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Abstract

The OECD seeks to align transfer pricing and profit taxation with value creation but fails to provide a clear definition. This paper argues that value creation requires international cooperation and that the profit tax base should therefore be allocated according to standards commonly considered as fair when distributing the surplus of cooperation. The claim that current rules of international profit taxation are aligned with value creation is rejected. If anything, the OECD's objective suggests a tax system in which profits are split between the involved jurisdictions. This result triggers the question of possible implementation which is discussed in some detail.

JEL-Codes: H250, F230, M480.

Keywords: international corporate income taxation, intellectual property, value creation, Shapley value, profit splitting.

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There are two remotely related but obsolete papers written by the same author. One is titled “Taxing Intellectual Property in the Global Economy: A Plea for Regulated and Internationally Coordinated Profit Splitting” and can be found as CESifo WP 6564. The other is titled “Taxing Direct Sales of Digital Services: A Plea for Regulated and Internationally Coordinated Profit Splitting” and can be found as CESifo WP 7017.

1. Introduction

In 2013, OECD and G20 countries adopted a 15-point Action Plan to address base erosion and profit shifting (BEPS) in the taxation of multinational enterprises (MNEs). A key objective was to align transfer pricing outcomes with value creation, however, a definition of “value creation” was not provided (Olbert et al., 2017). In a more recent study, the OECD (2018a) reveals a narrow understanding. Current rules are interpreted to mean that taxable value is only created through the economic activity of enterprises. User participation, public infrastructure, law enforcement and so forth are not acknowledged sources of value creation. A jurisdiction’s right of taxation is solely derived from the hosting of the taxed enterprise. There must be “nexus”.

The international failure to clarify the concept of value creation has been used by various countries to stretch current standards of corporate income taxation and to invent new taxes with the alleged objective to address tax challenges raised by digitalization. Examples are listed in Chap. 4 of OECD (2018a). The European Commission (2017, 2018), for instance, proposes to introduce a Digital Sales Tax with the argument to tax services where the “main value” is claimed to be “created through user participation”. The ad-hoc character of the justification shows the dire need to clarify the meaning of value creation before it can be used in international tax policy.

The present paper contributes to clarification by drawing on cooperative game theory. It is argued that the design and enforcement of international taxation require the legal cooperation of jurisdictions. There would be no international value creation of multinational enterprises (MNEs) if the countries in which the MNEs are active did not cooperate on legal issues. If this view is accepted, it, however, makes little sense to constrain the notion of value creation to the economic activity of enterprises. The ultimate source of value is international cooperation and the proceeds should be distributed according to standards commonly considered as fair and equitable when distributing the surplus of cooperation. At least, this should be the general rule to be overridden only in case of compelling reasons.

By drawing on cooperative game theory in general and on the Shapley (1953) value theory, in particular, this paper argues that intercountry equity in taxation requires splitting the profit which an MNE earns in a foreign country between the countries involved. The existence of a permanent establishment should not be necessary for claiming the right of taxation. This implication is a first indication that this paper’s terminological use of “profit splitting” differs from its traditional use. As a matter of fact, the use is much broader. The OECD (2018b) only

accepts profit splitting as a method of transfer pricing in controlled transactions between affiliated companies when each one makes a “unique and valuable contribution”. In this paper, the companies need not be affiliated. The Shapley approach even suggests some further notable deviations from the current tax system. For instance, the prominent role of the residence and source principles in international taxation is questioned. Another implication is that expenditures made for the use of intellectual property should not be deductible under profit taxation which they presently are. All this shows that the implications for tax policy would be far-reaching if the OECD’s declared objective of aligning taxation with value creation were taken serious and given a consistent interpretation according to accepted principles of cooperative game theory.

The literature related to the present paper is sparse. As indicated, the notion of value creation is not firmly established in OECD publications. Olbert et al. (2017) speak of a “new paradigm” and a “new gold standard” and they criticize the OECD for introducing the notion without providing an agreed definition. Meantime, the OECD (2018a) has published an interim report on the tax challenges arising from digitalization which provides an in-depth analysis of value creation across different digitalized business models. However, an agreed definition is still missing.

The idea of drawing on cooperative game theory when pricing transfers is not new. The suggestion has before been made by Gonnet et al. (2007) and Vögele et al. (2008). These authors even mention Shapley’s (1953) value as an appropriate concept when doing contribution analysis and applying the profit split method. However, they restrict the discussion to controlled transactions between affiliated enterprises which the present paper does not. Furthermore, they do not try to characterize the allocation of tax bases resulting from the application of Shapley-value theory.

The paper is structured as follows. In Section 2 it is shown that basic principles of the current system of international profit taxation cannot be justified by the wish to align profit taxation with value creation. Section 3 reinterprets Shapley’s axiomatic value theory in terms of the policy objective of aligning profit taxation with value creation. Section 4 focuses on profit earned with knowhow. It is shown that the Shapley approach suggests splitting the profit earned on knowhow among the involved jurisdictions. In Section 5, it is argued that little would be gained if profit splitting were also applied to the taxation of capital, land, or labor. Section 6 looks at questions of practical implementation. Section 7 summarizes and concludes.

2. Value creation and the current system of international profit taxation

The OECD seeks to align transfer pricing with value creation as the declared objective. The fact that the OECD fails to provide an explicit definition of “value” can be interpreted to mean that the definition is considered being obvious and at most dependent on the type of tax to be discussed. As this paper is on corporate income taxation, the term “value” is equated with “profit” in what follows.

The term “profit” is, however, not unambiguous. The sources of profit are diverse and it is not totally unreasonable to account for such diversity in taxation. A major source of profit is scarcity. Capital – but also other factors like land and labor – is commonly supplied at increasing cost so that profit is earned on the infra-marginal supply. The particular feature of factors supplied at increasing cost is their rival use. As the scarcity of rival factors and the profit earned on them may well increase when economic activity is internationalized, it is hard to argue that value is exclusively created in just one country. Instead, value creation is a multinational activity which contrasts with the current rule of international taxation to assign undivided rights of taxation to jurisdictions. For example, land is taxed at source and labor is taxed in the country of residence. Equally, business profit is taxed in the country of residence unless business is carried through a permanent establishment in another country. In short, there is a clear tendency to assign taxing rights to just one country. Although this has the advantage of mitigating double taxation, it allows questioning the claim that current profit taxation is aligned with value creation. Other considerations such as the pursuit of allocational efficiency or the availability of information have to be taken into account if the governing principles of residence or source taxation are to be justified.

The use of production factors needs not be rival. The typical example is the return to knowhow. Knowhow can be used again and again at zero marginal cost. Profit is, however, earned only if the use of the knowhow is restricted by the provider. The basis of restriction is legal and not technological. Scarcity is artificial and not natural. The prerequisite for any scarcity is that the knowhow is patentable in some broad sense. One could equally speak of intellectual property or intangible assets. The term of (patentable) knowhow refers to the sphere of production whereas the other terms refer to the sphere of legal ownership. In what follows, such notions are used interchangeably. The current system of international taxation assigns the right of taxing the return to knowhow to the country in which the patent is held. Obviously, this need not be the jurisdiction in which the economic value has been created.

In summary, it is not difficult to question the claim that the current system of international taxation aligns profit taxation with value creation. Still, this observation is worth to be stated.

Proposition 1: It is hard to justify basic principles of the current system of international profit taxation by simply referring to the objective of aligning profit taxation with value creation.

The following sections aim at unfolding the conceptual implications of the requirement to align profit taxation with value creation. For this purpose this paper focuses on profit earned with knowhow. This is suggested by the observation that the profitable exploitation of costly developed knowhow is considered to be the key driver of multinationalization in production. As stressed by Dunning (1979), the existence of knowhow is the primary reason why firms consider becoming multinational. By contrast, the wish to generate gains in the efficient use of rival factors of production cannot explain the emergence of MNEs. To be clear, the profitable exploitation of knowhow is not claimed to be the only determinant of multinationalization but the complementary determinants captured by Dunning's well-known OLI framework play no role in the subsequent discussion and will therefore be ignored.

3. Aligning profit taxation with value creation: An axiomatic approach

Let $N = \{1, \dots, n\}$ denote a collection of jurisdictions willing to cooperate on issues concerning profit taxation. The lower-case letter $j \in N$ denotes a representative jurisdiction and the capital letter $J \subseteq N$ denotes a subset of cooperating jurisdictions. Cooperation means that any MNE which is resident in one of the cooperating jurisdictions is allowed to carry out business in each cooperating jurisdiction and that the profit earned on such business is taxed according to a jointly agreed system of rules. The system which may reasonably be expected to be considered as fair and equitable is determined by way of axiomatization.

The object of axiomatization is the taxation of the (consolidated) profit an MNE earns when all jurisdictions cooperate. The proposed axiomatization allows for the theoretically conceivable case in which cooperation is constrained to a subset J of N . Thus let $\Pi(J)$ denote the MNE's profit if its business were constrained to J . $\Pi = \{\Pi(J) | J \subseteq N\}$ is called a *profit pattern*. Mathematically speaking, it is a function mapping subsets of N to the real numbers, \mathbb{R} . Let $B = (B_1, \dots, B_n) \in \mathbb{R}^n$ be an *allocation of tax bases*. In reduced form, a system of

international profit taxation is a function assigning to each profit pattern a particular allocation of tax bases, $B^\Pi = B(\Pi) \in \mathbb{R}^n$. The question to be answered by way of axiomatization is which properties (“desiderata” or “axioms”) the system should fulfill if it can reasonably be expected to be consented by the cooperating jurisdictions.

The first axiom is to account for the OECD’s declared objective that profit taxation should be aligned with value creation. In its weakest conceivable form this objective requires that a jurisdiction’s tax base should be zero if no profitable business is connected with this jurisdiction. In other words, the axiom stipulates *no taxation without value creation*:

$$(i) \quad B_j^\Pi = 0 \text{ if } \Pi(J \setminus j) = \Pi(J) \text{ for all constellations with } j \in J \subseteq N.$$

In this formula, $J \setminus j$ is a short-form for the subset of jurisdictions obtained when removing j from J . By similar misuse of notation, we shall write $\Pi(1,2,\dots)$ for $\Pi(\{1,2,\dots\})$ further below. Let us call $\Pi(J) - \Pi(J \setminus j)$ the *marginal value contributed by jurisdiction j* when cooperating with the subset of jurisdictions $J \setminus j$. According to axiom (i), the tax base of jurisdiction j should be zero if this jurisdiction’s marginal value contribution is never (strictly) positive.

The next two axioms (ii) and (iii) need no particular justification. It is difficult to argue against them. Axiom (ii) states that no profit should remain untaxed (“*no white income*”):

$$(ii) \quad \sum_{j=1}^N B_j^\Pi = \Pi(N) \text{ for all profit patterns } \Pi.$$

Axiom (iii) is a requirement of *equal treatment of jurisdictions*. No jurisdiction should enjoy particular privileges in taxation. In order to state this requirement in full generality, use is made of permutations which are bijective functions $\sigma: N \rightarrow N$. For the sake of notational ease use is also made of the following short-forms: $\sigma(J) \equiv \{\sigma(j): j \in J\}$, $\sigma\Pi(J) \equiv \Pi(\sigma(J))$ and $(\sigma B)_j^\Pi \equiv B_{\sigma(j)}^\Pi$.

$$(iii) \quad \sigma B^\Pi = B^{\sigma\Pi} \text{ for all permutations } \sigma \text{ and all profit patterns } \Pi.$$

The final axiom (iv) requires additivity of the assignment function, $\Pi \mapsto B(\Pi) = B^\Pi$. To state it in concise form the following short-form is used: $\Pi^1(J) + \Pi^2(J) \equiv (\Pi^1 + \Pi^2)(J)$. *Additivity* then requires

$$(iv) \quad B^{\Pi^1 + \Pi^2} = B^{\Pi^1} + B^{\Pi^2} \text{ for all profit patterns } \Pi^1, \Pi^2.$$

No doubt, such property is the axiom requiring the most words of justification. And still, it is plausible and, above all, like axiom (i) closely related to the OECD’s objective to align profit taxation with value creation. Just consider the scenario in which an MNE extends its operations in a particular jurisdiction. All other jurisdictions are not affected by assumption.

The wish to align profit taxation with value creation suggests that only the tax base of this particular jurisdiction increases and not the tax bases of other jurisdictions. Additivity ensures this result.

Theorem: (Shapley, 1953): The only function fulfilling axioms (i)-(iv) assigns to each jurisdiction j the marginal value this jurisdiction contributes on average when cooperating with a randomly selected set of jurisdictions, $J \setminus j$.

According to the theorem, there exists a function which is uniquely determined by the axioms (i)-(iv).² Let this function be called the *Shapley assignment function* best illustrated by a simple example featuring remote supply. In this example the considered firm is not multinational in the sense that it holds a permanent establishment in a foreign jurisdiction. It resides and produces in just one jurisdiction called home, h . However, it not only services home but also a foreign jurisdiction indexed by a (“abroad”). The following profit pattern features the scenario:

$$\Pi(h, a) > \Pi(h) > 0 = \Pi(a).$$

To derive the allocation of tax bases, the theorem suggests determining the marginal value contributed by a when it either stands alone or cooperates with home. With a probability of one half, the foreign country a stands alone which formally means that it cooperates with an empty set of jurisdictions. By assumption, a 's marginal value contribution is zero in this case. With an equal probability of one half, abroad cooperates with home so that a 's marginal value contribution is $\Pi(h, a) - \Pi(h)$. Hence, in the simple setting of remote supply, Shapley theory suggests that a is allocated half of the profit marginally created through cooperation with home. In mathematical terms, this means $B_a^\Pi = [\Pi(h, a) - \Pi(h)]/2$. The other half of $\Pi(h, a) - \Pi(h)$ adds to the base taxed by home when staying alone, $B_h^\Pi = [\Pi(h, a) - \Pi(h)]/2 + \Pi(h) = [\Pi(h, a) - \Pi(a)]/2 + \Pi(h)/2$.

For a formal proof of the theorem see Shapley (1953). In the simple case of remote supply the proof is straightforward. To see this, it is convenient to work with two auxiliary profit patterns Π^1, Π^2 :

² As a matter of fact, the original axiomatization suggested by Shapley (1953) looks a bit different. It has later been modified by several authors and the one presented has been chosen because it is particularly appropriate for interpretation.

$$\Pi^1(h) = \Pi^1(a) \equiv 0, \Pi^1(h, a) \equiv \Pi(h, a) - \Pi(h) > 0 \text{ and}$$

$$\Pi^2(h) = \Pi^2(h, a) \equiv \Pi(h) > 0 \equiv \Pi^2(a).$$

The profit pattern featuring remote supply is obtained by summing up the two auxiliary profit patterns, $\Pi \equiv \Pi^1 + \Pi^2$. Axiom (iii) implies

$$B_h^{\Pi^1} = B_a^{\Pi^1} = [\Pi(h, a) - \Pi(h)]/2.$$

Axiom (i) implies $B_a^{\Pi^2} = 0$. By (ii), $B_h^{\Pi^2} = \Pi(h)$. Finally, additivity implies

$$B_a^{\Pi} = B_a^{\Pi^1} + B_a^{\Pi^2} = [\Pi(h, a) - \Pi(h)]/2,$$

$$B_h^{\Pi} = B_h^{\Pi^1} + B_h^{\Pi^2} = [\Pi(h, a) - \Pi(h)]/2 + \Pi(h),$$

which was to be shown. \square

The current system of international corporate taxation is not compatible with a Shapley allocation of tax bases. The example of remote supplies shows this clearly. The current system assigns the right of taxing the profit earned on such supplies exclusively to the seller's country of residence. The resulting allocation is $B_a^{\Pi} = 0$ and $B_h^{\Pi} = \Pi(h, a)$ which obviously deviates from the Shapley allocation. The suggested conclusion is that one or more of the stated axioms must be violated by the current system of international taxation. As a matter of fact, it is additivity which is systematically violated. To see this clearly, consider the scenario in which the vendor of remote supplies extends its operations abroad while keeping those at home fixed. Under additivity, the resulting increase in profit is exclusively attributed to a while it is attributed to home under the current system of taxation. Things would be different if the firm would hold a permanent establishment abroad. The current system then prescribes a switch in taxation from residence to source. The example demonstrates that the current system is far from aligning profit taxation with value creation in the sense formalized in this section. The current system makes the allocation of tax bases distinctly dependent on the existence of a permanent establishment. The notion of aligning profit taxation with value creation does not justify this if interpreted in the framework of cooperative game theory. Still, a system of international taxation which is in line with Shapley-value theory does not produce totally unreasonable results. They will be looked at in more detail in the next sections.

4. Splitting the taxable profit earned with knowhow

As already mentioned, this paper's primary focus is on taxing the (pure) profit Π earned with (patented) knowhow, Q . Hence, Π equals revenue, R , minus opportunity cost, C . An immediate implication is that costs are only born in those jurisdictions in which knowhow is developed and that jurisdictions not developing knowhow contribute revenue without cost. The implicit assumption is that profit earned on patented knowhow can be separated from other income in tax assessment. This is a strong assumption taken up again in a later section.

The focus is on an MNE having developed patented knowhow in a non-empty subset of the cooperating jurisdictions, N . It is assumed throughout that the patent is held in the same jurisdiction in which the knowhow has been developed. The jurisdictions in which patents are held are called *home* and indexed by h_j ($j = 1, \dots, n$). The remaining jurisdictions are called *abroad* and indexed by a_j ($j = 1, \dots, m$). $H = \{h_j; j = 1, \dots, n\}$ denotes the set of jurisdictions hosting patents while $A = \{a_j; j = 1, \dots, m\}$ denotes the set of remaining ones. Hence $N = H \cup A$. Shapley's theorem suggests focusing on a particular jurisdiction j and determining the marginal value this jurisdiction contributes on average when cooperating with a randomly selected set of jurisdictions, $J \setminus j \subseteq N \setminus j$. Obviously, two cases have to be analyzed separately. In one, $j = h$ stands for a representative home jurisdiction and in the other, $j = a$ stands for a representative foreign jurisdiction.

The first case to be looked at is $j = h$. All patents held in home jurisdictions are assumed to be necessary for production. The Shapley approach to taxation then suggests treating all home jurisdictions equally, $B_{h_j}^\Pi = B_h^\Pi$ for all $j = 1, \dots, n$. Differences in market size or differing costs in research and development provide no reasons for treating home jurisdictions differently. This statement may be unexpected, it, however, makes good sense once one thinks about it carefully. Even if a market is large, its size does not really matter if the servicing requires a patent the right of usage has not been acquired before. If this necessary patent is held in a small jurisdiction, the large one has no compelling reason to claim a higher share in the jointly created value. Both jurisdictions must cooperate when value is to be created. That is why the Shapley approach treats them equally.

Proposition 2: All jurisdictions in which patents are held are treated equally by the Shapley approach. Furthermore, the tax base allocated to each of these jurisdictions exceeds an equal share of the jointly generated profit,

$$B_h^{\Pi} > \Pi(H)/n. \quad (1)$$

A formal proof goes as follows. Shapley's theorem suggests focusing on marginal value contributions. The marginal value contributed by h is positive only if h cooperates with a set of jurisdictions including all $j \in H \setminus h$. As $\Pi(H \cup J \setminus h)$ is zero for all $J \subseteq A$, h 's marginal value contribution equals $\Pi(H \cup J)$ which is the same value for all $h \in H$. Furthermore, $\Pi(H \cup J) > \Pi(H)$ for all non-empty sets $J \subseteq A$ as doing business in $a \in A$ is profitable by assumption. The probability of the scenario in which h is the last home jurisdiction joining a cooperation of all other home jurisdictions equals $1/n$. Hence, $B_h^{\Pi} > \Pi(H)/n$.

Proposition 2 allows one to contrast the Shapley approach with a number of prominent proposals made in the literature for reforming the current system of international corporate income taxation. Most prominently feature the destination-based cash flow tax (DBCFT) promoted by Auerbach and Devereux (2018), the Common Consolidated Corporate Tax Base (CCCTB) promoted by the European Commission (2011, 2015), and its sales-based version recommended by Avi-Yonah (1993) and Avi-Yonah et al. (2009). All these proposals share the characteristic feature that revenues are treated as an indicator for allocating the aggregate profit tax base. This differs from the Shapley approach in which revenues play no particular role as such. Profit contribution is all that counts. The revenue-based proposals are justified by referring to the objective of either sustaining global efficiency (Auerbach and Devereux) or constraining the profit shifting activity of MNEs (CCCTB, Avi-Yonah). The present analysis shows that it is difficult to justify a revenue-based proposal if aligning profit taxation with value creation is the agreed policy objective.

Consider next a jurisdiction $j = a \in A$ in which no patent is held. Such a jurisdiction only contributes positive value when cooperating with a set of jurisdictions J including all home jurisdictions, $H \subseteq J$. It has to be remembered that profit earned in a jurisdiction in which knowhow has not been developed is revenue without cost, $R^a > 0$. This revenue is, however, not necessarily a 's marginal value contribution in the cooperation with J . As shown in Appendix A, a 's marginal value contribution is positive but smaller – strictly speaking: not larger – than R^a . The reason is that the expanded use of knowhow in jurisdiction a may provide reason for the MNE to step up the costly production of knowhow in home jurisdictions. As a result,

$$0 < \Pi(H \cup J) - \Pi(H \cup J \setminus a) \leq R^a \text{ with } \subseteq A. \quad (2)$$

The difference between revenues, R^a , and the marginal value contribution, $\Pi(H \cup J) - \Pi(H \cup J \setminus a)$, is an adjustment effect of production on profit, $\varepsilon^a = \varepsilon^a(H \cup J \setminus a) \geq 0$. It can be interpreted as an external effect exerted on home jurisdictions' profit tax base when the MNE increases its production of knowhow in order to match expanded operations in jurisdiction a .

According to Shapley's theorem, a 's tax base B_a^Π equals the marginal value jurisdiction a contributes *on average* when cooperating with a randomly selected set of jurisdictions. A positive contribution can only be expected if a cooperates with a set of jurisdictions which includes all home jurisdictions. In Appendix B it is shown that the probability that a cooperates with such a set $H \cup J \setminus a$, $J \subseteq A$, equals $1/(n+1)$ and that this probability is independent of the number m of elements in A . The reason is that n home jurisdictions plus jurisdiction a – hence $n+1$ jurisdictions in total – must cooperate if a positive marginal value is to be contributed by a . The number of jurisdictions counting as abroad is irrelevant.

Proposition 3: Shapley-value theory suggests that a jurisdiction a not used by an MNE for holding patents is allocated a positive tax base which does not exceed an equal share of the revenue which the MNE earns in a if that jurisdiction cooperates with all jurisdictions in which patents are held:

$$0 < B_a^\Pi \leq R^a/(n+1). \quad (3)$$

B_a^Π is (strictly) positive as the servicing of jurisdiction a generates profitable business. The case that business in jurisdiction a is not profitable is not interesting and discarded by assumption.

The case in which all production adjustment effects on profit vanish, $\varepsilon^a = 0$, deserves special consideration. Then $B_a^\Pi = R^a/(n+1)$, and $\Pi(H \cup J) = \Pi(H) + \sum_{a \in A} R^a$. Respecting Axiom (ii), one obtains

$$\begin{aligned} B_h^\Pi &= \frac{1}{n} [\Pi(H \cup J) - \sum_{a \in A} B_a^\Pi] = \frac{1}{n} [\Pi(H) + \sum_{a \in A} (1 - \frac{1}{n+1}) R^a] \\ &= \frac{1}{n} \Pi(H) + \frac{1}{n+1} \sum_{a \in A} R^a. \end{aligned} \quad (4)$$

According to eq. (4), home jurisdiction h is allocated an equal share in all the profit contributions the generation of which requires the cooperation of h . The equations (1), (3), and (4) jointly convey the notion of *profit splitting* as suggested by the Shapley approach. As

the Shapley assignment function is uniquely determined by axioms derived from the objective to align profit taxation with value creation, one can rightly conclude that aligning profit taxation with value creation implies profit splitting:

Corollary: The objective of aligning profit taxation with value creation suggests splitting the profit earned on patented knowhow.

5. Taxing profit earned on rival factors

Shapley-value theory does not suggest taxing different sources of profit differently. The approach rather suggests treating them equally and splitting the surplus generated by cooperation, in general. To illustrate the implications, the taxation of a fixed factor like land is considered in some detail.

Let L denote the land endowment of home and let L^* be the endowment abroad. The land rents earned when home and abroad stay alone are denoted by \bar{w} and \bar{w}^* , respectively. If the jurisdictions cooperate, those rents change. Let the changed rents be denoted by w and w^* , respectively. If land is in abundant supply in a particular country, the price goes up in that country, while the price goes down in the other case. As land is in fixed supply, all income from land is (pure) profit. The tax base assigned to home by Shapley-value theory equals

$$B_h^{Sh} \equiv \bar{w}L + \frac{1}{2}[(w - \bar{w})L + (w^* - \bar{w}^*)L^*] \quad (5)$$

while the current tax system implies

$$B_h^c \equiv wL . \quad (6)$$

Taxation according to the Shapley approach may be considered as equitable in the sense that profit taxation is aligned with value creation. However, equity has its cost. A first cost is informational. Taxation according to eq. (6) is obviously much simpler than taxation according to eq. (5). The tax authority of home can implement the base (6) without relying on information which relates to the non-observable state of autarky, \bar{w} , or which must be supplied from abroad, $(w^* - \bar{w}^*)L^*$. Informational simplicity is a clear advantage. Furthermore, it is totally unclear whether the Shapley base apportionment promises any gain over the current base apportionment. *A priori*, it cannot be ruled out that B_h^c exceeds B_h^{Sh} . This is typically the case if profit is earned on a factor which is in abundant supply. An additional cost of the Shapley base apportionment has to be faced if the factor is mobile like capital. If

home and abroad tax mobile capital at differing rates, there will be a cost in efficiency. The clear advantage of residence taxation is to avoid such allocational inefficiency. In summary, little is gained and much is lost if the Shapley approach is extended to the taxation of profit earned on rival factors of production. In what follows, the proposal to consider profit splitting therefore only relates to profit earned on non-rival factors (knowhow) and not on rival factors like capital, land or labor.

6. Implementing profit splitting

Implementing profit splitting is far from being obvious and needs to be discussed in more detail.

A prerequisite of profit splitting is that (pure) profit earned on knowhow can be separated from other income. The separation may well raise problems in practice though not in theory. Theory suggests defining profit attributable to knowhow as the surplus derived when subtracting from revenues the opportunity costs of all rival inputs of production. Opportunity costs can be determined by applying the arm's length principle. The assumed existence of uncontrolled prices is less problematic in the case of rival factor incomes than it is in the case of knowhow. The recourse to the arm's length principle allows separating the profit earned on knowhow from income earned with rival inputs.

As mentioned, the notion of profit splitting as used in this paper strongly deviates from the common meaning. The OECD (2018) only tolerates profit splitting as a method of transfer pricing in controlled transactions between affiliated companies when each one makes a "unique and valuable contribution". Profit splitting in the present paper's sense does not refer to the profit earned on particular transactions but, more generally, to the MNE's consolidated profit earned on total business. Another difference has to be stressed. The Shapley approach suggests that expenditures made for the use of intellectual property such as royalties should not be deductible under profit taxation. This is a further clear break with the current system of international taxation. The current system treats royalties as deductible from the tax base. This is even the case when royalties are paid by an affiliate to the parent company. No arm's length reasoning, however, allows separating royalties from dividend payments when those royalties are paid for the right to use the parent company's knowhow. As the current system leaves it up to the concerned MNE to propose a particular separation, one may safely assume that the proposal serves the MNE's interest to minimize aggregate tax payments. The Shapley

approach would stop such practice. Expenditures made for the use of patented knowhow would not be deductible from the profit tax base.

Hence, separating profit earned on knowhow from other income is not the primary problem. The bigger one is the implementation of profit splitting as such in cases where production adjustment effects on profit do not vanish, $\varepsilon^a > 0$. The implementation is straightforward only if those effects vanish, $\varepsilon^a = 0$. All items needed for allocating the profit tax base are then observable. The consolidated profit, $\Pi(H \cup A)$, is observable as are the revenues, R^a , in jurisdictions $a \in A$ and also $\Pi(H) = \Pi(H \cup A) - \sum_{a \in A} R^a$. This means that in scenarios characterized by $\varepsilon^a \equiv 0$ profit splitting raises no informational problem of implementation. All the information needed to determine the tax bases B_j^Π ($j \in H \cup A$) in accordance with eq. (4) is observable.

However, the production adjustment effects on profit cannot be expected to vanish in general. If they do not vanish, the average marginal value contribution of a stops to be observable. Also, the profit home jurisdictions would earn if they did not cooperate with foreign jurisdictions is not observable. Under such circumstances, the only practical finding derived from the Shapley approach is that each jurisdiction should have the right of taxing a fair share of the profit which is only earned if this jurisdiction cooperates. Expressed as a formula, this means that a jurisdiction not hosting a patent should have the right to tax

$$B_a^\Pi \equiv \beta R^a / (n + 1) \text{ with some } \beta \in (0, 1] . \quad (7)$$

The problem with this formula is that purely normative reasoning does not allow justifying any particular choice of β . This means that the international community of governments would have to negotiate over the choice of the *splitting parameter* β to be applied in profit taxation.

One might hope to pin down β by resorting to bargaining theory. However, bargaining theory cannot solve the problem of lacking observability. This is easily seen when applying Nash's (1950) bargaining solution to the simple example of remote supply discussed before. In this case, the Nash bargaining solution does not differ from Shapley's value. The problem of lacking observability would not be solved by switching from Shapley to Nash. Both solution concepts suggest assigning the same tax base $B_a^\Pi = [\Pi(h, a) - \Pi(h)]/2$ to abroad. No additional information about β is obtained. The implementation of formula (7) therefore fails whenever the production adjustment effect, ε^a , is positive but not observable.

The system of current international standards solves the problem of achieving intercountry tax equity by shifting it from the micro to the macro level. Equitable taxation is not achieved at the level of an individual enterprise but at the country level. The implicit assumption is that each jurisdiction takes the role of home in some cases and the role of abroad in others. Profit is taxed in the MNE's home country of residence except for the profit contributions earned by permanent establishments in foreign countries. Those latter profit contributions are taxed at source. The Shapley approach suggests interpreting the simultaneous application of residence and source taxation as an imperfect attempt to achieve intercountry equity at the country level. The attempt is imperfect as the resulting distribution of taxable profit is not deemed to be fair and equitable by all countries. Fairness has been questioned for long by developing countries in their relation to the developed world and a new debate is fueled by the expansion of the digital economy.

The digital economy is characterized by economies of scale and scope and there are often network externalities. In addition, spillover effects in research and development (R&D) bring about regional concentration. The emergence of regionally concentrated natural monopolies fosters growth from which the whole world benefits. It would only harm global efficiency if the same kind of digital service were supplied by independent producers or if digital R&D were spread evenly throughout the world. For this and other reasons, achieving balanced trade in digital services is neither efficient nor competitively sustainable.

Investments in the digital economy can be highly profitable. In 2018, seven out of the ten most valuable firms worldwide made their money with digital business. They either reside in the U.S. or in China. Concern is widespread in Europe that profits earned in the digital economy are not effectively and fairly taxed (European Commission, 2017). The perception of lacking fairness is strengthened by the practice of MNEs to avoid taxes by profit shifting. Against this background, profit splitting promises increased fairness. At least, it is a form of international taxation deserving careful consideration by policy makers. It is quite obvious that the incentive of profit shifting is decreased when the return earned on knowhow in a foreign country is not exclusively taxed by a single country but jointly by all countries involved. The exclusive taxation in a single country provides strong incentives to hold patents in those countries where tax rates are low and to shift costs of R&D to those countries where tax rates are high. Governments feel the need to react by granting all kinds of preferential tax provisions for R&D. E.g., costs of R&D are subsidized and patent boxes are introduced to alleviate the taxes on income earned with intangible assets. In other words, the current tax

system triggers various types of tax competition. Profit splitting is, by nature, more resilient to such policies. The taxes saved when migrating patents to a low-tax country are reduced when some part of profit continues to be taxed in high-tax countries. This is why one may hope that international negotiations over the splitting parameter β might not be as antagonistic as international negotiations over taxation rights usually tend to be. When pleading for a particular value of β , governments have to trade off two opposing effects. A low value of β secures a large share in the taxable profit earned with hosted patents. By contrast, a high value of β reduces the incentive of resident MNEs to migrate patents to a foreign low-tax country. The tax savings are reduced as the share of profit taxed in the low-tax country decreases in β .

7. Summary and conclusions

According to the OECD's declared objective, profit taxation should be aligned with value creation. An agreed answer to the question of which activities create value is, however, not provided. In a recent study, the OECD (2018a) reveals a narrow understanding. Activities of enterprises are considered being the only source of value creation. This paper argues that such a narrow understanding is unconvincing. The true source of value creation is the international cooperation of jurisdictions. An MNE earns taxable profit abroad only if the involved jurisdictions cooperate on legal issues such as market access, the rules of taxation, and so forth. If profit taxation is to be aligned with value creation, then the tax base should ideally be allocated according to standards commonly accepted as fair and equitable when distributing the surplus of cooperation. The Shapley value has been designed with the aim to determine an equitable distribution of the surplus generated by cooperation. This paper therefore applies Shapley-value theory to the question of how to apportion an MNE's aggregate tax base among the jurisdictions in which the MNE operates. The axioms which uniquely characterize the Shapley value are interpreted and justified by reference to the objective to align profit taxation with value creation. Shapley-value theory is shown to imply that the profit contribution earned by an MNE in a particular jurisdiction should be split between all those jurisdictions whose cooperation is needed for generating this profit. I.e., each jurisdiction should have the right to tax a fair share of profit where fairness means that each jurisdiction is assigned the marginal profit generated on average when cooperating with a randomly selected subset of jurisdictions. The strength of this general result is that it allows deriving some noteworthy propositions.

According to a first one, it is hard to justify basic principles of the current system of international profit taxation by simply referring to the objective of aligning profit taxation with value creation. For instance, the prominent role of the residence and source principles in international taxation obviously conflicts with the suggestion of Shapley-value theory to apply profit splitting. Furthermore, the Shapley approach provides no justification for connecting the right of taxation with nexus in its standard interpretation. Whether an MNE holds a permanent establishment in a jurisdiction should not be the relevant question. The question should rather be whether the MNE's consolidated profit would decline if the jurisdiction did not cooperate.

One has to note, however, that this paper's usage of the profit concept differs from the common one. It is pure return earned on knowhow. Royalties and other expenditures paid for the use of non-rival inputs are not admitted for tax deduction. By contrast, opportunity costs of inputs which are rival in use are to be deducted. Profit attributable to the scarcity of rival inputs should only be taxed in the jurisdiction bearing the opportunity cost of supply. This is so as the expected gains in intercountry tax equity derived from splitting the profit earned on rival inputs might well not be large enough to justify the increased cost of information acquisition and the loss in efficiency in the international allocation of those inputs.

Shapley-value theory allows deriving another noteworthy proposition. This one relates to the scenario in which an MNE holds one or more necessary patents in more than just one jurisdiction. The suggestion is that all those jurisdictions should be assigned an identical share of the MNE's aggregate profit tax base. Different market sizes and different costs of development should provide no reason to allocate different tax bases. The tax base allocated to the set of all patent hosting jurisdictions should, however, exceed the profit those jurisdictions would earn if they did not cooperate with those jurisdictions in which patents are not held. Instead, they should tax a share of the profit contribution earned with the MNE's knowhow in jurisdictions in which patents are not held. On the other hand, a jurisdiction in which no patents are held should equally have the right to tax a share of the profit the MNE earns within its borders. Thus it is shown that the objective of aligning profit taxation with value creation suggests splitting the profit earned on patented knowhow between all those jurisdictions needed to generate that profit.

The weakness of the Shapley approach to international taxation is revealed when it comes to practical implementation of profit splitting. One would have to observe the effect on home profit being exerted when an MNE increases its production of knowhow in order to match

expanded operations abroad. If one reasonably assumes that such effects are positive but not observable, the Shapley approach cannot be used to pin down a particular profit-splitting parameter. In the present paper, this parameter is modelled by $\beta \in (0,1]$. It has been argued that governments would have to negotiate over the choice of β to be applicable in international profit taxation. As governments have to trade off opposing effects when pleading for a particular value of β one can, however, hope that such negotiations are not as antagonistic as international negotiations over taxation rights usually are. No need to stress that this is a theoretical result the relevance of which will have to be studied more intensively before it can be brought to bear in practical tax policy.

8. Appendices

Appendix A

Let Q_h be the quantity of knowhow developed in home jurisdiction $h = 1, \dots, n$. The development entails cost denoted by $C_h(Q_h)$. Revenues of $R^j(Q_1, \dots, Q_n)$ are earned in each jurisdiction $j \in H \cup A$. The revenue functions are monotone increasing and concave while the cost functions are monotone increasing and convex. Positive profit is earned only if all home jurisdictions cooperate.

$$\begin{aligned} \Pi(H \cup J) &= \max[\sum_{j \in H \cup J} R^j(Q_1, \dots, Q_n) - \sum_{h \in H} C_h(Q_h)] \\ &= \sum_{j \in H \cup J} R^j(Q_1^*, \dots, Q_n^*) - \sum_{h \in H} C_h(Q_h^*) \\ \Pi(H \cup J \setminus a) &= \max[\sum_{j \in H \cup J \setminus a} R^j(Q_1, \dots, Q_n) - \sum_{h \in H} C_h(Q_h)] \\ &= \sum_{j \in H \cup J \setminus a} R^j(\bar{Q}_1, \dots, \bar{Q}_n) - \sum_{h \in H} C_h(\bar{Q}_h) \end{aligned}$$

As R^a is assumed to be positive, $\Pi(H \cup J)$ is strictly larger than $\Pi(H \cup J \setminus a)$.

A Taylor Series expansion yields

$$0 < \Pi(H \cup J) - \Pi(H \cup J \setminus a) = R^a(Q_1^*, \dots, Q_n^*) - \varepsilon^a \quad (8)$$

with

$$\varepsilon^a = \varepsilon^a(H \cup J \setminus a) = -\frac{1}{2} \sum_{j \in H \cup J \setminus a} \sum_{h,k \in H} (Q_h^* - \bar{Q}_h) [R_{h,k}^j - C_h''] (Q_k^* - \bar{Q}_k)$$

where subscripts of $R_{h,k}^j$ and the superscript of C_h'' indicate (partial) derivatives. As revenue functions are concave and as cost functions are convex, the second-order term ε^a is non-negative. First-order terms in eq. (8) cancel out.

Appendix B

Shapley's theorem suggests analyzing sequences in which jurisdictions join cooperation one after the other. As the number of home jurisdictions is n and as the number of foreign jurisdictions is m , there are $(n + m)!$ possible sequences. Only if jurisdiction $a \in A$ cooperates with a set of jurisdictions including all home jurisdictions, is the contributed marginal value positive. The claim is that this happens in $(n + m)!/(n + 1)$ sequences. In other words, the probability of joining a set of cooperating jurisdictions including all home jurisdictions in a randomly selected sequence is $1/(n + 1)$. This is proved for fixed n and increasing m by induction.

The start is with $m = 1$. There exist $n!$ permutations of $\{h_1, \dots, h_n\}$ which are interpretable as sequences of arrival in the set of cooperation. As all $h \in H$ have to arrive before a does if a 's marginal value contribution is to be positive, the probability of some positive contribution equals $n!/(n + 1)! = 1/(n + 1)$.

Now assume that there are $(n + m)!/(n + 1)$ sequences of arrival of $\{h_1, \dots, h_n; a_1, \dots, a_m\}$ such that a_1 is preceded by all $h \in H$. Select any such sequence and keep it fixed. If a further jurisdiction a_{m+1} is added to A , there are $n + m + 1$ ranks in the sequence where a_{m+1} can be included without destroying the property that a_1 is preceded by all $h \in H$. The probability that a_1 contributes some positive marginal value therefore equals

$$\frac{(n+m+1) \cdot (n+m)! / (n+1)}{(n+m+1)!} = \frac{1}{n+1}.$$

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