Aligning Profit Taxation with Value Creation

by

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Abstract: The OECD seeks to align transfer pricing and profit taxation with value creation. This paper argues that taking this objective seriously requires profit splitting. This is shown by applying Shapley value theory to the problem of allocating a firm’s profit tax base to the jurisdictions in which the firm is active. The application of cooperative game theory is justified with the argument that interjurisdictional cooperation on legal issues is a necessary condition for firms earning profit abroad. The profit tax base should therefore be allocated to jurisdictions according to standards generally considered as equitable when distributing the surplus of cooperation.

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1 There exist two related but obsolete papers 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). Of the fifteen actions three were designed to “align transfer pricing outcomes with value creation” (OECD, 2015). Despite the significance of this objective, a definition of “value creation” was not provided (Olbert et al., 2017). In a more recent study, the OECD (2018a) reveals a narrow understanding of the term. 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 as sources of value creation. A jurisdiction’s right of taxation is solely derived from the hosting of the taxed enterprise. There must be “nexus”. This requirement is no longer undisputed, however, in its application to the digital economy (OECD, 2018a, 2019a).

The international failure to clarify the concept of value creation has led to various countries taking unilateral action in reinterpreting and adjusting the rules of international corporate income taxation with the alleged objective of addressing tax challenges raised by digitalization. Examples are compiled in Chap. 4 of OECD (2018a). One specific example is the proposal of the European Commission (2017, 2018) to introduce a Digital Services Tax with the argument that services should be taxed where the “main value” is claimed to be “created through user participation”. The ad-hoc character of this justification is proof of the need to clarify the meaning of ‘value creation’ before it can be used as a basic concept in international tax policy.

The present paper contributes to conceptual clarification by drawing on cooperative game theory. It argues that the design and enforcement of international taxation require the legal cooperation of jurisdictions. There would be no transboundary value creation by MNEs if the countries in which they are active did not cooperate on legal issues. If this view is accepted, however, it makes little sense to constrain the notion of value creation to the economic activity of enterprises. On the contrary, interjurisdictional cooperation is an absolute prerequisite of transboundary value creation. It is therefore argued that the resulting profits should be distributed according to standards which are generally considered fair and equitable for the allocation of gains obtained by cooperation. At least, this should be the general rule to be overridden only for compelling reasons.

By drawing on cooperative game theory in general, and on Shapley (1953) value theory in particular, this paper argues that aligning profit taxation with value creation requires profit
splitting in the sense that the profit earned by an MNE in a foreign country is evenly divided between the countries involved. This notion of profit splitting differs significantly from the one used by the OECD (2018b) when pricing transfers in controlled transactions between affiliated companies. In the present paper’s interpretation of the notion, the companies need not be affiliated and the existence of a permanent establishment is not considered necessary for exercising the taxing right. The deviations from current standards of international taxation suggested by the Shapley value theory go even further. Expenditures incurred for the use of intellectual property should not be recognized deductibles when made between the affiliates of the same MNE. Further, the residence and source principles dominating the current system are not supported by the Shapley approach to international profit taxation. All this shows that if the OECD’s declared objective of aligning profit taxation with value creation were taken seriously and given a consistent interpretation according to generally accepted principles of cooperative game theory, the implications for tax policy would be far-reaching.

One controversial implication of the Shapley approach to taxation is the suggestion that all sources of profit should be treated equally. This means that any profit derived from transactions requiring the legal cooperation of jurisdictions should be split. Accepting this implication strictly, however, would mean considerable administrative costs and loss of production efficiency. The paper therefore argues that splitting is better restricted to profit earned on non-rival factors of production. The reason for this is that if splitting is also applied to the profit earned on rival factors, the anticipated increase in intercountry tax equity might well not be enough to justify the administrative costs and negative effect on global production efficiency. Profit earned on rival factors should rather be taxed according to conventional rules in line with the arm’s length principle. This means that profit would have to be taxed on the basis of its source.

The idea of moving away from uniform profit taxation is not new. The most prominent proposal to date is to separate an MNE’s total profit into a “routine” and a “residual” part. See Devereux et al. (2019) with their references to the literature on “residual profit allocation”. Such a separation has received particular attention in the face of the tax challenges posed by the digital economy. It is part of the so-called “Unified Approach” developed by the Secretariat of the OECD (2019b) to facilitate a consensus solution on Pillar One of the Programme of Work adopted by the Inclusive Framework in May 2019 (OECD, 2019a). Despite obvious similarities, the Shapley profit allocation cannot, however, be equated with the concept of residual profit allocation as it is usually understood. The definitions of rival/non-rival differ from those of routine/residual. It should also be noted that, in contrast to
the Shapley approach, the proposals usually subsumed under residual profit allocation prescribe an allocation of an MNE’s residual profit based on cost, revenue or income. The Shapley approach limits the splitting to those profit contributions requiring interjurisdictional cooperation and it prescribes an even allocation among the countries involved. Thus, the profit allocation is determined neither by costs nor revenues but solely by the number of countries involved. In sum, the differences between the Shapley profit allocation and the residual profit allocation are considerable and can be explained by their divergent objectives. The proposals usually subsumed under the term residual profit allocation aim at applicability. They have a clear focus on administrability and they are designed to minimize deviations from current standards of corporate income taxation. By contrast, this paper has an academic focus. It seeks to unfold the theoretical implications for profit taxation if the OECD’s objective of aligning it with value creation is given an interpretation consistent with accepted principles of cooperative game theory.

With the exception of papers on residual profit allocation, the present paper has only sparse connections to the literature. 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 concept 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. Olbert et al. (2019) make an attempt to conceptualize value creation within the existing framework of international taxation. In contrast to the present paper, they find “no justification for introducing a new tax order for digital businesses.” Richter (2019) analyses the remote supply of digital business services and argues that there are good reasons to expect that profit splitting results when countries exporting and importing such services compete over tax design.

The idea of drawing on cooperative game theory when pricing transfers is not totally new. The suggestion has been made before by Hines (1990), Gonnet et al. (2007), and Vögele et al. (2008). All these authors even mention Shapley value theory. However, their application differs from the present one. Their focus is solely on the problem of pricing controlled transactions between affiliated enterprises, while the present paper applies Shapley value theory to the problem of apportioning an MNE’s profit tax base among independent jurisdictions. Hines finds certain implications of Shapley value theory unconvincing and he offers his own solution to the transfer pricing problem. Part of his critique applies primarily to
the problem of pricing transfers between affiliated enterprises. His other issues are picked up at the appropriate points below. The other authors cited refer to Shapley value theory as an appropriate framework when pricing transfers and relying on the profit split method. However, in contrast to the present paper, they make no attempt to characterize the resulting profit allocation.

The paper is structured as follows. Section 2 reinterprets Shapley’s axiomatic value theory in terms of the objective of aligning profit taxation with value creation. It is shown that pursuing this objective leads to the concept of profit splitting. Section 3 contrasts this concept with current rules of taxation and with proposals made in the literature for reforming them. Section 4 explicates the implications of profit splitting when applied to profit earned on goods and services produced with inputs which are non-rival in use. Section 5 looks at questions of practical implementation. Section 6 deals with the case of production inputs that are rival in use, arguing that there is little to be gained from extending splitting to the profit earned on such inputs. This insight provides the basis in Section 7 for arguing in favor of a tax regime designed in analogy to residual profit allocation. Section 8 summarizes and concludes.

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

The OECD seeks to align transfer pricing with value creation, without, unfortunately, specifying what activity can be regarded as creating value. In this section, an axiomatic approach is used to fill the gap. The approach relies on two key assumptions. The first is that value can be equated with profit. The second is that transboundary value creation requires interjurisdictional cooperation.

Let \( N = \{1, \ldots, n\} \) denote a collection of jurisdictions willing to cooperate on legal issues related to business activity. 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 able to carry out business in all cooperating jurisdictions and that the profit earned on such business is taxed according to a jointly agreed system of rules. An appropriate system which can reasonably be expected to be considered fair and equitable is determined by way of axiomatization.

The object of axiomatization is the allocation of the right to tax the aggregate profit an MNE earns when all jurisdictions cooperate. The proposed axiomatization allows for the fictitious case in which cooperation is constrained to a subset \( J \) of \( N \). More specifically, let \( \Pi(J) \) denote the MNE’s aggregate 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 \( B = (B_1, \ldots, B_n) \in \mathbb{R}^n \) be an allocation of tax bases. In reduced form, a system assigning the right of international profit taxation – an assignment of taxing rights, for short – is a function assigning to each profit pattern, \( \Pi \), 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 assignment of taxing rights needs to fulfill for it reasonably to be expected that it will be consented to 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 be zero if no profitable business is connected with this jurisdiction. In other words, the axiom stipulates no taxation without value creation:

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

In this formula, \( J \setminus j \) is an abbreviation for the subset of jurisdictions obtained when removing \( j \) from \( J \). With similar misuse of notation, we shall write \( \Pi(1,2,\ldots) \) for \( \Pi(\{1,2,\ldots\}) \) further below. Let us call \( \Pi(J) - \Pi(J \setminus j) \) the profit 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 profit contribution is never (strictly) positive.

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

\[
\text{(ii)} \quad \sum_{k=1}^{N} B^\Pi_k = \Pi(N) \quad \text{for all profit patterns} \ \Pi.
\]

Axiom (iii) excludes (procedural) discrimination. No jurisdiction should be discriminated against by the mutually accepted rules of taxation (“no discrimination”). The formal definition makes use of fictitious sequences \( \sigma: N \to N \) by which jurisdictions are thought to join the interjurisdictional cooperation, i.e. \( \sigma(j) \) is interpreted as the place in sequence \( \sigma \) at which \( j \) joins the cooperation of \( N \). In general, the profit contributed by \( j \) varies with \( \sigma \). Discrimination is excluded if the tax base allocated to jurisdiction \( j \) does not depend on the numbering in any particular sequence. To state this requirement in concise form, the following short-forms are used: \( \sigma(j) \equiv \{ \sigma(j): j \in J \} \), \( \sigma\Pi(J) \equiv \Pi(\sigma(J)) \) and \( \sigma B^\Pi_j \equiv B^\Pi_{\sigma(j)} \).

\[
\text{(iii)} \quad \sigma B^\Pi = B^{\sigma\Pi} \quad \text{for all sequences} \ \sigma \ \text{and all profit patterns} \ \Pi.
\]
The final axiom (iv) requires additivity in the allocation of taxing rights, \( \Pi \leftrightarrow B(\Pi) = B^\Pi \). It is best stated by using the following short-form: \( \Pi^1(J) + \Pi^2(J) \equiv (\Pi^1 + \Pi^2)(J) \). Additivity then requires

\[(iv) \quad B^{\Pi_1+\Pi_2} = B^{\Pi_1} + B^{\Pi_2} \text{ for all profit patterns } \Pi_1, \Pi_2.
\]

This is the axiom undoubtedly requiring the most justification. Yet it is plausible and, above all, like axiom (i) closely related to the OECD’s objective of aligning profit taxation with value creation. Just consider the scenario in which an MNE extends its operations in a particular jurisdiction. All other jurisdictions are assumed not to be affected. Aligning profit taxation with value creation entails 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 assignment of taxing rights fulfilling axioms (i)-(iv) assigns to each jurisdiction \( j \) the profit this jurisdiction contributes on average when joining the cooperation of all jurisdictions in a randomly chosen sequence.

According to this theorem, there exists an assignment of taxing rights which is uniquely determined by the axioms (i)-(iv).\(^2\) Let this assignment be called the *Shapley assignment of taxing rights*. It is best illustrated by a simple example featuring remote supply, in which the firm under consideration is not multinational in the sense that it holds a permanent establishment in a foreign jurisdiction. It produces in just one jurisdiction called *home*, \( h \). However, it not only services home but also a foreign jurisdiction called *abroad* and indexed by \( a \). The following profit pattern models such a scenario:

\[ \Pi(h, a) > \Pi(h) > 0 = \Pi(a). \quad (1) \]

To derive the Shapley assignment of taxing rights, the theorem suggests determining the profits contributed by \( a \) when it ranks either first or second in the sequence of joining the cooperation. With a probability of one half, abroad ranks first, which means that it initially stands alone or cooperates with an empty set of jurisdictions. By assumption, \( a \)’s profit contribution is zero in such a case. With an equal probability of one half, abroad ranks second. In this case, abroad cooperates with home and its profit contribution is \( \Pi(h, a) - \Pi(h) \).

\(^2\) In fact, the original axiomatization suggested by Shapley (1953) looked slightly different. It has since been modified by several authors and the version presented here has been chosen because it is particularly appropriate for interpretation.
Hence, in the simple setting of remote supply, Shapley theory suggests that abroad is allocated one half of the profit contributed when cooperating with home. In mathematical terms, this means $B_a^h = \frac{[\Pi(h, a) - \Pi(h)]}{2}$. The remaining half of $\Pi(h, a) - \Pi(h)$ adds to the base taxed by home when it remains alone, $B_h^a = \frac{[\Pi(h, a) - \Pi(h)]}{2} + \Pi(h) = \frac{[\Pi(h, a) - \Pi(a)]}{2} + \Pi(h)/2$.

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 the following two auxiliary profit patterns, $\Pi^1, \Pi^2$:

$$\Pi^1(h) = \Pi^1(a) \equiv 0, \Pi^1(h, a) \equiv \Pi(h, a) - \Pi(h) > 0$$

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

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

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

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

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

$$B_h^\Pi = B_h^{\Pi^1} + B_h^{\Pi^2} = \frac{[\Pi(h, a) - \Pi(h)]}{2} + \Pi(h), \quad (3)$$

which was to be shown. □

The equations (2) and (3) suggest a kind of profit splitting where the profit contribution earned by servicing the market abroad is evenly divided between $h$ and $a$. It is worth noting that the splitting does not extend to the profit $\Pi(h)$ the MNE earns if home stands alone. Interjurisdictional cooperation is only needed for earning additional profit. An intuitive argument for splitting is that home is assigned the right to tax one half of $\Pi(h, a) - \Pi(h)$ because it hosts the MNE and abroad is assigned the right to tax the other half because it provides the market with its profit potential. How this notion of profit splitting extends to more complex scenarios is discussed further below. Before proceeding, it is worth noting an important implication of Shapley’s theorem:

**Remark:** Transactions of an MNE leaving profit patterns unchanged do not alter the Shapley allocation of tax bases.
This remark follows from the assumption that feasible assignments of taxing rights are functions of profit patterns, \( \Pi = \{ \Pi(J) | J \subseteq N \} \), and of nothing else. An immediate implication is that MNEs do not gain from shifting profit between jurisdictions if they are taxed according to Shapley. This is so as aggregate profit \( \Pi(J) \) is not altered when profit is shifted between the jurisdictions \( j \in J \) in which the MNE is active.

3. **Profit splitting in taxation**

Profit splitting as suggested by the Shapley approach implies divided taxing rights. This is at variance with the current system of international corporate income taxation. A characteristic of the current system is that it assigns undivided taxing rights to jurisdictions. For example, land is taxed at source and labor is taxed in the country of residence if this is also the country of employment. Business profit is taxed in the country of residence unless the business is carried out by a permanent establishment in another country. In short, there is a clear tendency to assign taxing rights to just one country.

The difference between the Shapley assignment of taxing rights and the current system becomes particularly clear in the taxation of remote supplies. The current system assigns the right to tax 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 deviates distinctly from the Shapley allocation of tax bases (2) and (3). Hence, the current system of international taxation must violate one or more of the stated axioms. The axiom it actually violates is additivity. To see this clearly, consider a scenario in which a vendor of remote supplies extends its operations abroad while keeping those at home fixed. Under additivity, the resulting increase in profit, which under the current system of taxation is taxed at home, is exclusively taxed abroad. Things would be different if the firm maintained 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 the preceding section. The current system makes the allocation of tax bases distinctly dependent on the existence of a recognized nexus. The Shapley approach, with its implicit notion of intercountry tax equity, provides no justification for connecting taxing rights with nexus. If the aim is to align profit taxation with value creation, whether an MNE maintains a permanent establishment in a jurisdiction should not be the deciding factor.
The question should rather be whether the MNE’s aggregate profit would decline if the jurisdiction did not cooperate.\(^3\)

Not only is the relevance of nexus questioned by the Shapley approach. Under it, the amount of local business activity measured by such indicators as cost and/or revenue is considered equally irrelevant for the assignment of taxing rights. Indeed, the only information it regards as relevant is the distribution of profit contributions. The Shapley approach therefore contrasts even with the most prominent proposals which have been made for reforming the current system of international corporate income taxation. These include: 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); residual profit allocation by income (RPA-I) recommended by Devereux et al. (2019); and the sales-based version recommended by Avi-Yonah (1993) and Avi-Yonah et al. (2009). All these proposals share the characteristic feature that (a residual part of) aggregate profit is apportioned and that one or more indicators of local business activity such as cost, revenue, or income determine the apportioned share. By contrast, the Shapley approach restricts the splitting to the profit contributions requiring interjurisdictional cooperation and it prescribes an even allocation among the contributing countries. Hence, the number of contributing countries is a key determinant of apportioned shares while costs, revenues, or income provide no relevant information. The revenue-based proposals are justified by referring to the objective of either sustaining global production efficiency (Auerbach et al., Devereux et al.) or constraining the profit shifting activity of MNEs (CCCTB, Avi-Yonah). By contrast, cost basing is often vaguely defended by reference to interjurisdictional equity or business pricing practices. The present analysis shows that it is difficult to justify revenue or cost basing if aligning profit taxation with value creation is the agreed policy objective.

It is not that profit splitting has played no role in the OECD world. However, the OECD (2018) accepts profit splitting only as a method of transfer pricing in controlled transactions between firms when each one makes a “unique and valuable contribution”. The definition justified in the present paper by recourse to Shapley value theory is much broader. It refers to uncontrolled transactions and assumes \textit{inter alia} that even providing access to a foreign market is value creating.

\(^3\) Cf. Hines (1990): “The contribution of an affiliate to firm profit potential is properly measured by the extent to which profits would fall in the absence of the affiliate.” It should be noted, however, that Hines is here applying Shapley value theory to the cooperation between an MNE’s affiliates while in the present paper it is applied to the cooperation of jurisdictions.
It is only recently that governments have agreed to examine profit splitting on a “without prejudice” basis as one of competing proposals designed to address the tax challenges arising from digitalization (OECD, 2019a, p. 6). “Issues and options in connection with new profit allocation rules” are to be explored. One option explicitly mentioned is the “modified residual profit split method” which “would allocate to market jurisdictions a portion of an MNE group’s non-routine profit that reflects the value created in markets that is not recognised under the existing profit allocation rules” (OECD, 2019a, p. 12). Notwithstanding this recent development, it remains puzzling why profit splitting has not been recognized before as a feasible profit allocation rule under the current tax system. The following suggests some tentative answers to this question.

One answer might be that the current rules of international taxation are targeted at global production efficiency, which favors residence taxation. The implicit assumption here is that efficiency could be considered a guiding policy objective. Irrespective of whether this is a realistic hypothesis or not, it is disproved by the significant role which source taxation plays in the current system.

Alternatively, it could be argued that there is no real need to achieve intercountry tax equity at the level of the individual firm. Trade between countries is a reciprocal activity. The absence of intercountry tax equity in specific cases is overcome at the country level. A country which suffers disadvantages from undivided rights of taxation in some cases may benefit from them in others. On balance, the undivided assignment of taxing rights allows equity to be achieved at the country level. This argument is all the more convincing in view of the informational problems incurred when implementing profit splitting. If tax bases were defined in line with equations (2) and (3), one would have to determine the profit term $\Pi(h)$. This may not be straightforward, as $\Pi(h)$ refers to the unobservable, counterfactual scenario of autarky. However, this objection can be reversed. If profit splitting is being seriously discussed in the context of digitalization, this could have technological reasons. It might well be that the requirements for implementing profit splitting are more easily satisfied in the new economy than in the old.

To analyze this possibility, in the following sections three particular cases are studied more closely. The first one largely features production in the old economy. All inputs are rival in use so that the marginal cost of quantity is positive. An appropriate example would be food, whose production relies on land, labor, and capital, all of which are rival in use. For the sake of brevity, production where all inputs are rival in use is labeled rival production. The polar
opposite case is called non-rival production. Here, inputs are non-rival in use and the marginal cost of quantity is insignificant. An appropriate example is the production of digital services like the online placement of advertising. The cost of servicing additional customers is so low that it can be ignored (Commission Expert Group, 2014; Goldfarb et al., 2019). The only significant cost comes from the development of service quality which is, however, fixed when quantity is produced. Finally, there are mixed cases where the production of quantity relies on both rival and non-rival inputs. Here, smartphones may serve as a pertinent example. Their production combines hardware with software, which are respectively rival and non-rival in use. In what follows, it will be argued that the case for profit splitting is the strongest when production is non-rival. The discussion starts by outlining the implications when the Shapley approach is applied to such non-rival production.

4. Profit splitting when production of quantity is non-rival

If the marginal cost of quantity for a service is zero, the supplier must be able to exercise market power. If this is not the case, the service cannot command a positive price and the supplier will be unable to cover the fixed costs incurred in providing a service quality sufficient to stimulate demand. Furthermore, the supplier must be able to restrict the use of the service by legal means such as trademarks or patents. This means that the quality must be produced with particular knowhow which is in some broad sense patentable. In other words, the supplier must have acquired excludable property rights before servicing the market.

Consider an MNE with affiliates, some of which develop patentable knowhow and some not. The jurisdictions in which patentable knowhow is developed are called home jurisdictions and indexed by \( h_j \) \((j = 1, \ldots, n)\). The remaining ones are called non-home and indexed by \( a_j \) \((j = 1, \ldots, m)\). \( H = \{h_j; j = 1, \ldots, n\} \) denotes the set of home jurisdictions and \( A = \{a_j; j = 1, \ldots, m\} \) the set of the others. Hence \( N = H \cup A \). It should be noted that the differentiation between home and non-home refers to the real activity of developing patentable knowhow. Where these patents are held is not relevant since the Shapley allocation of tax bases does not change when patents are traded between affiliates of the same MNE. Mentioning patentability in the definition of home jurisdictions serves only one purpose: to stress that the knowhow developed is an excludable and essential input in the production of quality.

Shapley’s theorem suggests focusing on a particular jurisdiction \( j \) and determining the profit this jurisdiction contributes on average when cooperating with a randomly selected set of
other jurisdictions, \( J \setminus j \subseteq N \setminus j \). Here, two cases need to be distinguished. In one, \( j = h \) stands for a representative home jurisdiction and in the other, \( j = a \) stands for a representative non-home jurisdiction.

The first case to be looked at is \( j = h \). By assumption, all home jurisdictions have developed knowhow which is necessary for the production of quality. The Shapley approach then suggests treating all home jurisdictions equally, \( B^\Pi_{h_j} = B^\Pi_h \) for all \( j = 1, \ldots, n \). Differences in market size or research and development (R&D) costs are not cogent reasons for treating home jurisdictions differently. Hines (1990) is critical of this implication, yet it makes sense. The size of a market, however large, is of no particular significance if servicing it requires knowhow for which no right of usage has been acquired. If this necessary knowhow has been developed in a small jurisdiction, a larger one has no compelling reason to claim an expanded taxing right. Both jurisdictions must cooperate when value is to be created. That is why the tax bases of home jurisdictions should not vary in the size of home jurisdictions’ markets.

**Proposition 1:**

(i) All home jurisdictions used for developing patentable knowhow are treated equally by the Shapley approach, \( B^\Pi_{h_j} = B^\Pi_h \) for all \( j = 1, \ldots, n \).

(ii) The tax base allocated to each home jurisdiction exceeds an even share of the profit earned when only home jurisdictions cooperated, \( B^\Pi_h > \Pi(H)/n \). (4)

A formal proof goes as follows. Shapley’s theorem suggests a focus on profit contributions. The profit contributed by \( h \) is positive only if \( h \) cooperates with a set of jurisdictions including all other home jurisdictions, \( j \in H \setminus h \). As \( \Pi(H \cup J \setminus h) \) is zero for all \( J \subseteq A \), \( h \)’s profit contribution equals \( \Pi(H \cup J) \), which is of equal value for all \( h \in H \). This proves statement (i). Assuming that business is profitable abroad, \( \Pi(H \cup J) \) must exceed \( \Pi(H) \) for all non-empty sets \( J \subseteq A \). If \( h \) is the last home jurisdiction joining the cooperation of \( H \cup J \setminus h \), its profit contribution exceeds \( \Pi(H) \). The probability of a scenario in which \( h \) is the last home jurisdiction joining the cooperation of all other home jurisdictions equals \( 1/n \). Hence, \( B^\Pi_h > \Pi(H)/n \). This is statement (ii).

Consider next a jurisdiction \( j = a \in A \) in which no patentable knowhow is developed. Such a jurisdiction only contributes positive profit when cooperating with a set of jurisdictions \( J \) including all home jurisdictions, \( H \subseteq J \). It has been assumed that production is non-rival. The
only cost incurred then comes from developing knowhow. As knowhow is not developed in jurisdiction \( a \), the profit earned in that jurisdiction is revenue without allocable cost, \( R^a > 0 \). This revenue does not, however, equal \( a \)’s profit contribution in the cooperation with \( J \). As shown in Appendix A, \( a \)’s profit contribution is positive but may well be smaller than \( R^a \). The reason is that the expansion of business to jurisdiction \( a \) may impact the profit to be earned from cooperation restricted to jurisdictions \( J \setminus a \). Revenues from \( J \setminus a \) may drop when the market in \( a \) is serviced, or sales in \( a \) may provide a reason for the MNE to step up the costly development of knowhow in home jurisdictions. As a result,

\[
0 < \Pi(J) - \Pi(J \setminus a) \leq R^a \quad \text{when} \quad H \subseteq J \subseteq H \cup A .
\]  

(5)

The balance between the revenues, \( R^a \), and the profit contributed by \( a \), i.e. \( \Pi(J) - \Pi(J \setminus a) \), is a business adjustment effect on the distribution of profits, \( \varepsilon^a = \varepsilon^a(J \setminus a) \geq 0 \). It can be interpreted as an external effect exerted on the profit tax base of \( J \setminus a \) when the MNE adjusts its pricing strategy or the development of knowhow in response to expanded sales in jurisdiction \( a \).

According to Shapley’s theorem, \( a \)’s tax base \( B^H_a \) equals the profit jurisdiction \( a \) contributes on average when cooperating with a randomly selected set of jurisdictions. As mentioned, \( a \)’s profit contribution can only be expected to be positive 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 a set \( J \setminus a \) with \( H \subseteq J \subseteq H \cup A \) equals \( 1/(n + 1) \) and that this probability is independent of the number \( m \) of elements in \( A \). Intuitively speaking, the reason is that \( n \) home jurisdictions plus jurisdiction \( a \) – i.e. \( n + 1 \) jurisdictions in total – must cooperate if positive profit is to be earned in \( a \). The number of jurisdictions counting as non-home is irrelevant.

*Proposition 2*: The Shapley approach suggests that a jurisdiction \( a \) in which an MNE does not develop patentable knowhow is allocated a positive tax base which does not exceed an even share of the revenue which the MNE earns in \( a \) if that jurisdiction cooperates with all home jurisdictions:

\[
0 < B^H_a \leq R^a / (n + 1) .
\]  

(6)
$B_a^n$ is (strictly) positive as the servicing of jurisdiction $a$ generates profitable business. The case that business in jurisdiction $a$ is not profitable is of no interest and discarded by assumption.

The case in which all business adjustment effects on profit vanish, $\varepsilon^a = 0$, deserves special notice. Then

$$B_a^n = R^a/(n + 1),$$  \hspace{1cm} (7)$$

and $\Pi(H \cup J) = \Pi(H) + \sum_{a \in J} R^a$. Respecting Axiom (ii), one obtains

$$B_h^n = \frac{1}{n} [\Pi(H \cup A) - \sum_{a \in A} B_a^n] = \frac{1}{n} [\Pi(H) + \sum_{a \in A} (1 - \frac{1}{n+1}) R^a]$$

$$= \frac{1}{n} \Pi(H) + \frac{1}{n+1} \sum_{a \in A} R^a.$$  \hspace{1cm} (8)$$

Eq. (8) shows clearly that home jurisdiction $h$ is allocated an even share in all the profit contributions whose creation requires the cooperation of $h$.

5. Implementing profit splitting when production is non-rival

Two reasons have been emphasized as possible explanations for the fact that the current system of international taxation does not rely on profit splitting but assigns undivided taxing rights. One reason referred to the difficulty encountered when determining the profit contributed by a jurisdiction on average. The term, $\Pi(J) - \Pi(J \setminus j)$, is not directly observable. It is profit generated in the counterfactual situation in which not all jurisdictions cooperate, $J \subset N$. The other reason emphasized reciprocity in trade, which obviates the need to achieve intercountry tax equity at the firm level. Both these reasons require qualification when production is non-rival, a characteristic feature of the digital economy.

Implementing profit splitting raises no particular difficulty when all business adjustment effects on profit vanish so that $\varepsilon^a = 0$ holds for all $a \in A$. In such a case, one may plausibly assume that all items needed for allocating the profit tax base are observable. The aggregate profit, $\Pi(H \cup A)$, is observable, as are the revenues, $R^a$, collected from jurisdiction $a \in A$. The balance $\Pi(H) = \Pi(H \cup A) - \sum_{a \in A} R^a$ is then observable, too. This means that in scenarios characterized by $\varepsilon^a \equiv 0$, profit splitting presents no serious informational hindrance to implementation. All the information needed to determine the tax bases $B_j^n$, $j \in H \cup A$ in line with the equations (7) and (8) is observable, at least in principle.
One might hypothesize that business adjustment effects tend to be insignificant when production is non-rival. If this were true, there would not be any serious informational obstacle to implementation. A priori, the business adjustment effects on profit cannot, however, be expected to be insignificant even when production is non-rival. If the effects are significant, the average profit contribution of $j$ ceases to be observable. Under such circumstances, the only practical finding derived from the Shapley approach is that each jurisdiction should have the right to tax an equitable share of the profit which is only earned if this jurisdiction cooperates. Expressed as a formula, this means that a jurisdiction not used for developing patentable knowhow should have the right to tax

$$B_a^\Pi = \beta R^a / (n + 1) \text{ for some } \beta \in (0, 1]. \quad (9)$$

The problem with this formula is that purely normative reasoning provides no justification for any particular value of $\beta$. This means that the community of governments would have to negotiate over the value of the splitting parameter $\beta$ to be applied in profit taxation.

One might hope to pin down $\beta$ by resorting to bargaining theory. However, bargaining theory cannot solve the problem of lack of observability. This is easily shown by applying Nash’s (1950) bargaining solution to the simple example of remote supply discussed above. In this case, the Nash bargaining solution does not differ from the Shapley value. Thus the problem of lack of observability would not be solved by switching from Shapley to Nash. Both solution concepts suggest allocating the same tax base $B_a^\Pi = [\Pi(h, a) - \Pi(h)]/2$ to jurisdiction $a$. No additional information about $\beta$ is obtained. The implementation of formula (9) therefore presents difficulties whenever the business adjustment effect, $\epsilon^a$, is positive but not observable.

The current system of international taxation can be interpreted as seeking intercountry tax equity at the country level and denying any need to achieve equitable taxation at the level of the individual firm. The implicit assumption is that each jurisdiction takes the role of home in some cases and of non-home 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, which are taxed at source. The Shapley approach suggests that the simultaneous application of residence and source taxation can be interpreted as an imperfect attempt to achieve intercountry equity at the country level. The attempt is imperfect inasmuch as one cannot expect the roles of residence and source to be evenly distributed among countries. In fact, intercountry tax equity has long been questioned by developing countries in their
relations with the developed world and a similar debate is being 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 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 of the ten most valuable firms worldwide made their money with digital business. And these companies are all resident either 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 a lack of fairness is strengthened by the practice of MNEs of avoiding taxes by profit shifting. In this situation, profit splitting promises increased fairness. At the very least, it is a form of international taxation that deserves careful consideration by policy makers. It is obvious that the incentive to relocate R&D and the holding of patents is reduced when the return earned in a foreign low-tax country is not exclusively taxed by that country but jointly by all countries involved. Any one-sided taxation in a single country is a strong incentive to hold patents in those countries where tax rates are low and to shift R&D costs to those countries where tax rates are high. This is why many countries feel obliged to grant all kinds of preferential tax provisions for R&D, such as the introduction of patent boxes to alleviate taxes on income earned with intangible assets. In other words, the current tax system triggers various types of tax competition. Profit splitting is by its very nature more resilient to such policies. The taxes saved when patents are migrated from a high-tax to a low-tax country are reduced when part of the profit they generate continues to be taxed in the high-tax country. The hope may thus not be vain that international negotiations over the splitting parameter $\beta$ might not be as antagonistic as international negotiations over taxing rights usually tend to be (Richter, 2019). When pleading for a particular value of $\beta$, governments have to trade off two opposing effects. A low value of $\beta$ secures a large share of the taxable profit earned with home-developed knowhow. By contrast, a high value of $\beta$ reduces the incentive of resident MNEs to move R&D to a low-tax country. The tax savings are reduced as the share of profit taxed in the low-tax country decreases in $\beta$. 
6. Little gain from profit splitting when production is rival

The Shapley theorem does not provide any \textit{a-priori} reason for taxing different sources of profit differently. The approach rather suggests that all sources should be treated equally and profit split irrespective of whether it is earned on non-rival or rival production. To illustrate the implications of splitting profit on rival production, let us consider a scenario in which a good is produced with land at constant returns to scale.

Let $L_h, L_a$ denote the fixed land endowments of home and abroad respectively. The land rents earned when both home and abroad stay in autarky are $\bar{w}_j, j = h, a$. Home is assumed to be the country in which land is in abundant supply. In free trade, home will therefore export the good which drives up the home rent, $w_h > \bar{w}_h$. If free trade is a perfect substitute for perfect factor mobility, equilibrium rents will even be equal, $w_j = w, j = h, a$. As land is in fixed supply, all income from land is lump-sum. It is profit earned on a rival factor. Now assume that all home land is owned by a firm resident in home. In free trade, this firm makes sales abroad. The profit pattern associated with this firm is therefore given by $\Pi(h,a) = w_hL_h > \bar{w}_hL_h = \Pi(h) > 0 = \Pi(a)$. The resulting tax bases are

$$B_{h}^{Sh} \equiv \frac{1}{2}(w_h + \bar{w}_h)L_h, \quad B_{a}^{Sh} \equiv \frac{1}{2}(w_h - \bar{w}_h)L_h$$

(10)

if the Shapley approach applies. By contrast, the tax bases are

$$B_{h}^{C} \equiv w_hL_h \quad B_{a}^{C} \equiv 0$$

(11)

if the current system applies. The key argument for the Shapley approach is intercountry tax equity in the sense axiomatized in Section 2. Such equity, however, has its costs, as mentioned already in Section 3. One cost is informational. Taxation according to eq. (11) is much simpler to implement than taxation according to eq. (10). The tax bases (11) can be implemented without relying on information which relates to the non-observable state of autarky, $\bar{w}_h$. Moreover, implementing $B_{a}^{Sh}$ places high demands on the level of interjurisdictional cooperation as the information needed abroad to tax $B_{a}^{Sh}$ must be provided by home. Informational simplicity is a clear advantage of (11). As mentioned before, this is not the only argument against (10). The need to achieve intercountry tax equity at the firm level is weaker if the goods traded are produced with rival inputs at constant returns to scale.

Assuming trade in such goods to be balanced is not unrealistic. The tax base gained on imports is lost on exports and it is not clear whether a country would gain on balance by moving to the Shapley assignment of taxing rights. The Shapley assignment also causes an
additional cost in efficiency when applied to factor income which is rival and mobile. An example illustrating this point is the taxation of capital income. If home and abroad tax mobile capital at differing rates, there will be a loss in global production efficiency. The clear advantage of residence taxation is that it avoids such allocational inefficiency. In sum, it is not clear whether applying the Shapley approach to the taxation of profit earned on rival factors of production has more advantages or disadvantages. In what follows, it is assumed that the Shapley approach is not applied to such profit.

Purely rival production and purely non-rival production are extreme cases. More relevant will be cases which are mixed in the sense that some factors are rival in use and others are non-rival. To deal with such mixed cases it makes sense to decompose them into their pure components and to tax each pure component according to agreed rules. To enable the decomposition, profit contributions earned on rival factors must be separated from those earned on non-rival factors. The separation suggested in the literature is known as residual profit allocation.

7. **Residual profit allocation when production is mixed**

The approach known as residual profit allocation relies on separating an MNE’s total profit into a “routine” part and a “residual” part (OECD, 2019b; Devereux et al., 2019). This paper applies the separation by analogy. This means that profit earned on rival factors is treated like routine profit and profit earned on patentable knowhow is treated like residual profit. The proposed separation and profit allocation follows a two-step procedure. In the first step, profit earned on rival factors is determined by applying arm’s length pricing and allocated to those jurisdictions where the opportunity cost of factor supply is incurred. In the second step, residual economic profit is interpreted as profit earned on patentable knowhow to be split and allocated to the jurisdictions in accordance with the Shapley assignment of taxing rights. In more detail:

Arm’s length pricing assumes the existence of uncontrolled prices. Such an assumption is certainly less problematic in the case of rival factor income than it is in the case of income earned from knowhow. Since knowhow is by its nature specific there will generally be no uncontrolled price of its value. At best, the cost of development can be priced at arm’s length. Uncontrolled prices ideally reflect the opportunity cost of factor supply. It is thus logical to assign the right to tax the profit earned on rival factors to the jurisdictions incurring the opportunity cost of supply. To a great extent, this is in line with current rules. In principle,
land is taxed at source, labor is taxed in the supplier’s country of residence, and interest paid on debt is taxed in the lender’s country of residence. A major discrepancy only exists in the case of equity. Under current law, the return on equity is taxed where business is carried out and not necessarily where the supplier of capital is resident. However, current law does not separate income earned on equity from income earned on knowhow. By contrast, the two-step procedure proposed here aims at taxing income where the opportunity cost of factor supply is incurred. And if the opportunity cost is zero, as is the case when knowhow is used, the Shapley approach suggests splitting the return between the jurisdictions involved.

If this two-step procedure were strictly implemented, a jurisdiction $a$ in which an MNE did not develop patentable knowhow would obtain the right to tax

$$B_a^n \equiv \beta \frac{(R^a - C^a)}{(n + 1)}$$

with some $\beta \in (0,1]$. (12)

This is eq. (9) when $R^a$ is replaced with $R^a - C^a$ with $C^a$ denoting allocable rival costs. This is what follows from a stringent application of the Shapley approach. Whether the world would be well advised to implement eq. (12) in practice, however, is a different matter. The benefits and costs would have to be carefully weighed against each other. One of the most far-reaching and controversial implications of its implementation is that countries would be allocated a share of the profit earned on all imports of goods and services produced with patentable knowhow. Practical implementation would require an extensive exchange of information between home and non-home countries. Policy makers might well hesitate to implement such a system. The exchange of information required would be less demanding if profit splitting were only applied to purely non-rival production.

8. Summary and conclusions

Digitalization is a challenge for international corporate income taxation to which quite a number of countries have already responded with unilateral action. The OECD and G20 countries view unilateral action with concern and they have invited other countries to jointly work out a consensual solution. The process for achieving consensus is guided by the principle that 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 publication, the OECD (2018a) reveals a narrow understanding of the concept, with business activities considered the only source of value creation. The present paper argues that such a narrow definition is unconvincing. The true source of transboundary value creation is the international cooperation of jurisdictions. An MNE earns taxable profit abroad only if the
jurisdictions involved cooperate on legal issues such as market access, commercial law, the rules of taxation, and so forth. If this view is accepted and if profit taxation is to be aligned with value creation, then taxing rights should ideally be allocated according to standards generally accepted as fair and equitable when distributing the surplus of cooperation. The Shapley value is designed to determine an equitable distribution of the surplus generated by cooperation. This paper therefore applies Shapley value theory to the question of how to allocate an MNE’s aggregate tax base to all the jurisdictions in which the MNE is active. The axioms uniquely characterizing the Shapley value are interpreted and justified by reference to the objective of aligning profit taxation with value creation. Shapley value theory is shown to suggest that each jurisdiction is assigned the right to tax the profit that jurisdiction contributes on average when cooperating with a randomly selected subset of jurisdictions. This means that the profit contribution earned by an MNE in a particular jurisdiction should be split between all those jurisdictions whose cooperation is required. Hence, Shapley value theory provides a firm normative framework for allocating an MNE’s profit tax base according to a rule not recognized by current international tax standards but certainly worth being considered “without prejudice” when the tax challenges arising from digitalization are addressed (OECD, 2019a, p. 6).

The theoretical implications of the Shapley approach for corporate income tax design are set out in Sections 4 to 7 of this paper. The starting point is a classification of different sources of profit. Profit earned on rival factors of production is differentiated from profit earned on non-rival factors in general, and on patentable knowhow, in particular. This distinction makes particular sense in connection with international corporate income taxation. The profitable exploitation of expensively 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. This view suggests that profit earned on rival factors be separated from that earned on non-rival factors and that the latter be interpreted as the return on patentable knowhow.4

Taxing profit according to the Shapley approach has some noteworthy implications. The first of these relates to the case in which an MNE develops patentable knowhow in more than one jurisdiction. In this paper, such jurisdictions are called home jurisdictions. The approach

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4 This is not to claim that the profitable exploitation of knowhow is the only determinant of multinationalization; however, the complementary determinants captured by Dunning’s well-known OLI framework play no role in this paper’s analysis and are therefore disregarded.
suggests that all home jurisdictions should be allocated an even share of the MNE’s aggregate profit tax base. Differences in market size and development costs are no justification for different tax bases. The tax base allocated to the set of all home jurisdictions should, however, exceed the profit those jurisdictions would earn if they did not cooperate with non-home jurisdictions. Thus they should tax a positive share of the profit contribution earned with the MNE’s knowhow in non-home jurisdictions. On the other hand, a jurisdiction in which patentable knowhow is not developed should also tax a positive share of the profit the MNE earns from business in that jurisdiction. Thus it is shown that the objective of aligning profit taxation with value creation requires splitting the profit earned on patentable 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 the practical implementation of profit splitting. This would necessitate observing the effect exerted on its domestic profit by an MNE going international. If it is assumed, as it reasonably could be, that such “external” effects are positive but not observable, the Shapley approach cannot be used to pin down a particular profit-splitting parameter, which in the present paper is modeled by $\beta \in (0,1]$. It is argued that governments would have to negotiate over the value of $\beta$ to be applied in international profit taxation. However, given that governments have to trade off opposing effects when pleading for a particular value of $\beta$ it is to be hoped that such negotiations would be less antagonistic than international negotiations over taxing rights usually are. Of course, this is a theoretical statement which like many others in this paper will have to be studied more intensively before it can be brought to bear on practical tax policy.

In Section 6, it is argued that there are good reasons to restrict splitting to the taxation of profit earned from non-rival factors. The gains in intercountry-tax equity expected to be derived from splitting the profit earned on rival factors may well not justify the increased cost of information acquisition and the efficiency loss in the international allocation of those factors. Profit from rival factors should preferably be taxed only in the country bearing the opportunity cost of supply. This is very much in line with current standards of international taxation, with the only discrepancy concerning equity capital. Under current law, the return on equity capital is taxed where business is carried out and not necessarily where the supplier of equity is resident.

Taxing profit earned on rival and non-rival factors of production differently requires separating profit according to source. The separation proposed in Section 7 is designed in analogy to the concept of residual profit allocation known from the literature. First, profit
earned from rival factors is determined by applying arm’s length pricing and allocated to those jurisdictions where the opportunity cost of factor supply is incurred. Then, residual economic profit is interpreted as profit earned from patentable knowhow and allocated to the jurisdictions involved in accordance with the Shapley approach. Despite obvious similarities, this procedure differs from the concept of residual profit allocation as it is usually understood. Not only do the definitions of rival/non-rival differ from those of routine/residual, but the proposals usually subsumed under residual profit allocation prescribe an allocation of an MNE’s residual profit based on cost, revenue or income, which the Shapley approach does not. The Shapley approach constrains the splitting to those profit contributions requiring interjurisdictional cooperation and it prescribes an even allocation of tax bases to the countries involved. The difference can be explained by deviating objectives. The proposals usually subsumed under the term residual profit allocation focus on administrability and they aim at minimizing deviations from current standards of corporate income taxation. By contrast, this paper has an academic focus. It seeks to unfold the theoretical implications for profit taxation if the OECD’s objective of aligning profit taxation with value creation is taken seriously and interpreted in line with principles of cooperative game theory.

9. Appendices

Appendix A

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

$$
\Pi(H \cup J) = \max[\Sigma_{j \in H \cup J} R^j(Q_1, \ldots, Q_n) - \Sigma_{h \in H} C_h(Q_h)]
= \Sigma_{j \in H \cup J} R^j(Q_1^*, \ldots, Q_n^*) - \Sigma_{h \in H} C_h(Q_h^*)
$$

$$
\Pi(H \cup J \setminus a) = \max[\Sigma_{j \in H \cup J \setminus a} R^j(Q_1, \ldots, Q_n) - \Sigma_{h \in H} C_h(Q_h)]
= \Sigma_{j \in H \cup J \setminus a} R^j(\bar{Q}_1, \ldots, \bar{Q}_n) - \Sigma_{h \in H} C_h(\bar{Q}_h)
$$

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

$$
0 < \Pi(H \cup J) - \Pi(H \cup J \setminus a) = R^a(Q_1^*, \ldots, Q_n^*) - \varepsilon^a
$$
with
\[
\varepsilon^a = \varepsilon^a(H \cup J \setminus a) = -\frac{1}{2} \sum_{j \in E \cup J \setminus a} \sum_{h,k \in H} (Q^*_h - \bar{Q}_h)[R^j_{h,k} - C^*_h](Q^*_k - \bar{Q}_k)
\]
where subscripts of \( R^j_{h,k} \) and the superscript of \( C^*_h \) indicate (partial) derivatives. As revenue functions are concave and as cost functions are convex, the second-order term \( \varepsilon^a \) is non-negative. First-order terms in eq. (13) cancel each other out.

**Appendix B**

The Shapley theorem suggests analyzing sequences in which jurisdictions consecutively join a cooperation. 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 profit 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 \( \{h_1, \ldots, h_n\} \) 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 profit 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 \( \{h_1, \ldots, h_n; a_1, \ldots, a_m\} \) 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 profit therefore equals

\[
\frac{(n+m+1)!/(n+1)}{(n+m+1)!} = \frac{1}{n+1}.
\]

**10. References**


OECD, 2015, OECD/G20 Base Erosion and Profit Shifting Project, Final Reports, Executive Summaries


