pi}{d\bar{Q}}\frac{d\bar{Q}}{d\theta}=\frac{2\alpha-1}{(\gamma+1-2\alpha)(2\mu+1-\theta)}. \tag{F.2}$$

Plugging this expression into eq. (21') yields eq. (22). □

G) By relying on Appendix C, global efficiency can be expressed as a function of $\bar{Q}$:

$$W(\bar{Q})=\int_0^{\bar{X}}PdX+\int_0^{\bar{x}}pdx-C(\bar{Q})=\frac{3}{8}\left[\frac{A^2}{B}+\frac{a^2}{b}\right]\bar{Q}^{2(\alpha-1)}-\bar{Q}^{\gamma} \tag{G.1}$$

with $\bar{Q}$ being a solution of eq. (F.1). Solving eq. (F.1) for $\bar{Q}$ and inserting in eq. (G.1) yields

$$W\left(\bar{Q}(\theta)\right)=\frac{[\frac{3\gamma}{4(\alpha-1/2)}-1](2\mu+1)+\theta}{2\mu+1-\theta}\bar{Q}^{\gamma} \tag{G.2}$$

Taxation increases global efficiency if $W\left(\bar{Q}(\theta^N)\right) > W(\bar{Q}(0))$. A sufficient condition requires $\frac{d}{d\theta}W\left(\bar{Q}(\theta)\right)$ to be negative for all negative values of θ in the interval $[\theta^N, 0]$. By some tedious calculations, it can be shown show that $\frac{d}{d\theta}W\left(\bar{Q}(\theta)\right) < 0$ holds for all $\theta > -\mu - \frac{1}{2}$. Therefore it remains to show that $\theta^N > -\mu - \frac{1}{2}$. In order to prove this, it is necessary to compute T^N and t^N. Solving eq. (20') for $t = 1 - \frac{\mu}{\sigma}(\frac{1}{T} - 1)$, inserting in eq. (22) and rearranging yields

$$\gamma\sigma T - \gamma\mu(1-T) = (\gamma + 1 - 2\alpha)[2\mu(1-T) + 1 - (1-\sigma)T]T - (\alpha - \frac{1}{2})T \quad \text{(G.3)}$$

which is quadratic in T. By solving this equation for T^N and going through some straightforward but tedious calculations one obtains $T^N > \mu/(\mu + \sigma + \frac{1}{2}) \Leftrightarrow \mu + \frac{1}{2} > 0$. By relying again on eq. (20'), $(\sigma - \theta^N)T^N = \sigma\frac{1-t^N}{1-T^N}T^N = \mu$, one finally obtains

$$T^N > \frac{\mu}{\mu+\sigma+\frac{1}{2}} \Leftrightarrow \theta^N > -\mu - \frac{1}{2}, \quad \text{(G.4)}$$

which was to be proved. Implicit differentiation of eq. (G.3) implies

$$\frac{d}{d\mu}T^N = \frac{\gamma\left(\frac{1-T}{T}\right)+2(\gamma+1-2\alpha)(1-T)}{\gamma\mu T^{-2}+(\gamma+1-2\alpha)[2\mu+(1-\sigma)]} > 0 \text{ and} \quad \text{(G.5)}$$

$$\frac{d}{d\sigma}T^N = -\frac{\gamma(1-T)+(2\alpha-1)T}{\gamma\mu T^{-2}+(\gamma+1-2\alpha)[2\mu+(1-\sigma)]} < 0, \quad \text{(G.6)}$$

as claimed in the text. □

9. References

Auerbach, A.J., Devereux, M.P., 2018. Cash-Flow Taxes in an International Setting, *American Economic Journal: Economic Policy* 10, 69-94.

Avi-Yonah, R.S., Clausing, K.A., Durst, M. C., 2009. Allocating Business Profits for Tax Purposes: A Proposal to Adopt a Formulary Profit Split, *Florida Tax Review* 9, 497-553.

Brander, J.A., Spencer, B.J., 1984. Trade Warfare: Tariffs and Cartels, *Journal of International Economics* 16, 227-242.

Bunn, D., Asen, E., Enache, C., 2020. Digital Taxation around the World, Tax Foundation.

Collier, R.S., Devereux, M.P., Vella, J., 2021. Comparing Proposals to Tax Some Profit in the Market Country, *World Tax Journal* 13, No. 3.

Cui, W., Hashimzade, N., 2019. The Digital Services Tax as a Tax on Location-Specific Rent, CESifo WP 7737

De Mooij, R., Liu, L., Prihardini, D., 2021. An Assessment of Global Formula Apportionment, *National Tax Journal* 74, 431-465.

Devereux, M.P., Auerbach, A.J., Keen, M., Oosterhuis, P., Schön, W., Vella, J., 2021a. *Taxing Profit in a Global Economy*, Chap. 6: Residual Profit Allocation by Income, Oxford University Press, 189-265.

Devereux, M.P., Auerbach, A.J., Keen, M., Oosterhuis, P., Schön, W., Vella, J., 2021b. *Taxing Profit in a Global Economy*, Chap. 7: Destination-Based Cash Flow Taxation, Oxford University Press, 267-333.

European Commission, 2011. Proposal for a Council Directive on a Common Consolidated Corporate Tax Base (CCCTB), Brussels, COM (2011) 121/4.

Finke, K., Fuest, C., Nusser, H., Spengel, C., 2014. Extending Taxation of Interest and Royalty Income at Source: An Option to Limit Base Erosion and Profit Shifting? ZEW Discussion Papers 14-073.

Frenkel, J.A., Razin, A., Sadka, E., 1991. *International Taxation in an Integrated W*orld, The MIT Press, Cambridge, Mass.

Fuest, C., Spengel, C., Nicolay, K., Heckemeyer, J.H., Nusser, H., 2013. Profit Shifting and 'Aggressive' Tax Planning by Multinational Firms: Issues and Options for Reform, *World Tax Journal* 5, 307-324.

Grubert, H., 2003. Intangible Income, Intercompany Transactions, Income Shifting, and the Choice of Location, *National Tax Journal* LVI, 221-242.

Karkinsky, T., Riedel, N., 2012. Corporate Taxation and the Location of Patents Within Multinational Firms, *Journal of International Economics* 88, 176-185.

Mintz, J., Weiner, J.M., 2003. Exploring Formula Allocation for the European Union, *International Tax and Public Finance* 10, 695-711.

OECD, 2019. Programme of Work to Develop a Consensus Solution to the Tax Challenges Arising from the Digitalisation of the Economy, OECD/G20 Inclusive Framework on BEPS, OECD, Paris.

OECD, 2021. Statement on a Two-Pillar Solution to Address the Tax Challenges Arising from the Digitalisation of the Economy, OECD/G20 Base Erosion and Profit Shifting Project, Paris.

Ogawa, H., 2021. Still Under-Taxing the Digital MNE? Assessing Tax Principles of Pillar One in the BEPS Project, Discussion Paper CIRJE-F-1161.

Richter, W.F., 2021a. Aligning Profit Taxation with Value Creation, *World Tax Journal* 13, 3-23.

Richter, W.F., 2021b. The Taxation of Digital Services as a Rent-Extracting Policy, *FinanzArchiv/Public Finance Analysis* 77, 225-246.