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Quantitative Research in Taxation – Discussion Papers

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arqus Discussion Paper No. 265
August

Real effects of an international tax reform for MNEs*

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Working Paper – August, 2021

With multinational enterprises (MNEs) centralizing production facilities, market countries claim not to receive their fair share of taxes. A reform of international business taxation that includes new profit allocation rules as well as the introduction of minimum taxation is being considered as a problem mitigating mechanism. We analyze theoretically the real effects of the aforementioned tax reform, i.e., MNEs' adjustments of production and sales decisions. Our findings show that the effects of an international tax reform on sales quantities depend on the properties of the underlying product markets. If national demand resembles characteristics of traditional industries, sales quantities remain unchanged. However, sales quantities are affected if specific demand characteristics of modern business models are assumed. For traditional industries a reformed tax regime increases tax revenues in high-tax market countries and even attracts production. In contrast, for modern business models tax revenues of high-tax countries can even decrease.

JEL-Classification: C70, H26, H32, M48
Keywords: BEPS, corporate taxation, minimum taxation, profit shifting, tax avoidance

*The authors gratefully acknowledge financial support by the German Research Foundation (DFG) - Collaborative Research Center (SFB/TRR) Project-ID 403041268 - TRR 266 Accounting for Transparency. They also thank Sebastian Kronenberger (TRR Conference discussant), Stacie Laplante, and participants at the 2020 TRR 266 Annual Conference, the EAA Annual Congress 2021, as well as workshop participants at ESCP Business School, WHU - Otto Beisheim School of Management, and the University of Toulouse for their valuable comments and suggestions.
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1. Introduction

Cross-border sales have gained increasing attention (see OECD (2018)), because production of foreign affiliates tripled, recently. Moreover, the major part of outward production is controlled by multinational enterprises (MNEs) domiciled in just a few developed countries.[1] As MNEs often centralize production the only economic activity in market countries is sales – typically compensated by cost-plus or resale-minus based transfer prices. From a tax revenue perspective, many market states believe not to receive their fair share because of transfer prices being prone to profit-shifting.[2]

To ensure a more fair and just allocation of taxation rights a concept for a two-pillar solution to address global tax challenges has been accepted by the OECD and G 20 in July 2021 (OECD, 2021).[3] A detailed implementation plan will be published in October 2021. If members agree, this reform will be brought into law in 2022, to be effective in 2023. The OECD concept rests on two pillars: Pillar One aims at sourcing more revenues to market jurisdictions where goods or services are used or consumed. The OECD envisages a closer link between the allocation of an MNE's taxable income and the distribution of sales.[4] Pillar Two stipulates the introduction of a global minimum tax.

However, an effective reform has to anticipate MNEs' reactions to a change in the taxation regime. In terms of production, firms could build up capacities located in market countries or withdraw from those markets in fear of local tax authorities pushing for higher tax payments. In this paper, we investigate the impact of an international tax reform on the (de)centralization of production operations, on sales quantities and on transfer pricing decisions. We analyze these key decisions based on a two-country model with a single-product MNE. In a first setting, we model traditional product markets, where local prices are independent from sales quantities in the other country. In a second setting, we consider national sales as complements reflecting demand characteristics of modern product markets, e.g. for social network services. We always focus on how the MNE anticipates tax measures by adjusting the location of production, sales and transfer prices.

Our paper is related to two streams of literature: First, our paper responds to the call for research on tax effects on the business activities of MNEs (Dyreng and Maydew, 2018). Specifically, we contribute to the growing literature on minimum

[1] These countries are the US, the UK, Germany, France, Japan, Switzerland and the Netherlands.
[2] See, e.g., Merle (2016) or Norris (2013).
[3] Digital service taxes can be regarded as unilateral attempts to secure taxation rights that would become superfluous after a global tax reform. See, e.g., Cui and Hashimzade (2019).
[4] On the importance of a global accord on the applicable tax base, see, e.g., Bunn (2021).

taxation (see, for example, Scot et al. (2020); Li (2018); Best et al. (2015)). Second, by analyzing the choice between centralized and decentralized production we contribute to the literature concerned with tax-induced distortions of investment. In line with the focus of our paper, Marques et al. (2019) assess the extent to which real investment responsiveness to corporate taxation is affected by cross-border income shifting. Altering production locations as a reaction to changes in tax regimes replicates this decision problem in our model. However, our results largely depend on the product market characteristics above and beyond the installed tax regime. Our paper also extends Martini et al. (2012) who analyze the impact of different combinations of tax allocation and managerial accounting regimes on investment and production decisions under Formula Apportionment (FA). In contrast to them we consider effects of a minimum taxation regime.

Our results show that the effects of the aforementioned international tax reform on sales quantities depend on the properties of the underlying product markets. If national demand resembles characteristics of traditional industries, sales quantities remain unchanged. Here, the MNE only adjusts its transfer prices reacting to the introduction of the new taxation regime. On the contrary, sales quantities are affected if specific demand characteristics of modern business models are assumed. Further, for traditional industries the tax reform increases tax revenues in the high-tax market country, and even attracts production facilities. In contrast, applied to modern business models tax revenues of the high-tax market country can even decrease after the reform. Finally, our results suggest that the mere threat to be taxed according to a sales formula results in adjustments of MNEs' production location, sales quantities, and transfer prices.

The paper proceeds as follows. In section 2 we consider traditional business models where national sales are independent from global activities, i.e. separability of domestic and foreign sales is given. After analyzing a pre-tax regime, we consider a regular corporate taxation regime. Finally, we investigate a minimum taxation regime after an international tax reform that advances minimum taxation by means of a sales-based re-allocation of taxable income. Following the same structure, section 3 explicitly considers complementarities between national sales which are a common characteristic of many modern business models (see for example Hein et al. (2020)). In section 4 we compare the results across the settings and discuss potential implications for fiscal policy. Section 5 concludes.

2. Separability of foreign and domestic sales

We consider a multinational enterprise that produces and sells a single product in two countries $i, i \in \{A, B\}$. The MNE centralizes decisions on both production quantities x_i and sales quantities s_i. We assume a single-stage production process with production taking place either in country A (centralized production) or in both countries simultaneously (decentralized production). The applied inverse demand function reflects characteristics of traditional product markets, i.e., sales in one country do not affect sales in the other country. The local sales price p_i^{sep} is determined as:

$$p_i^{sep}(s_i) = d_i - s_i \tag{1}$$

The parameter d_i denotes the maximum willingness to pay and indirectly reflects market size. Further, we assume constant unit production cost, c_i, neglecting fixed costs. Moreover, in case of goods being exported, transaction costs of c_T per unit apply. We consider only profitable sales, i.e. $p_i^{sep}(s_i) > c_i$ or, if applicable, $p_B^{sep}(s_i) > c_A + c_T$. Transactions costs are borne by the receiving entity B. For ease of presentation we assume the exporting country to be A (if necessary), implying that $x_A \geq s_A$. We exclude stockkeeping and backorder sales. Thus, the quantity of imported goods, $q_B = x_A - s_A$, added to the domestic production in country B, x_B, has to meet the local demand, i.e., $x_B + q_B = s_B$. The total transfer payment, $T(q_B)$ for all exported goods, q_B, amounts to $T(q_B) = tq_B$, with t reflecting the transfer price per unit.[5] Thus, the total profit $\Pi^{no,sep}(s_A, s_B, q_B)$ in a pre-tax regime reads:

$$\begin{aligned} \Pi^{no,sep}(\cdot) &= \underbrace{(d_A - s_A)s_A + tq_B - c_A x_A}_{\Pi_A^{no,sep}} + \underbrace{(d_B - s_B)s_B - tq_B - c_B x_B - c_T q_B}_{\Pi_B^{no,sep}} \\ &= (d_A - s_A)s_A - c_A(s_A + q_B) + (d_B - s_B)s_B - c_B\,(s_B - q_B) - c_T q_B \end{aligned} \tag{2}$$

Thereby, the first three terms in the upper line of (2) represent the reported profit in country A, $\Pi_A^{no,sep}$; the next four terms represent the reported profit in country B, $\Pi_B^{no,sep}$, with the last term accounting for potential transaction costs. Observe the well-known effect that in the absence of taxation, transfer prices do not affect the overall profit of the MNE.

With corporate tax rates $\tau_i \in]0, 1[$, and $\tau_A \neq \tau_B$ applied to reported profits, the total

[5] The applied transfer price could result from cost-plus, i.e., $c_A + \varepsilon$, or from resale-minus, i.e., $p_B - \varepsilon$.

profit $\Pi^{tax,sep}(s_A, s_B, q_B)$ in the corporate tax regime changes to:

$$\begin{aligned}\Pi^{tax,sep}(\cdot) &= \Pi_A^{no,sep}(1-\tau_A) + \Pi_B^{no,sep}(1-\tau_B) \\ &= \left[(d_A - s_A)s_A + tq_B - c_A(s_A + q_B)\right](1-\tau_A) \\ &+ \left[(d_B - s_B)s_B - tq_B - c_B\left(s_B - q_B\right) - c_T q_B\right](1-\tau_B) \end{aligned} \tag{3}$$

As there exists no theoretically justified benchmark for transfer prices,[6] every legally accepted transfer price is a political compromise reflecting negotiation power, fairness considerations and current development conditions of the involved countries. In our model, transfer prices are accepted by the local fiscal authorities whenever the export of goods or services has non-negative effects on national tax bases, i.e., $t \in [\underline{t}, \bar{t}]=[c_A, d_B - s_B - c_T]$. We assume that both tax authorities are bound to this range irrespective of the fiscal regime. This assumption excludes an abuse of a specific fiscal regime, such as minimum taxation, on behalf of the fiscal authorities.

In the minimum taxation regime the local tax base rests on a sales based allocation formula. Sales are widely believed to be a good proxy for allocating profits:[7] First of all, revenues are less prone to manipulation than profits, total book-value of assets or employees' compensation. Second, companies are not discouraged to expand their property and payroll as these criteria do not enter the tax formula (Andrus and Oosterhuis, 2017; Goolsbee and Maydew, 2000). Third, sales-based formulas have been widely accepted in real life.[8] Finally, market countries lobby for sales-based allocations of taxation rights emphasizing the economic value of the customer-base in the current political discussions (see, e.g., GrantThornton (2019), OECD (2021)).

Accordingly, the minimum required tax base, TB_i is:

$$TB_i = \frac{p_i s_i}{p_i s_i + p_{\neg i} s_{\neg i}} \left(\Pi_i^{no} + \Pi_{\neg i}^{no}\right) \tag{4}$$

Observe that (4) implies $TB_{\neg i} = (1 - \frac{p_i s_i}{p_i s_i + p_{\neg i} s_{\neg i}}) \left(\Pi_i^{no} + \Pi_{\neg i}^{no}\right)$ for identical apportionment formulas.[9] Specifically, country i compares the reported local profit to

[6] For a technical proof see Alchian and Demsetz (1972).

[7] For a discussion of the advantages and disadvantages of this factor, see, for example, Radaelli and Klemm (2001).

[8] In the U.S., a majority of states heavily relies on sales factors for inter-state profit allocation (Clausing, 2016).

[9] Focusing on effects of information endowment, we eliminate any confounding effects from applying the allocation formula. Therefore, we do not allow for different formulas in different countries.

the minimum tax base and potentially adjusts the local profit upwards:

$$\Pi_i^{min}(\cdot) = \begin{cases} \frac{p_i s_i}{p_i s_i + p_{\neg i} s_{\neg i}} (\Pi_i^{no} + \Pi_{\neg i}^{no}) & \text{if } \Pi_i^{no} \leq TB_i \\ \Pi_i^{no} & \text{if } \Pi_i^{no} > TB_i \end{cases} \tag{5}$$

Accordingly, the total after-tax profit with minimum taxation reads as follows:

$$\Pi^{min}(\cdot) = \begin{cases} \Pi_i^{no} - \frac{p_i s_i}{p_i s_i + p_{\neg i} s_{\neg i}} \left(\Pi_i^{no} + \Pi_{\neg i}^{no}\right) \tau_i + \Pi_{\neg i}^{no}(1 - \tau_{\neg i}) & \text{if } \Pi_i^{no} \leq TB_i \\ \Pi_i^{no}(1 - \tau_i) + \Pi_{\neg i}^{no} - \frac{p_{\neg i} s_{\neg i}}{p_i s_i + p_{\neg i} s_{\neg i}} \left(\Pi_i^{no} + \Pi_{\neg i}^{no}\right) \tau_{\neg i} & \text{if } \Pi_i^{no} > TB_i \end{cases} \tag{6}$$

Lemma 1 shows our results for the pre-tax regime without taxation as derived from (2).

Lemma 1. *In the pre-tax regime, the MNE centralizes production, with $x_A = s_A + s_B$, if*

$$c_B > c_A + c_T \tag{7}$$

The optimal sales quantities are:

$$s_A^* = \frac{1}{2}(d_A - c_A) \text{ and } s_B^* = \begin{cases} \frac{1}{2}(d_B - c_A - c_T) & \text{for centralized production} \\ \frac{1}{2}(d_B - c_B) & \text{for decentralized production} \end{cases} \tag{8}$$

Proof: See Appendix A.1 and setting $\alpha_i = 0$.

Lemma 2 summarizes our findings for a regime where reported profits are taxed at tax rates τ_i, as represented by (3).

Lemma 2. *In a regime with corporate income taxation at rates τ_i, the MNE centralizes production if*

$$c_B > \begin{cases} c_A + c_T & \text{for } \tau_A > \tau_B \\ \left(1 - \sqrt{\frac{1-\tau_A}{1-\tau_B}}\right) d_B - \sqrt{\frac{1-\tau_A}{1-\tau_B}}(c_A + c_T) & \text{for } \tau_A < \tau_B \end{cases} \tag{9}$$

The optimal transfer price t^* under centralized production is

$$t^* = \begin{cases} c_A & \text{for } \tau_A > \tau_B \\ \frac{1}{2}(d_B + c_A - c_T) = p_B^*(s_B^*) - c_T & \text{for } \tau_A < \tau_B \end{cases} \tag{10}$$

The optimal sales quantities are

$$s_A^* = \frac{1}{2}(d_A - c_A) \text{ and } s_B^* = \begin{cases} \frac{1}{2}(d_B - c_A - c_T) & \text{for centralized production} \\ \frac{1}{2}(d_B - c_B) & \text{for decentralized production} \end{cases} \tag{11}$$

The resulting tax revenues $\mathcal{T}_A$ in country A are

$$\mathcal{T}_A = \begin{cases} \frac{1}{4}\tau_A \left(d_A - c_A\right)^2 & \textit{for decentralized production} \\ \frac{1}{4}\tau_A \left(d_A - c_A\right)^2 & \textit{for centralized production and } \begin{cases} \tau_A > \tau_B \\ \tau_A < \tau_B \end{cases} \\ \frac{1}{4}\tau_A \left[\left(d_A - c_A\right)^2 + \left(d_B - c_A - c_T\right)^2\right] & \end{cases} \tag{12}$$

The resulting tax revenues $\mathcal{T}_B$ in country B are

$$\mathcal{T}_B = \begin{cases} \frac{1}{4}\tau_B \left(d_B - c_B\right)^2 & \textit{for decentralized production} \\ \frac{1}{4}\tau_B \left(d_B - c_A - c_T\right)^2 & \textit{for centralized production and } \begin{cases} \tau_A > \tau_B \\ \tau_A < \tau_B \end{cases} \\ 0 & \end{cases} \tag{13}$$

Proof: See Appendix A.2 and setting $\alpha_i = 0$.

(11) shows that sales quantities remain unchanged compared to the pre-tax regime. (9) shows that the location decision remains unaffected as long as $\tau_A > \tau_B$. If $\tau_A < \tau_B$, comparing the threshold for the unit production costs c_B in the pre-tax case, (7), with the one of the corporate tax regime, (9), reveals:

$$c_A + c_T > d_B - \left(d_B - c_A - c_T\right)\sqrt{\frac{1-\tau_A}{1-\tau_B}} \Leftrightarrow c_A + c_T < d_B \tag{14}$$

The latter inequality is true by assumption. The lower threshold in the corporate tax regime indicates that the *MNE* centralizes production more often than in the pre-tax regime. Thus, country *A* is able to attract production facilities by ways of a lower tax rate.

Changing the legal framework and introducing the possibility of minimum taxation has the following effects.

Lemma 3. *If minimum taxation is feasible, let $d_B \leq \left(1 + \frac{c_T}{c_A}\right) d_A$ and $c_B > c_A + c_T$. Then, production is centralized.*

The optimal transfer price t^* is

$$t^* = c_A \tag{15}$$

The optimal sales quantities are

$$s_A^* = \frac{1}{2}\left(d_A - c_A\right) \textit{and}\, s_B^* = \frac{1}{2}\left(d_B - c_A - c_T\right) \tag{16}$$

The resulting tax revenues $\mathcal{T}_{min}$ in countries A and B are

$$\mathcal{T}_{min} = \begin{cases} \frac{1}{4}\tau_A \left(d_A - c_A\right)^2 & \text{in country } A \\ \frac{1}{4}\tau_B \left(d_B - c_A - c_T\right)^2 & \text{in country } B \end{cases} \tag{17}$$

For $d_B \leq \left(1 + \frac{c_T}{c_A}\right) d_A$ and $c_B < c_A + c_T$ decentralized production is optimal. The optimal sales quantities of Lemma 2 apply.

Proof: See Appendix A.3 with $\alpha_i = 0$

Due to the feasibility of minimum taxation location incentives stemming from the corporate income taxation regime are nullified as long as $d_B \leq \left(1 + \frac{c_T}{c_A}\right) d_A$. That is, compared to the corporate income taxation regime the feasibility of minimum taxation re-establishes incentives to decentralize production. For $\tau_A < \tau_B$, this implies that A loses production capacities to B. Moreover, tax revenues decrease in country A and increase in B due to the mere possibility of applying a sales based formula. Note that here no country actually applies the sales formula to determine its tax base due to the anticipation of the MNE. Only if the d_B-threshold is exceeded, both countries would determine taxable income based on sales, which is beyond the scope of this paper. Tax revenues of both countries do not change for $\tau_B < \tau_A$ under a minimum tax regime as long as the d_B-threshold is not exceeded.

3. Complementarities between foreign and domestic sales

The previous analyses are based on separable national sales. That is, at least in the absence of taxes, a change in sales in country A does not affect price and sales quantity in country B, and vice versa. In this section, we integrate complementarities between foreign and domestic sales.[10]

Modern business models such as digital service platforms often generate customer value because of network effects. This implies that national demand is downward-sloping in the charged price, but upward-sloping in the number of total users. Thus, demand can be quantified as:

$$s_i(p_i, s_{\neg i}) = d_i - p_i + \alpha_i s_{\neg_i} + \beta_i s_i \tag{18}$$

Here, α_i (β_i) is a scaling parameter indicating the strength of the network effect in country i from foreign (domestic) sales. Deriving the inverse demand function from

[10] If not stated otherwise the assumptions and model settings of the previous section hold.

(18) by suppressing factor $(1-\beta_i)$, which only scales the price impact of local sales, and re-arranging terms gives:

$$p_i(s_i, s_{\neg i}) = d_i - s_i + \alpha_i s_{\neg_i} \tag{19}$$

where $0 < \alpha_i < 1$ is assumed. Thus, the total profit in the pre-tax regime, $\Pi^{no,co}(s_A, s_B, q_B)$, reads:

$$\begin{aligned}
\Pi^{no,co}(\cdot) &= \underbrace{(d_A - s_A + \alpha_A s_B)s_A + tq_B - c_A x_A}_{\Pi_A^{no,co}} \\
&+ \underbrace{(d_B - s_B + \alpha_B s_A)s_B - tq_B - c_B x_B - c_T q_B}_{\Pi_B^{no,co}} \\
&= (d_A - s_A + \alpha_A s_B)s_A - c_A(s_A + q_B) \\
&+ (d_B - s_B + \alpha_B s_A)s_B - c_B\,(s_B - q_B) - c_T q_B
\end{aligned} \tag{20}$$

Analogously, the total profit in the corporate tax regime, $\Pi^{tax,co}(s_A, s_B, q_B)$, reads:

$$\begin{aligned}
\Pi^{tax,co}(\cdot) &= \Pi_A^{no,co}(1-\tau_A) + \Pi_B^{no,co}(1-\tau_B) \\
&= [(d_A - s_A + \alpha_A s_B)s_A + tq_B - c_A(s_A + q_B)]\,(1-\tau_A) \\
&+ [(d_B - s_B + \alpha_B s_A)s_B - tq_B - c_B\,(s_B - q_B) - c_T q_B]\,(1-\tau_B)
\end{aligned} \tag{21}$$

Transfer prices are accepted by the local fiscal authorities whenever the export of goods has non-negative effects on national tax bases, i.e., $t \in [\underline{t}, \overline{t}] = [c_A, d_B - s_B + \alpha_B s_A - c_T]$. The rules for minimum taxation apply analogously.

3.1. Pre-tax regime

To analyze the effects of complementarities between national sales, our benchmark regime is a regime without taxes based on profit function (20). Lemma 4 summarizes the findings.

Lemma 4. *The MNE chooses centralized production, with $x_A = s_A + s_B$, if*

$$c_B > c_A + c_T \tag{22}$$

The optimal sales quantities are

$$s_A^* = \begin{cases} \frac{2(d_A - c_A) + (d_B - c_A - c_T)(\alpha_A + \alpha_B)}{4 - (\alpha_A + \alpha_B)^2} & \textit{for centralized production} \\ \frac{2(d_A - c_A) + (d_B - c_B)(\alpha_A + \alpha_B)}{4 - (\alpha_A + \alpha_B)^2} & \textit{for decentralized production} \end{cases} \tag{23}$$

and

$$s_B^* = \begin{cases} \frac{2(d_B - c_A - c_T) + (d_A - c_A)(\alpha_A + \alpha_B)}{4 - (\alpha_A + \alpha_B)^2} & \textit{for centralized production} \\ \frac{2(d_B - c_B) + (d_A - c_A)(\alpha_A + \alpha_B)}{4 - (\alpha_A + \alpha_B)^2} & \textit{for decentralized production} \end{cases} \tag{24}$$

Proof: See Appendix A.1.

The results show that different from section 2, complementarities in international sales lead to different sales quantities depending on the firm's choice of a centralized or decentralized production process not only in country B, but in the exporting country A as well.

Comparing the first terms in the numerators of the centralized and the decentralized production quantities in (24) shows the direct effect of cost differences between centralized and decentralized production on the sales quantity s_B^*. The second term in the numerator in (24) shows the indirect ("complementary") effect of the sales in A (which depend on d_A, c_A and $\alpha_{A/B}$) on the sales in B.

3.2. Corporate income tax regime

In this section we assume that reported profits $\Pi_i^{no,co}$ are taxed at corporate tax rates τ_i. By means of transfer pricing the MNE can shift profits between the countries.

Lemma 5. *In a regime with corporate income taxation at rates τ_i, the MNE chooses centralized production if*

$$c_B > \begin{cases} c_A + c_T & \\ \frac{1}{2}(d_A - c_A)\left(\alpha_A \frac{1-\tau_A}{1-\tau_B} + \alpha_B\right) + d_B - s_B^* \frac{2\sqrt{4-(\alpha_A+\alpha_B)^2}}{(1-\tau_B)} & \textit{for} \\ \cdot\sqrt{(4 - 2\alpha_A\alpha_B)(1-\tau_A)(1-\tau_B) - \alpha_A^2(1-\tau_A)^2 - \alpha_B^2(1-\tau_B)^2} & \end{cases} \begin{matrix} \tau_A > \tau_B \\ \\ \tau_A < \tau_B \end{matrix} \tag{25}$$

The optimal transfer price t^* under centralized production is

$$t^* = \begin{cases} c_A & \\ \frac{(1-\alpha_B)(2+\alpha_A+\alpha_B)c_A + (\alpha_B - \alpha_A)d_A + \left(2 - \alpha_A^2 - \alpha_A\alpha_B\right)(d_B - c_T)}{(2-\alpha_A-\alpha_B)(2+\alpha_A+\alpha_B)} & \end{cases} \textit{for} \quad \begin{matrix} \tau_A > \tau_B \\ \tau_A < \tau_B \end{matrix} \tag{26}$$

The optimal sales quantities under centralized production for $\tau_A > \tau_B$ are

$$s_A^* = \frac{2(d_A - c_A) + (d_B - c_A - c_T)\left(\alpha_A + \alpha_B \frac{1-\tau_B}{1-\tau_A}\right)}{4 - \left(\alpha_A\sqrt{\frac{1-\tau_A}{1-\tau_B}} + \alpha_B\sqrt{\frac{1-\tau_B}{1-\tau_A}}\right)^2} \tag{27}$$

and

$$s_B^* = \frac{2(d_B - c_A - c_T) + (d_A - c_A)\left(\alpha_B + \alpha_A \frac{1-\tau_A}{1-\tau_B}\right)}{4 - \left(\alpha_A \sqrt{\frac{1-\tau_A}{1-\tau_B}} + \alpha_B \sqrt{\frac{1-\tau_B}{1-\tau_A}}\right)^2} \tag{28}$$

The optimal sales quantities under centralized production and $\tau_A < \tau_B$ are

$$s_A^* = \frac{2\,(d_A - c_A) + (d_B - c_A - c_T)\,(\alpha_A + \alpha_B)}{4 - (\alpha_A + \alpha_B)^2} \tag{29}$$

and

$$s_B^* = \frac{2\,(d_B - c_A - c_T) + (d_A - c_A)\,(\alpha_A + \alpha_B)}{4 - (\alpha_A + \alpha_B)^2} \tag{30}$$

The optimal sales quantities under decentralized production are

$$s_A^* = \frac{2(d_A - c_A) + (d_B - c_B)\left(\alpha_A + \alpha_B \frac{1-\tau_B}{1-\tau_A}\right)}{4 - \left(\alpha_A \sqrt{\frac{1-\tau_A}{1-\tau_B}} + \alpha_B \sqrt{\frac{1-\tau_B}{1-\tau_A}}\right)^2} \tag{31}$$

and

$$s_B^* = \frac{2(d_B - c_B) + (d_A - c_A)\left(\alpha_B + \alpha_A \frac{1-\tau_A}{1-\tau_B}\right)}{4 - \left(\alpha_A \sqrt{\frac{1-\tau_A}{1-\tau_B}} + \alpha_B \sqrt{\frac{1-\tau_B}{1-\tau_A}}\right)^2} \tag{32}$$

Proof: See Appendix A.2.

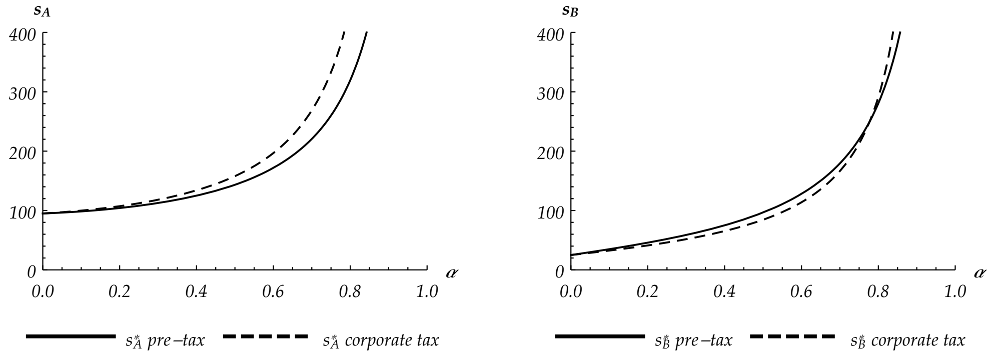
For $\tau_B > \tau_A$, country B realizes no tax revenues ($\mathcal{T}_B = 0$) under centralized production. In contrast, country A generates strictly positive tax revenues ($\mathcal{T}_A > 0$).

The results in (26) show that the *MNE* also chooses a transfer price at the lower end (if $\tau_A > \tau_B$) or the upper end (if $\tau_A < \tau_B$) of the legally accepted interval if complementarities between national sales exist.

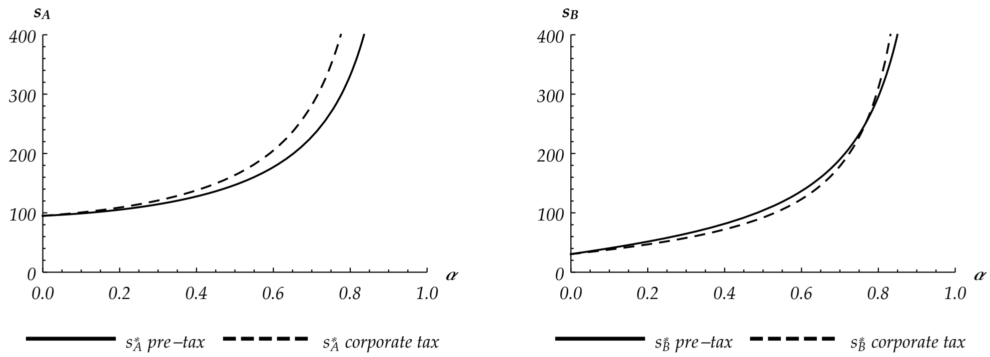
Next, we look at the optimal sales quantities under centralized production. Compared to the pre-tax case, the implementation of corporate taxation does not have an impact on s_A^* and s_B^* in both countries if $\tau_A < \tau_B$. In contrast, under $\tau_A > \tau_B$ the implementation of corporate taxation changes the optimal sales quantities in both countries. For simplicity reasons we again assume symmetric complementarities in both countries, $\alpha = \alpha_A = \alpha_B$. For the optimal sales quantity s_A^* holds that it increases with the implementation of corporate taxation.[11] The optimal sales quantity s_B^* is higher under corporate taxation

[11]Under centralized production, the optimal after-tax sales quantity s_A^* is higher than the pre-tax sales quantity under $\tau_A > \tau_B$ if the following condition holds: $\alpha_B < \frac{2\sqrt{1+\tau_A\tau_B-\tau_A-\tau_B}}{2-\tau_A-\tau_B}$. Since $\frac{2\sqrt{1+\tau_A\tau_B-\tau_A-\tau_B}}{2-\tau_A-\tau_B} > 1$, this condition is always fulfilled.

Figure 1: Comparison of optimal s_A and s_B



Panel A: Comparison of optimal s_A and s_B under central production and $\tau_A > \tau_B$



Panel B: Comparison of optimal s_A and s_B under decentral production and $\tau_A > \tau_B$

The figure illustrates the choice of the optimal sales quantities s_A^* and s_B^* contingent on α. Panel A shows optimal sales quantities under central production and $\tau_A > \tau_B$. Panel B exhibits sales quantities under decentral production. Both panels are based on the following parameter assumptions: $d_A = 200$, $d_B = 80$, $c_A = 10$, $c_T = 20$, $\tau_A = 0.5$, $\tau_B = 0.01$. In addition, Panel A assumes that $c_B \geq 30$ which warrants central production. Panel B assumes $c_B = 19$.

compared to the pre-tax regime if α exceeds a certain threshold.[12] This threshold increases in τ_B, c_T, d_A and decreases in d_B. Thus, the after-tax sales quantity s_B^* can (but does not have to) be higher than the pre-tax sales quantity if complementarities between national sales are high. Panel A of Figure 1 shows a numerical example for the optimal sales quantities s_A^* and s_B^* in the pre-tax and corporate tax regime in the centralized setting depending on α.

[12]The exact threshold is provided in (93) in Appendix A.4.

Under decentralized production, the implementation of taxation impacts the optimal sales quantities in both countries as well. In country A the implementation of corporate taxation results always in a higher optimal sales quantity s_A^* compared to the pre-tax case.[13] In country B the optimal sales quantity s_B^* always increases after the implementation of corporate taxes if $\tau_A < \tau_B$. For $\tau_B < \tau_A$, the optimal sales quantity s_B^* under corporate taxation exceeds the one under the pre-tax regime if α meets a certain threshold.[14] This threshold increases in τ_B, c_B, d_A and decreases in c_A, d_B. Panel B of Figure 1 provides a numerical example for the optimal sales quantities s_A^* and s_B^* in the pre-tax and corporate tax regime depending on α if decentralized production is chosen.

Finally, we look at the location decision of the MNE. (25) shows that this decision remains unaffected compared to the regime without taxes if $\tau_A > \tau_B$. To analyze the impact of taxation on the company's location decision if $\tau_A < \tau_B$ we compare the threshold for centralized production under corporate income taxation, $\widehat{c_B^c}$ (see (25)), with the pre-tax case, $\widehat{c_B}$ (see (22)). We further assume symmetric complementarities in both countries, $\alpha = \alpha_A = \alpha_B$.[15] We find that

$$\begin{aligned}
&\widehat{c_B^c} - \widehat{c_B} \\
&= \frac{\alpha\,(2-\tau_A-\tau_B)\,(d_A-c_A)}{2\,(1-\tau_B)} + d_B - 2c_A - 2c_T \\
&+ \frac{\sqrt{\frac{(1-\alpha)(4(1-\tau_A)(1-\tau_B)-\alpha^2(2-\tau_A-\tau_B)^2)}{1+\alpha}}\,((1+\alpha)c_A - \alpha d_A - d_B + c_T)}{2(1-\alpha)\,(1-\tau_B)}
\end{aligned} \tag{33}$$

The threshold, that the production cost in country B must exceed to trigger a centralized production, increases (decreases) compared to a pre-tax regime if (33) takes on a positive (negative) value. Contrary to our finding in the absence of complementarities (see (14)), the impact of corporate taxation on the threshold is not clear-cut. Figure 2 shows that it depends on different factors whether the threshold for c_B increases or decreases compared to a pre-tax regime. While no or low complementarities in sales always lead to a lower c_B-threshold (and thus increased incentives for centralized production), the threshold may even increase if high complementarities in sales exist.[16] Panel B shows that this effect is even stronger for low

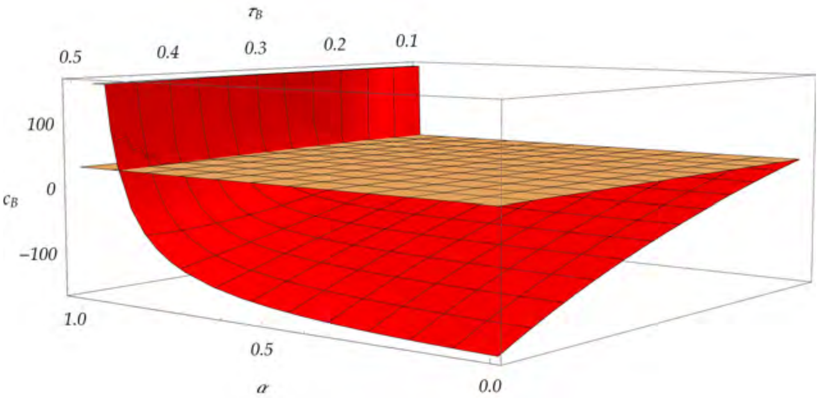
[13] In the decentralized setting, the optimal after-tax sales quantity s_A^* is higher than the pre-tax sales quantity if $\alpha_B < \frac{2\sqrt{1+\tau_A\tau_B-\tau_A-\tau_B}}{2-\tau_A-\tau_B}$. This condition is always fulfilled, see FN[11].

[14] The exact threshold is provided in (94) in Appendix A.4.

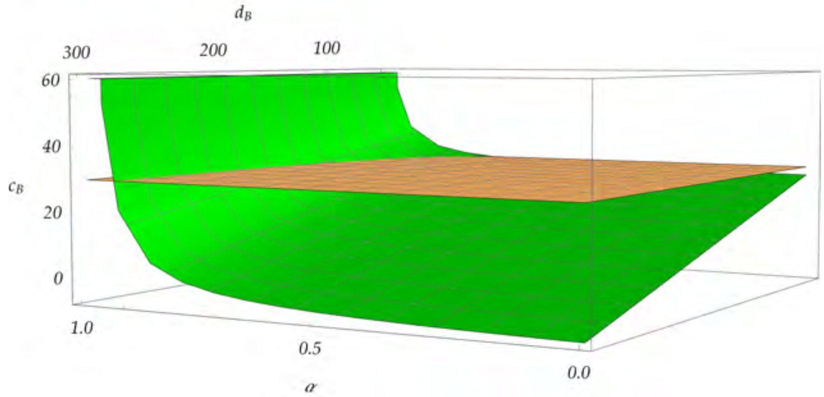
[15] This implies that the increase in customers' willingness to pay caused by a higher number of customers in the other country is independent from the customers' location (in country A or B).

[16] Note that negative values for the c_B - threshold under corporate taxation indicate that the MNE would prefer a centralized production even if production costs would be zero in country B since the fiscal advantages from centralized production overcompensate the cost differences between both countries.

Figure 2: Determinants of the $MNE's$ location decision



Panel A: The impact of taxes and complementarities in sales on firm location



Panel B: The impact of market size and complementarities in sales on firm location

The figure illustrates the effect of different factors on the threshold for c_B that has to be met to warrant centralized production. Both panels show thresholds under a pre-tax regime and under corporate taxation. Panel A shows the effect of varying complementarities in sales (with $\alpha = \alpha_A = \alpha_B$) and of a variation in the tax rate τ_B (for a constant value $\tau_A = 0.1$) on the threshold for c_B. The red area refers to the threshold under corporate taxation, and the brown area refers to the threshold before tax. Panel B illustrates the impact of complementarities in sales and of the market size d_B. Here, the green area refers to the threshold under corporate taxation, and the brown area refers to the threshold before tax.

levels of d_B, that is, if the margin in country B would be relatively low in the absence of complementarities.

3.3. Minimum taxation regime

Lemma 6. *If minimum taxation is feasible, let* $d_B \leq \frac{\eta}{\theta}$[17] *and* $c_B > c_A + c_T$*. Then, production is centralized.*

The optimal transfer price t^* *is*

$$t^* = c_A \tag{34}$$

The optimal sales quantities under centralized production are

$$s_A^* = \frac{2(d_A - c_A) + (d_B - c_A - c_T)\left(\alpha_A + \alpha_B \frac{1-\tau_B}{1-\tau_A}\right)}{4 - \left(\alpha_A \sqrt{\frac{1-\tau_A}{1-\tau_B}} + \alpha_B \sqrt{\frac{1-\tau_B}{1-\tau_A}}\right)^2} \tag{35}$$

and

$$s_B^* = \frac{2(d_B - c_A - c_T) + (d_A - c_A)\left(\alpha_B + \alpha_A \frac{1-\tau_A}{1-\tau_B}\right)}{4 - \left(\alpha_A \sqrt{\frac{1-\tau_A}{1-\tau_B}} + \alpha_B \sqrt{\frac{1-\tau_B}{1-\tau_A}}\right)^2} \tag{36}$$

For $d_B \leq \frac{\eta}{\theta}$ *and* $c_B < c_A + c_T$ *decentralized production is optimal. The optimal sales quantities of Lemma 5 apply.*

Proof: See Appendix A.5.

For $\tau_A > \tau_B$, the location decision of the MNE, t^*, and s_i^* are not distorted. Thus, $\mathcal{T}_A$ and $\mathcal{T}_B$ remain the same compared to the corporate tax regime. For $\tau_B > \tau_A$, $\mathcal{T}_B$ increases due to the implementation of minimum taxation. Depending on the parameter setting $\mathcal{T}_A$ decreases or increases compared to the corporate tax regime.[18]

With regard to the location decision of the *MNE*, our previous result (see Lemma 3) based on the separability of sales is confirmed. Specifically, centralized production is chosen if $c_B > c_A + c_T$ as long as d_B falls short of a certain threshold.[19] Thus, minimum taxation reinstates the pre-tax cost threshold for the MNE's production decision. As described above, this means that the location decision of the *MNE* is identical to the one under corporate taxation if $\tau_A > \tau_B$. If $\tau_A < \tau_B$ the incentives to choose a centralized or decentralized production process change compared to the corporate taxation regime. However, the direction of this change is not clear-cut and depends on different factors such as d_B and α.[20]

[17] For the exact threshold see (95) in Appendix A.5.

[18] An illustration of this tax revenue effect is provided in Appendix A.6.

[19] Note, however, that the specific value of this threshold and therefore the likelihood of a unilateral application of minimum taxation changes.

[20] For $d_B > \frac{\eta}{\theta}$ the sales formula is applied by both countries under minimum taxation. For an analysis of a

As for $\alpha = 0$, a unilateral application of minimum taxation leads to a transfer price of c_A. If $\tau_A < \tau_B$, this implies a reduction of the transfer price from the upper to the lower end of the allowed continuum, i.e. from $p_B - c_T$ to c_A. However, considering complementarities in sales (α_A and $\alpha_B > 0$) we find that the implementation of minimum taxation not only leads to an adjustment of the transfer price but also changes optimal sales quantities for $\tau_B > \tau_A$. In case both countries determine taxable profits according to the sales formula, adjustments in sales occur as well.

4. Discussion

Our analysis shows that the implementation of a minimum taxation regime can have an impact on optimal sales quantities and on the production location of the MNE, but also on the transfer prices and tax revenues of both countries. Thereby, our results suggest that real effects of taxation depend on the characteristics of the product markets. Table 1 provides an overview of the findings.

Our results show for independent local demand, see section 2, that local sales remain unchanged - both under corporate taxation and under minimum taxation given unaltered location decisions. In contrast, when we allow for complementarities between national sales in section 3, optimal sales quantities are affected by the fiscal regime. For $\tau_A > \tau_B$, optimal sales quantities change under corporate taxation compared to a pre-tax regime. As shown in Figure 1 in section 3, the optimal sales quantity in country A, s_A^*, under corporate taxation exceeds the one of the pre-tax regime. The sales quantity in country B, s_A^*, decreases or increases compared to the pre-tax regime, depending on the extent of the complementarities in sales and on further parameters, namely tax rates, transaction costs, and the size of the respective markets. Under minimum taxation, sales quantities remain the same compared to the corporate tax regime if $\tau_A > \tau_B$. If $\tau_A < \tau_B$, optimal sales quantities do not change under corporate taxation compared to the pre-tax regime. Under a minimum tax regime however, sales quantities in both countries are adjusted.

While taxation does not affect the location decision of the MNE as long as $\tau_A > \tau_B$, it changes incentives for centralized or decentralized production if $\tau_A < \tau_B$. Specifically, minimum taxation reinstates the cost parameter threshold from the pre-tax regime if $\tau_A < \tau_B$. Compared to the corporate tax regime this leads to a relocation of real activity in form of assets and labor from the low-tax country A to the high-tax country B. In

complete tax base allocation via formula apportionment, which is beyond the scope of this paper, see, e.g. Martini et al. (2012).

contrast, the effect of a corporate taxation regime depends on the characteristics of the product market. In the absence of complementarities, corporate taxation always provides incentives to centralize production in country A (see section 2). For high complementarities in sales, corporate taxation can even provide incentives to produce decentrally, as illustrated by Figure 2 in section 3.2.[21]

Based on a simulation, Figure 3 illustrates how the MNE's location decision depends on the respective fiscal regime for $\tau_A < \tau_B$. In Panels A – C a minimum tax rate of 15% in the low-tax country is applied. In each panel, the figure on the left assumes $\alpha = 0$ and the figure on the right assumes $\alpha_A = \alpha_B = 0.5$. The red areas indicate that decentralized production is optimal under all three fiscal regimes. The green areas indicate that decentralized production is optimal for the pre-tax and the minimum tax regime, while centralized production is optimal for the corporate tax regime. The blue areas suggest centralized production under all three fiscal regimes. Sections 2 and 3 allow for sales re-allocations due to a direct application of the sales formula by both countries. While a detailed analyses of the resulting optima is beyond the scope of this paper, the grey areas in Figure 3 indicate parameter settings where both countries would apply the sales formula under a minimum taxation setting.

[21] In these cases, a minimum taxation regime always entails an application of the sales formula by both countries. If an MNE chooses centralized production its after-tax profit under minimum taxation can never be higher than its after-tax profit under corporate taxation (if not, the MNE would have chosen this optimum under corporate taxation in the first place). Therefore, a minimum taxation regime will never make centralized production more attractive compared to decentralized production.

Table 1: The effects of an international tax reform

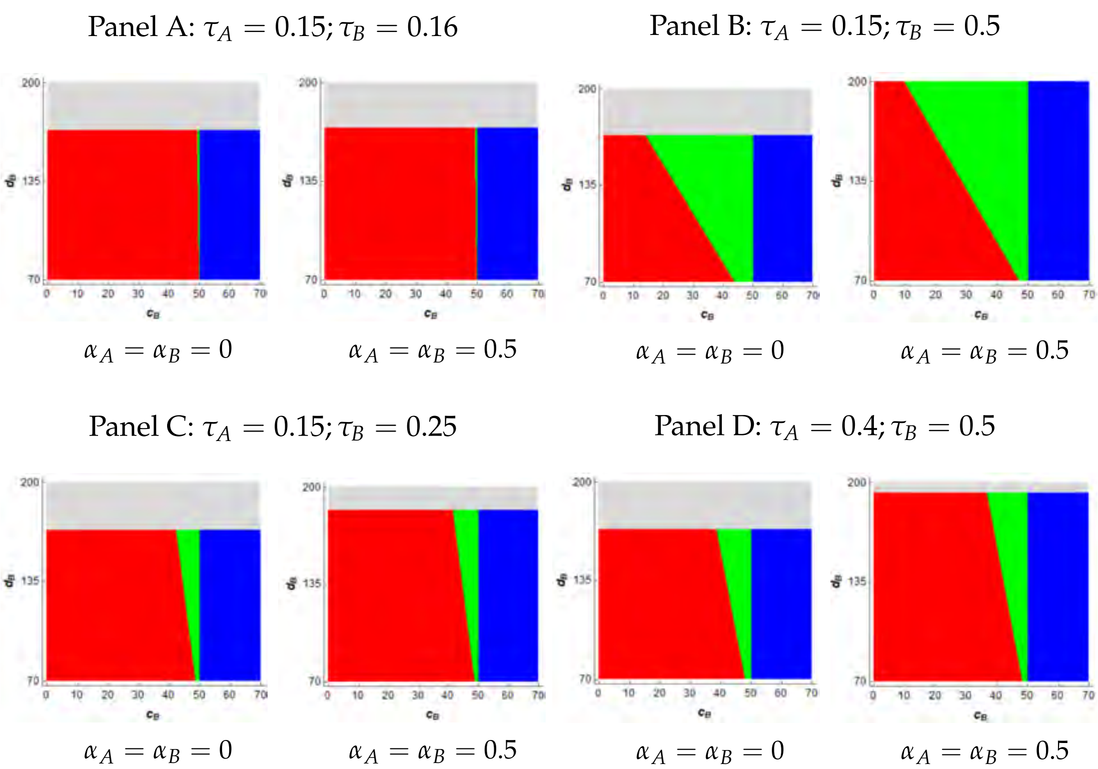
	Separable sales	Complementarities in sales
Sales quantities:		
$\tau_A > \tau_B$	• s_A^*, s_B^* remain unchanged • sales re-allocations only possible if both countries apply sales formula	• corporate taxation: s_A^*, s_B^* change • minimum taxation: same quantities of s_A^*, s_B^* as under corporate taxation • further sales re-allocations onlypossible if both countries apply sales formula
$\tau_A < \tau_B$	• s_A^*, s_B^* remain unchanged (presupposed unaltered location decisions) • sales re-allocations only possible if both countries apply sales formula	• corporate taxation: s_A^*, s_B^* remain unchanged (presupposed unaltered location decisions) • minimum taxation: adjustments of s_A^*, s_B^* compared to quantities under pre-tax regime and under corporate taxation • further sales re-allocations only possible if both countries apply sales formula
Location decision:		
$\tau_A > \tau_B$	• no impact of fiscal regime • application of sales formula by both countries possible	• no impact of fiscal regime • application of sales formula by both countries possible
$\tau_A < \tau_B$	• corporate taxation: provides incentives to centralize production • minimum taxation: reinstates pre-tax incentives	• corporate taxation: incentives to centralize or to decentralize production depending on parameter setting (see Figure 2) • minimum taxation: reinstates pre-tax incentives
Tax revenues:		
$\tau_A > \tau_B$	• $\mathcal{T}_A, \mathcal{T}_B$ remain unchanged	• $\mathcal{T}_A, \mathcal{T}_B$ remain unchanged
$\tau_A < \tau_B$	• $\mathcal{T}_A$ decreases • $\mathcal{T}_B$ increases	• $\mathcal{T}_A$ increases or decreases depending on parameter setting • $\mathcal{T}_B$ increases

The figure provides an overview of our analytical results in the previous sections. If not specified otherwise, reported results for the minimum taxation regime refer to equilibria if one country applies the minimum taxation unilaterally. The reported changes of $\mathcal{T}_A$, $\mathcal{T}_B$ are based on a comparison with a corporate tax regime.

Panel A of Figure 3 shows that even for small tax rate differentials between country A and B a specific unit cost range in country B (for a given cost parameter c_A) exists where a minimum tax regime changes the location decision of the MNE. Comparing Panels A and B confirms that this range increases the higher the tax rate differential between A and B, and comparing Panels C and D reaffirms that not only the amount of the tax rate differential, but also the levels of the respective tax rates matter. For the demand functions assumed in sections 2 and 3 we also show that changes in the MNE's location decision after the introduction of a minimum taxation regime (as indicated by the green area) are more likely the greater the market size of country B, d_B. Comparing the left and the right figure in each panel illustrates that complementarities in sales affect the likelihood that both countries apply the sales formula if a minimum tax is feasible. This outcome which typically involves a change of the optimal sales quantities compared to the pre-tax setting is denoted by a grey area.

Finally, we analyze the impact of taxation on the tax revenues in both countries. Thereby, we investigate the difference between fiscal revenues under a corporate income tax and a minimum taxation regime. For $\tau_A > \tau_B$, the tax revenues in both countries remain unchanged. If $\tau_A < \tau_B$, the tax revenue for the high-tax country, $\mathcal{T}_B$, increases under minimum taxation for both types of product markets. In contrast, the tax revenue of the low-tax country, $\mathcal{T}_A$, decreases for traditional product markets, but might even increase under certain parameter settings if complementarities in sales exist.

Figure 3: Location decisions under different fiscal regimes



The figure provides an overview of the MNE's location decision under the three fiscal regimes. The red area indicates that decentralized production is optimal under all three fiscal regimes. The green area indicates that decentralized production is optimal for the pre-tax and the minimum tax regime, while centralized production is optimal for the corporate tax regime. The blue area suggests centralized production under all three fiscal regimes. The grey area indicates that both countries would apply the sales formula under a minimum taxation setting. In the simulations we use the following parameters: $d_A = 135, c_A = 40, c_T = 10$

5. Conclusion

In this study we theoretically analyze an MNE's decision about the location of its production facilities, about its sales quantities, and about the transfer price in a two-country setting. We compare a pre-tax regime, a common corporate taxation regime, and a minimum taxation regime. In the latter regime countries can unilaterally determine taxable income based on the distribution of sales. Moreover, we analyze different types of inverse demand functions: Firstly, we assume that national sales are fully separable and do not affect each other. Secondly, we allow for national sales acting as complements, which is typical for social network services. Hereby, an increase in sales in one country results in a higher sales price in the other country.

Our results show that the implementation of an international tax reform that includes new profit allocation rules as well as the introduction of minimum taxation triggers re-locations of production facilities. Regularly, minimum taxation restores the MNE's location decision from the pre-tax regime. Moreover, the fiscal regime affects optimal sales quantities for modern business models. Independently from the characteristics of the product market, the implementation of a minimum taxation regime causes the MNE to adjust the reported transfer price significantly compared to a corporate tax regime. Thus, besides impacting transfer prices an international tax reform affects real activities such as sales and production location. Whereas the tax revenue effect in the low-tax country depends on market characteristics, minimum taxation increases tax revenues in the high-tax country for both traditional and modern product markets.

The results of our study have to be interpreted against the background of the model assumptions. For instance, we base our analysis on a linear cost function without fixed costs. Moreover, our paper considers a sales formula as a means to determine the allocation of taxable income. In practice, different proposals to determine taxable income in an international tax reform are currently discussed. Nevertheless, our study provides fundamental insights about the real effects of an international tax reform. Policy makers should consider these insights in the development of a future international minimum tax regime.

Our study also provides a theoretical basis for future empirical studies on the real effects of minimum taxation. For example, empirical analyses could test whether the implementation of a minimum taxation regime actually leads to more decentralized production structures. Moreover, they could investigate the impact of product market characteristics on the development of fiscal revenues.

A. Proofs

A.1. Proof of Lemmas 1 and 4

We start with determining optimal sales quantities, s_A^* and s_B^*, under both a) centralized and b) decentralized production. We then c) compare the resulting profits and determine the threshold for centralized production.

a) With centralized production, i.e, $x_A = s_A + s_B$ and $q_B = s_B$, the total profit function (20) simplifies to:

$$\Pi^{no,co}(s_A, s_B) = (d_A - s_A + \alpha_A s_B)s_A - c_A(s_A + s_B) + (d_B - s_B + \alpha_B s_A)s_B - c_T s_B \tag{37}$$

Equalizing the first partial derivatives of (37) to zero gives:

$$\begin{aligned} \frac{\delta \Pi^{no,co}(\cdot)}{\delta s_A} &= d_A - c_A - 2s_A + \alpha_A s_B + \alpha_B s_B = 0 \\ \Leftrightarrow s_A &= \frac{1}{2}[d_A - c_A + s_B(\alpha_A + \alpha_B)] \end{aligned} \tag{38}$$

and

$$\begin{aligned} \frac{\delta \Pi^{no,co}(\cdot)}{\delta s_B} &= d_B - c_A - c_T - 2s_B + \alpha_A s_A + \alpha_B s_A = 0 \\ \Leftrightarrow s_B &= \frac{1}{2}\left[d_B - c_A - c_T + s_A(\alpha_A s_A + \alpha_B)\right] \end{aligned} \tag{39}$$

Simultaneously solving (38) and (39) gives the optimal sales quantities s_A^* and s_B^*:

$$s_A^* = \frac{2\,(d_A - c_A) + (d_B - c_A - c_T)\,(\alpha_A + \alpha_B)}{4 - (\alpha_A + \alpha_B)^2} \tag{40}$$

$$s_B^* = \frac{2(d_B - c_A - c_T) + (d_A - c_A)(\alpha_A + \alpha_B)}{4 - (\alpha_A + \alpha_B)^2} \tag{41}$$

(40) and (41) display maximizers as can be inferred from the Hessian. It is negative definite indicating a strictly concave function.

$$H(s_A, s_B) = \begin{pmatrix} \frac{\delta^2 \Pi^{no}(\cdot)}{\delta s_A^2} & \frac{\delta^2 \Pi^{no}(\cdot)}{\delta s_A \delta s_B} \\ \frac{\delta^2 \Pi^{no}(\cdot)}{\delta s_A \delta s_B} & \frac{\delta^2 \Pi^{no}(\cdot)}{\delta s_B^2} \end{pmatrix} = \begin{pmatrix} -2 & \alpha_A + \alpha_B \\ \alpha_A + \alpha_B & -2 \end{pmatrix} \tag{42}$$

b) Under decentralized production, i.e., $x_i = s_i \forall i$, the total profit function (20) becomes:

$$\Pi^{no,co}(\cdot) = (d_A - s_A + \alpha_A s_B - c_A)\, s_A + (d_B - s_B + \alpha_B s_A - c_B)\, s_B \tag{43}$$

Equalizing the first partial derivatives of (43) to zero yields:

$$\begin{aligned} \frac{\delta \Pi^{no,co}(\cdot)}{\delta s_A} &= d_A - c_A - 2s_A + \alpha_A s_B + \alpha_B s_B = 0 \\ \Leftrightarrow s_A &= \frac{1}{2}\left[d_A - c_A + s_B(\alpha_A + \alpha_B)\right] \end{aligned} \tag{44}$$

$$\begin{aligned} \frac{\delta \Pi^{no,co}(\cdot)}{\delta s_B} &= d_B - c_B - 2S_B + \alpha_A s_A + \alpha_B s_A = 0 \\ \Leftrightarrow s_B &= \frac{1}{2}\left[d_B - c_B + s_A(\alpha_A + \alpha_B)\right] \end{aligned} \tag{45}$$

Simultaneously solving (44) and (45) yields the optimal sales quantities s_A^* and s_B^*:

$$s_A^* = \frac{2\,(d_A - c_A) + (d_B - c_B)\,(\alpha_A + \alpha_B)}{4 - (\alpha_A + \alpha_B)^2} \tag{46}$$

$$s_B^* = \frac{2\,(d_B - c_B) + (d_A - c_A)\,(\alpha_A + \alpha_B)}{4 - (\alpha_A + \alpha_B)^2} \tag{47}$$

(46) and (47) display maximizers as the Hessian is negative definite.

$$H(s_A, s_B) = \begin{pmatrix} -2 & \alpha_A + \alpha_B \\ \alpha_A + \alpha_B & -2 \end{pmatrix} \tag{48}$$

c) To determine the threshold c_B that has to be exceeded to warrant a centralized production we compare the resulting profits under centralized and decentralized production.[22] For this comparison, let $s_{A,c}^*, s_{B,c}^*$ denote optimal sales quantities under centralized production and $s_{A,d}^*$, $s_{B,d}^*$ optimal sales quantities under

[22]We assume that production is decentralized if $c_B = c_A + c_T$.

decentralized production. Then, centralized production requires

$$\left(d_A - s^*_{A,c} + \alpha_A s^*_{B,c}\right) s^*_{A,c} - c_A \left(s^*_{A,c} + s^*_{B,c}\right) + \left(d_B - s^*_{B,c} + \alpha_B s^*_{A,c}\right) s^*_{B,c} - c_T s^*_{B,c}$$
$$> \left(d_A - s^*_{A,d} + \alpha_A s^*_{B,d} - c_A\right) s^*_{A,d} + \left(d_B - s^*_{B,d} + \alpha_B s^*_{A,d} - c_B\right) s^*_{B,d} \tag{49}$$

Solving for c_B yields

$$\begin{aligned} c_B > & \frac{\left(d_A - s^*_{A,d} + \alpha_A s^*_{B,d} - c_A\right) s^*_{A,d} + \left(d_B - s^*_{B,d} + \alpha_B s^*_{A,d}\right)}{s^*_{B,d}} \\ & - \frac{\left(d_A - s^*_{A,c} + \alpha_A s^*_{B,c} - c_A\right) s^*_{A,c} + \left(d_B - s^*_{B,c} + \alpha_B s^*_{A,c} - c_A - c_T\right) s^*_{B,c}}{s^*_{B,d}} \end{aligned} \tag{50}$$

Replacing $s^*_{A,c}$ and $s^*_{B,c}$ with the optimal sales quantities from (40) and (41), and $s^*_{A,d}$ and $s^*_{B,d}$ with the optimal sales quantities from (46) and (47) yields the threshold that must be met to warrant centralized production:

$$c_B > c_A + c_T \tag{51}$$

A.2. Proof of Lemmas 2 and 5

We start with determining the optimal transfer price, t^*, occurring under centralized production. The first partial derivative of the total profit function, (21), with respect to the transfer price t yields

$$\frac{\delta \Pi^{tax,co}(\cdot)}{\delta t} = q_B \left(\tau_B - \tau_A\right) \tag{52}$$

(52) indicates that the $MNE's$ after-tax profit is strictly increasing (decreasing) in t if $\tau_B > (<) \tau_A$.[23] Thus, the MNE always chooses a transfer price t^* at the upper (lower) end of the interval that is accepted by the fiscal authorities.

$$t^* = \begin{cases} c_A & \text{for } \tau_A > \tau_B \\ p^*_B\left(s^*_B\right) - c_T = d_B - s^*_B + \alpha_B s^*_A - c_T & \text{for } \tau_A < \tau_B \end{cases} \tag{53}$$

Thereby, $p^*_B\left(s^*_B\right)$ and s^*_B indicate the optimal sales price and the optimal sales quantity in country B. t^* depending on the relation between τ_A and τ_B shows that the MNE engages in profit shifting.

[23] We do not consider the case of $\tau_B = \tau_A$ since no fiscal incentives for profit shifting would exist.

Since the optimal transfer price t^* in (53) depends on the relation of tax rates, we distinguish 1.) $\tau_A > \tau_B$ and 2.) $\tau_A < \tau_B$. Within these cases we further distinguish a) centralized and b) decentralized production.

1. Let $\tau_A > \tau_B$, then the optimal transfer price becomes c_A under centralized production.

   a) Assume centralized production, i.e., $x_A = s_A + s_B$ and $q_B = s_B$. The total profit function (21) becomes:

$$\begin{aligned}\Pi^{tax,co}(s_A, s_B) = s_A\left(d_A - s_A + \alpha_A s_B - c_A\right)(1-\tau_A) \\ + s_B\left(d_B - s_B + \alpha_B s_A - c_A - c_T\right)(1-\tau_B)\end{aligned} \tag{54}$$

   Equalizing the partial derivatives of (54) to zero gives:

$$\begin{aligned}\frac{\delta\Pi^{tax,co}(\cdot)}{\delta s_A} &= \left(d_A - 2s_A + \alpha_A s_B - c_A\right)(1-\tau_A) + \alpha_B s_B (1-\tau_B) = 0 \\ \Leftrightarrow s_A &= \frac{1}{2}\left[d_A - c_A + s_B\left(\alpha_A + \alpha_B\frac{1-\tau_B}{1-\tau_A}\right)\right]\end{aligned} \tag{55}$$

$$\begin{aligned}\frac{\delta\Pi^{tax,co}(\cdot)}{\delta s_B} &= \alpha_A s_A (1-\tau_A) + \left(d_B + \alpha_B s_A - 2s_B - c_A - c_T\right)(1-\tau_B) = 0 \\ \Leftrightarrow s_B &= \frac{1}{2}\left[d_B - c_A - c_T + s_A\left(\alpha_B + \alpha_A\frac{1-\tau_A}{1-\tau_B}\right)\right]\end{aligned} \tag{56}$$

   Simultaneously solving (55) and (56) yields:

$$s_A^* = \frac{2(d_A - c_A) + (d_B - c_A - c_T)\left(\alpha_A + \alpha_B\frac{1-\tau_B}{1-\tau_A}\right)}{4 - \left(\alpha_A\sqrt{\frac{1-\tau_A}{1-\tau_B}} + \alpha_B\sqrt{\frac{1-\tau_B}{1-\tau_A}}\right)^2} \tag{57}$$

   and

$$s_B^* = \frac{2(d_B - c_A - c_T) + (d_A - c_A)\left(\alpha_B + \alpha_A\frac{1-\tau_A}{1-\tau_B}\right)}{4 - \left(\alpha_A\sqrt{\frac{1-\tau_A}{1-\tau_B}} + \alpha_B\sqrt{\frac{1-\tau_B}{1-\tau_A}}\right)^2} \tag{58}$$

   (57) and (58) display maximizers as the Hessian is negative definite. That is

the case for all reasonable tax rate combinations of τ_A and τ_B:

$$H(s_A, s_B) = \begin{pmatrix} -2\left(1-\tau_A\right) & \alpha_A\left(1-\tau_A\right)+\alpha_B\left(1-\tau_B\right) \\ \alpha_A\left(1-\tau_A\right)+\alpha_B\left(1-\tau_B\right) & -2(1-\tau_B) \end{pmatrix} \tag{59}$$

b) Assume decentralized production, i.e., $x_i = s_i, \forall i$ and $q_B = 0$, then the total profit function (21) becomes:

$$\begin{aligned} \Pi^{tax,co}(s_A, s_B) = &\left(s_A\left(d_A - s_A + \alpha_A s_B\right) - c_A s_A\right)\left(1-\tau_A\right) \\ &+ \left(s_B\left(d_B - s_B + \alpha_B s_A\right) - c_B s_B\right)\left(1-\tau_B\right) \end{aligned} \tag{60}$$

Equalizing the first partial derivatives of (60) to zero yields:

$$\begin{aligned} \frac{\delta\Pi^{tax,co}(\cdot)}{\delta s_A} &= \left(d_A - 2s_A + \alpha_A s_B - c_A\right)\left(1-\tau_A\right) + \alpha_B s_B\left(1-\tau_B\right) = 0 \\ \Leftrightarrow s_A &= \frac{1}{2}\left[d_A - c_A + s_B\left(\alpha_A + \alpha_B\frac{1-\tau_B}{1-\tau_A}\right)\right] \end{aligned} \tag{61}$$

$$\begin{aligned} \frac{\delta\Pi^{tax}(\cdot)}{\delta s_B} &= \alpha_A s_A\left(1-\tau_A\right) + \left(d_B - 2s_B\alpha_B s_A - c_B\right)\left(1-\tau_B\right) = 0 \\ \Leftrightarrow s_B &= \frac{1}{2}\left[d_B - c_B + s_A\left(\alpha_B + \alpha_A\frac{1-\tau_A}{1-\tau_B}\right)\right] \end{aligned} \tag{62}$$

Inserting (61) and (62) in each other yields the optimal sales quantities. For s_A^* it holds:

$$s_A^* = \frac{2(d_A - c_A) + (d_B - c_B)\left(\alpha_A + \alpha_B\frac{1-\tau_B}{1-\tau_A}\right)}{4 - \left(\alpha_A\sqrt{\frac{1-\tau_A}{1-\tau_B}} + \alpha_B\sqrt{\frac{1-\tau_B}{1-\tau_A}}\right)^2} \tag{63}$$

For s_B^* it holds:

$$s_B^* = \frac{2(d_B - c_B) + (d_A - c_A)\left(\alpha_B + \alpha_A\frac{1-\tau_A}{1-\tau_B}\right)}{4 - \left(\alpha_A\sqrt{\frac{1-\tau_A}{1-\tau_B}} + \alpha_B\sqrt{\frac{1-\tau_B}{1-\tau_A}}\right)^2} \tag{64}$$

The Hessian is identical to case 1a.

c) Finally, comparing the resulting profits under centralized and decentralized production we determine the threshold that c_B has to exceed under corporate taxation to warrant a centralized production process. Analogously to Appendix A.1, let $s^*_{A,c}, s^*_{B,c}$ denote optimal sales quantities under centralized production and $s^*_{A,d}$, $s^*_{B,d}$ optimal sales quantities under decentralized production. Then, centralized production requires

$$\begin{aligned}
&\left[\left(d_A - s^*_{A,c} + \alpha_A s^*_{B,c}\right) s^*_{A,c} - c_A \left(s^*_{A,c} + s^*_{B,c}\right) + c_A s^*_{B,c}\right] (1 - \tau_A) \\
&+ \left[\left(d_B - s^*_{B,c} + \alpha_B s^*_{A,c}\right) s^*_{B,c} - c_A s^*_{B,c} - c_T s^*_{B,c}\right] (1 - \tau_B) \\
&> \left(d_A - s^*_{A,d} + \alpha_A s^*_{B,d} - c_A\right) s^*_{A,d} (1 - \tau_A) \\
&+ \left(d_B - s^*_{B,d} + \alpha_B s^*_{A,d} - c_B\right) s^*_{B,d} (1 - \tau_B)
\end{aligned} \tag{65}$$

Solving for c_B yields

$$\begin{aligned}
c_B > &\frac{\left(d_A - s^*_{A,d} + \alpha_A s^*_{B,d} - c_A\right) s^*_{A,d} (1 - \tau_A)}{s^*_{B,d} (1 - \tau_B)} + \left(d_B - s^*_{B,d} + \alpha_B s^*_{A,d}\right) \\
&- \frac{\left(d_A - s^*_{A,c} + \alpha_A s^*_{B,c} - c_A\right) s^*_{A,c} (1 - \tau_A)}{s^*_{B,d} (1 - \tau_B)} \\
&- \frac{\left(d_B - s^*_{B,c} + \alpha_B s^*_{A,c} - c_A - c_T\right) s^*_{B,c}}{s^*_{B,d}}
\end{aligned} \tag{66}$$

Replacing $s^*_{A,c}$ and $s^*_{B,c}$ with the optimal sales quantities from (57) and (58), and $s^*_{A,d}$ and $s^*_{B,d}$ with the optimal sales quantities from (63) and (64) we find that centralized production is beneficial whenever

$$c_B > c_A + c_T \tag{67}$$

2. Let $\tau_A < \tau_B$, implying that the optimal transfer price (53) becomes $t^* = p^*_B(s^*_B) - c_T$ whenever production is centralized.

   a) Assume centralized production, then inserting $t^* = p^*_B(s^*_B) - c_T$ and $x_A = s_A + s_B$ into (21) yields:

$$\begin{aligned}
\Pi^{tax,co}(s_A, s_B) &= \left[p_A s_A + (p^*_B(s^*_B) - c_T)s_B - c_A(s_A + s_B)\right](1 - \tau_A) \\
&+ \left[d_B s_B - (p^*_B(s^*_B) - c_T)s_B - c_T s_B\right](1 - \tau_B) \\
&= ((d_A - s_A + \alpha_A s_B)s_A)(1 - \tau_A) \\
&+ \left[(d_B - s_B - c_T + \alpha_B s_A) s_B - c_A (s_A + s_B)\right](1 - \tau_B)
\end{aligned} \tag{68}$$

The partial derivatives of (68) with respect to s_A and s_B are:

$$\begin{aligned} \frac{\delta \Pi^{tax,co}}{\delta s_A} &= (d_A - 2s_A + \alpha_A s_B + \alpha_B s_B - c_A)\,(1-\tau_A) = 0 \\ \Leftrightarrow s_A &= \frac{1}{2}\left[d_A - c_A + s_B(\alpha_A + \alpha_B)\right] \end{aligned} \tag{69}$$

$$\begin{aligned} \frac{\delta \Pi^{tax,co}}{\delta s_B} &= (\alpha_A s_A + \alpha_B s_A + d_B - 2s_B - c_A - c_T)\,(1-\tau_A) = 0 \\ \Leftrightarrow s_B &= \frac{1}{2}\left[d_B - c_A - c_T + s_A(\alpha_A + \alpha_B)\right] \end{aligned} \tag{70}$$

Simultaneously solving (69) and (70) and yields:

$$s_A^* = \frac{2\,(d_A - c_A) + (d_B - c_A - c_T)\,(\alpha_A + \alpha_B)}{4 - (\alpha_A + \alpha_B)^2}, \tag{71}$$

$$s_B^* = \frac{2\,(d_B - c_A - c_T) + (d_A - c_A)\,(\alpha_A + \alpha_B)}{4 - (\alpha_A + \alpha_B)^2}. \tag{72}$$

Thus, $p_B^*(s_B^*)$ equals:

$$\begin{aligned} &p_B^*(s_B^*) = \\ &\frac{2[d_B + c_A + c_T] - (\alpha_A - \alpha_B)(d_A - c_A) - (\alpha_A + \alpha_B)[\alpha_A d_B + \alpha_B(c_A + c_T)]}{4 - (\alpha_A + \alpha_B)^2} \end{aligned} \tag{73}$$

The Hessian remains the same as in 1a.

b) For a decentralized production calculations and results from 1b hold.

c) As for the setting with $\tau_A > \tau_B$, we finally compare the resulting profits under centralized and decentralized production to determine the threshold for c_B. Again, let $s_{A,c}^*, s_{B,c}^*$ denote optimal sales quantities under centralized production and $s_{A,d}^*$, $s_{B,d}^*$ optimal sales quantities under decentralized production. Then, for $\tau_A < \tau_B$ centralized production requires

$$\begin{aligned} &\left[\left(d_A - s_{A,c}^* + \alpha_A s_{B,c}^* - c_A\right) s_{A,c}^* + \left(d_B - s_{B,c}^* + \alpha_B s_{A,c}^* - c_T - c_A\right) s_{B,c}^*\right] (1-\tau_A) \\ &> \left(d_A - s_{A,d}^* + \alpha_A s_{B,d}^* - c_A\right) s_{A,d}^* \,(1-\tau_A) \\ &+ \left(d_B - s_{B,d}^* + \alpha_B s_{A,d}^* - c_B\right) s_{B,d}^* \,(1-\tau_B) \end{aligned} \tag{74}$$

Solving for c_B yields

$$c_B > \frac{\left(d_A - s^*_{A,d} + \alpha_A s^*_{B,d} - c_A\right) s^*_{A,d} \left(1 - \tau_A\right)}{s^*_{B,d}\left(1-\tau_B\right)} + \left(d_B - s^*_{B,d} + \alpha_B s^*_{A,d} - c_A - c_T\right)$$
$$- \frac{\left(d_A - s^*_{A,c} + \alpha_A s^*_{B,c} - c_A\right) s^*_{A,c} \left(1 - \tau_A\right)}{s^*_{B,d}\left(1-\tau_B\right)}$$
$$- \frac{\left(d_B - s^*_{B,c} + \alpha_B s^*_{A,c} - c_T - c_A\right) s^*_{B,c} \left(1 - \tau_A\right)}{s^*_{B,d}\left(1-\tau_B\right)} \tag{75}$$

Replacing $s^*_{A,c}$ and $s^*_{B,c}$ with the optimal sales quantities from (71) and (72), and $s^*_{A,d}$ and $s^*_{B,d}$ with the optimal sales quantities from (63) and (64) we find that centralized production is beneficial whenever

$$\begin{aligned} c_B > \frac{1}{2}\left(d_A - c_A\right)\left(\alpha_A \frac{1-\tau_A}{1-\tau_B} + \alpha_B\right) + d_B \\ - \omega\left[2\left(d_B - c_A - c_T\right) + \left(\alpha_A + \alpha_B\right)\left(d_A - c_A\right)\right] \end{aligned} \tag{76}$$

with

$$\omega = \frac{\sqrt{\left(4 - 2\alpha_A\alpha_B\right)\left(1-\tau_A\right)\left(1-\tau_B\right) - \alpha_A^2\left(1-\tau_A\right)^2 - \alpha_B^2\left(1-\tau_B\right)^2}}{2\sqrt{2-\alpha_A-\alpha_B}\sqrt{2+\alpha_A+\alpha_B}\left(1-\tau_B\right)}$$

Since

$$\begin{aligned} &\omega\left[2\left(d_B - c_A - c_T\right) + \left(\alpha_A + \alpha_B\right)\left(d_A - c_A\right)\right] \\ &= s^*_B \frac{2\sqrt{4-\left(\alpha_A+\alpha_B\right)^2}}{\left(1-\tau_B\right)} * \sqrt{\left(4 - 2\alpha_A\alpha_B\right)\left(1-\tau_A\right)\left(1-\tau_B\right) - \alpha_A^2\left(1-\tau_A\right)^2 - \alpha_B^2\left(1-\tau_B\right)^2} \end{aligned} \tag{77}$$

(25) follows.

For centralized production, tax revenues $\mathcal{T}_A$ in country A and $\mathcal{T}_B$ in country B are calculated by inserting optimal transfer prices and sales for the considered tax scenarios in $\mathcal{T}_A = \tau_A\left(p_A s_A + t s_B - c_A\left(s_A + s_B\right)\right)$ and $\mathcal{T}_B = \tau_B s_B\left(p_B - c_T - t\right)$. For decentralized production, tax revenues are calculated by inserting optimal sales into $\mathcal{T}_A = \tau_A s_A\left(p_A - c_A\right)$ and $\mathcal{T}_B = \tau_B s_B\left(p_B - c_B\right)$.

A.3. Proof of Lemma 3

As seen before, minimum taxation applies only if production is centralized. Since minimum taxation is only applied if the reported profits in one country fall short of the taxable profit according to the formula, we first determine whether the calculated optima in the corporate tax regime miss the threshold. We again assume $\alpha_A = \alpha_B = 0$ and differentiate between $\tau_A > \tau_B$ and $\tau_A < \tau_B$. We focus on the relevant cases where the high-tax country initiates minimum taxation. Note that throughout the paper we consistently assume that both countries accept a tax payment that results from the most favorable transfer price (from their respective perspective) within the allowed interval ($t \in [c_A, d_B - s_B + \alpha_B s_A]$). Since a transfer price of c_A ($p_B - c_T$) is already chosen under corporate taxation if $\tau_A > \tau_B$ ($\tau_A < \tau_B$), there is no reason to apply the minimum tax formula for country B (country A) if they are the low-tax country.

1. If $\tau_A > \tau_B$, the optimal transfer price under corporate income taxation is $t^* = c_A$ and optimal sales quantities are $s_A^* = \frac{1}{2}(d_A - c_A)$ and $s_B^* = \frac{1}{2}(d_B - c_A - c_T)$.

   Thus, the reported profit in country A equals

$$\begin{aligned}\Pi_A^{no} = &\left(d_A - \frac{1}{2}(d_A - c_A)\right)\frac{1}{2}(d_A - c_A) + c_A\frac{1}{2}(d_B - c_A - c_T)\\ &- c_A\left(\frac{1}{2}(d_A - c_A) + \frac{1}{2}(d_B - c_A - c_T)\right) = \frac{1}{4}(d_A - c_A)^2\end{aligned} \tag{78}$$

   An application of the sales formula according to (4) would lead to the following profit allocated to country A:

$$\frac{\left(d_A^2 - c_A^2\right)\left[2c_A(c_A + c_T - d_A - d_B) + d_A^2 + (c_T - d_B)^2\right]}{4\left[d_A^2 + d_B^2 - (c_A + c_T)^2 - c_A^2\right]} \tag{79}$$

   Comparing (78) and (79) we find that the reported profit in country A is lower than the the profit according to the formula if

$$d_B > \left(1 + \frac{c_T}{c_A}\right)d_A \tag{80}$$

   Consequently, country A applies the formula if this condition is fulfilled. As long as country B continues to accept the reported profit as a basis of taxation the following profit function holds:

$$\begin{aligned}\Pi = &\left(d_A - s_A\right)s_A + ts_B - c_A\left(s_A + s_B\right) - \frac{\left(d_A - s_A\right)s_A}{\left(d_A - s_A\right)s_A + \left(d_B - s_B\right)s_B}\tau_A \\ &\cdot\left[\left(d_A - s_A\right)s_A + \left(d_B - s_B\right)s_B - c_A\left(s_A + s_B\right) - c_T s_B\right] \\ &+ \left[\left(d_B - s_B\right)s_B - ts_B - c_T s_B\right]\left(1 - \tau_B\right)\end{aligned} \tag{81}$$

The first derivative with regard to the transfer price t yields

$$\frac{\delta\Pi}{\delta t} = s_B\tau_B \tag{82}$$

The profit of the MNE strictly increases in the transfer price t as long as a unilateral minimum taxation in country A is applied. Thus, one potential optimum could be reached by increasing t to $p_B - c_T$. Since $p_B - c_T$ is the most favorable transfer price for country A within the allowed interval this transfer price would be accepted by country A even if an application of the sales formula would lead to an even higher taxable income.

$$\begin{aligned}&\left[\left(d_A - s_A\right)s_A + ts_B - c_A\left(s_A + s_B\right)\right]\left(1 - \tau_A\right) \\ &+ \left[\left(d_B - s_B\right)s_B - ts_B - c_T s_B\right]\left(1 - \tau_B\right) \\ &\geq \left(d_A - s_A\right)s_A + ts_B - c_A\left(s_A + s_B\right) - \frac{\left(d_A - s_A\right)s_A}{\left(d_A - s_A\right)s_A + \left(d_B - s_B\right)s_B}\tau_A \\ &\cdot\left[\left(d_A - s_A\right)s_A + \left(d_B - s_B\right)s_B - c_A\left(s_A + s_B\right) - c_T s_B\right] \\ &+ \left[\left(d_B - s_B\right)s_B - ts_B - c_T s_B\right]\left(1 - \tau_B\right)\end{aligned} \tag{83}$$

From the $MNE's$ perspective, the reported optimal after-tax profit for any given transfer price t always equals or exceeds the optimal after-tax profit if the formula is applied. Therefore, the MNE would have no incentive to deviate from the optimal sales quantities derived in Lemma 2 for a transfer price of $p_B - c_T$ as long as country B would accept the reported profit based on a transfer price $t = p_B - c_T$ as well.

To test whether such a solution with a transfer price at the upper end of the allowed interval would be accepted by country B, we compare the reported profit in country B with $t = p_B - c_T, s_A^* = \frac{1}{2}\left(d_A - c_A\right)$ and $s_B^* = \frac{1}{2}\left(d_B - c_A - c_T\right)$ with the profit allocated to country B according to the formula.

$$\Pi_B^{no} = p_B s_B^* - (p_B - c_T)\, s_B^* - c_T s_B^* = 0$$
$$< \frac{p_B s_B^*}{p_A s_A^* + p_B s_B^*} \left(\Pi_A^{no} + \Pi_B^{no}\right) \forall s_A^*, s_B^* > 0 \tag{84}$$

Thus, a unilateral minimum taxation in country A is never an optimal solution if $\tau_A > \tau_B$. As country B would not accept the reported profit resulting from that solution, the sales formula is applied in both countries.

2. If $\tau_A < \tau_B$, the optimal transfer price under corporate income taxation is $t^* = p_B - c_T$ and optimal sales quantities are $s_A^* = \frac{1}{2}(d_A - c_A)$ and $s_B^* = \frac{1}{2}(d_B - c_A - c_T)$.
Thus, the reported profit in country B equals

$$\begin{aligned} \Pi_B^{no} = & \left(d_B - \frac{1}{2}(d_B - c_A - c_T)\right) \frac{1}{2}(d_B - c_A - c_T) \\ & - \left(d_B - \frac{1}{2}(d_B - c_A - c_T) - c_T\right) \frac{1}{2}(d_B - c_A - c_T) \\ & - c_T \frac{1}{2}(d_B - c_A - c_T) \\ & = 0 \end{aligned} \tag{85}$$

$$\Pi_B^{no} < \frac{p_B s_B^*}{p_A s_A^* + p_B s_B^*} \left(\Pi_A^{no} + \Pi_B^{no}\right) \forall s_A^*, s_B^* > 0 \tag{86}$$

Since the reported profit in country B is always lower than the profit allocated to B according to the formula, minimum taxation is applied.

Let's assume that minimum taxation is applied unilaterally in country B. Then, the following profit function holds:

$$\begin{aligned} \Pi = & \left[(d_A - s_A)\, s_A + t s_B - c_A (s_A + s_B)\right](1 - \tau_A) \\ & + \left[(d_B - s_B)\, s_B - t s_B - c_T s_B\right] - \frac{(d_B - s_B)\, s_B}{(d_A - s_A)\, s_A + (d_B - s_B)\, s_B} \tau_B \\ & \left[(d_A - s_A)\, s_A + (d_B - s_B)\, s_B - c_A (s_A + s_B) - c_T s_B\right] \end{aligned} \tag{87}$$

The first derivative with regard to the transfer price t yields

$$\frac{\delta \Pi}{\delta t} = -s_B \tau_A \tag{88}$$

The profit of the MNE strictly decreases in the transfer price t as long as a unilateral minimum taxation in country B is applied. Thus, one potential optimum could be reached by choosing the minimal $t = c_A$. Country B always accepts $t = c_A$ as it is the most favorable transfer price for it within the allowed interval. If country A would accept the reported profit based on a transfer price $t = c_A$ as well, the MNE would have no incentive to deviate from the optimal sales quantities derived in Lemma 2 for this transfer price.

To test whether such a solution would be accepted by country A, we compare the reported profit in country A with $t = c_A, s_A^* = \frac{1}{2}(d_A - c_A)$ and $s_B^* = \frac{1}{2}(d_B - c_A - c_T)$ with the profit allocated to country A according to the formula. As shown in (78), the reported profit in country A would be $\frac{1}{4}(d_A - c_A)^2$. (79) shows that the profit allocated to A according to the sales formula would be

$$\frac{\left(d_A^2 - c_A^2\right)\left[2c_A\left(c_A + c_T - d_A - d_B\right) + d_A^2 + \left(c_T - d_B\right)^2\right]}{4\left[d_A^2 + d_B^2 - \left(c_A + c_T\right)^2 - c_A^2\right]} \tag{89}$$

The reported profit in A equals or exceeds the profit allocated according to the formula if

$$d_B \leq \left(1 + \frac{c_T}{c_A}\right) d_A \tag{90}$$

Thus, if $d_B \leq \left(1 + \frac{c_T}{c_A}\right) d_A$ country A taxes the reported profit with $t = c_A, s_A^* = \frac{1}{2}(d_A - c_A)$ and $s_B^* = \frac{1}{2}(d_B - c_A - c_T)$. Country B uses minimum taxation, forcing the MNE to adjust the transfer price from $p_B - c_T$ to c_A compared to the corporate tax regime. If d_B exceeds this threshold, the sales based formula is applied in both countries.

To determine the impact of minimum taxation on the location decision of the MNE we compare the resulting after-tax profits under minimum taxation (Π^{min}) and under decentralized production (Π^{dec}) that is based on the optimal sales quantities under decentralized production derived in Lemma 2).

$$
\begin{aligned}
&\Pi^{min} - \Pi^{dec} \\
&= \left\{ \left[d_A - \frac{1}{2}(d_A - c_A) \right] \frac{1}{2}(d_A - c_A) - \frac{1}{2} c_A (d_A - c_A) \right\} (1 - \tau_A) \\
&+ \left\{ \left[d_B - \frac{1}{2}(d_B - c_A - c_T) - c_A - c_T \right] \frac{1}{2}(d_B - c_A - c_T) \right\} (1 - \tau_B) \\
&- \left\{ \left[d_A - \frac{1}{2}(d_A - c_A) - c_A \right] \frac{1}{2}(d_A - c_A) \right\} (1 - \tau_A) \\
&- \left\{ \left[d_B - \frac{1}{2}(d_B - c_B) - c_B \right] \frac{1}{2}(d_B - c_B) \right\} (1 - \tau_B)
\end{aligned} \tag{91}
$$

Solving for c_B shows that

$$
\Pi^{min} > \Pi^{dec} \text{ for } c_B > c_A + c_T \tag{92}
$$

Thus, a centralized solution under a unilateral minimum taxation regime in country B is preferred to decentralized production if $c_B > c_A + c_T$.

Tax revenues $\mathcal{T}_A$ and $\mathcal{T}_B$ in country A and B for an optimal transfer price $t^* = c_A$ can be inferred from (12) and (13) for centralized production and for the tax rate differential $\tau_A > \tau_B$.

A.4. Proofs of Section 3.2

Under centralized production, the optimal sales quantity s_B^* after the implementation of corporate taxation (see (30)) is higher compared to the pre-tax regime (see (24)) if the following condition holds:

$$
\begin{aligned}
&\frac{1}{2(\tau_A + \tau_B - 2)(c_A - d_A)} * \left[(\tau_A - \tau_B)(c_A - d_B + c_T) + \sqrt{\psi} \right] < \alpha \\
&\text{with} \\
&\psi = (\tau_A - \tau_B)^2 (c_T - d_B)^2 \\
&\quad + 2c_A \left[(\tau_A - \tau_B)^2 (c_T - d_B) - 8 d_A (\tau_A - 1)(\tau_A + \tau_B - 2) \right] \\
&\quad + c_A^2 (3\tau_A + \tau_B - 4)^2 + 8 d_A^2 (\tau_A - 1)(\tau_A + \tau_B - 2)
\end{aligned} \tag{93}
$$

Under decentralized production, the optimal sales quantity s_B^* is higher after the implementation of corporate taxation (see (32)) compared to the pre-tax regime (see

(24)) if the following condition holds:

$$\frac{1}{2\left(\tau_A+\tau_B-2\right)\left(c_A-d_A\right)}*\left[\left(\tau_A-\tau_B\right)\left(c_B-d_B\right)+\sqrt{\zeta}\right]<\alpha$$

with

$$\begin{aligned}\zeta=&-16c_Ad_A\left(\tau_A-1\right)\left(\tau_A+\tau_B-2\right)+\left(\tau_A-\tau_B\right)^2\left(c_B-d_B\right)^2\\&+8c_A^2\left(\tau_A-1\right)\left(\tau_A+\tau_B-2\right)+8d_A^2\left(\tau_A-1\right)\left(\tau_A+\tau_B-2\right)\end{aligned} \tag{94}$$

A.5. Proof of Lemma 6

The analysis of a minimum taxation regime with complementarities between national sales ($\alpha_i>0$) follows systematically the same procedure as for $\alpha_A=\alpha_B=0$.

1. If $\tau_A>\tau_B$, the optimal transfer price under corporate income taxation is $t^*=c_A$ and optimal sales quantities are given by (27) and (28). Country A applies the sales formula if reported profits in A (i.e., $(p_A-c_A)*s_A$) are lower than taxable profits according to the formula (i.e. $\frac{p_A*S_A}{p_A*S_A+p_B*S_B}*\Pi^{no}$). We insert both $t^*=c_A$ and the optimal sales quantities to determine the threshold that has to be exceeded to warrant an application of the formula by country A.

$$d_B>\frac{\eta}{\theta} \tag{95}$$

with

$$\begin{aligned}\eta=&\,\alpha_B\left(1-\tau_B\right)c_A\left[\left(1+\alpha_A\right)d_A\left(1-\tau_A\right)-2\left(1-\tau_B\right)c_T\right]\\&+\alpha_B\left(1-\tau_B\right)c_T\left[\alpha_Ad_A\left(1-\tau_A\right)-\left(1-\tau_B\right)c_T\right]\\&-\alpha_B\left(1-\tau_B\right)c_A^2\left(2-\tau_A-\tau_B\right)\\&+\left(1-\tau_A\right)\alpha_Ac_A^2\left[2+\alpha_A-\left(1+\alpha_A\right)\tau_A-\tau_B\right]\\&-\left(1-\tau_A\right)c_A\left[\alpha_A\left(1-\tau_A\right)-2\tau_B+2\right]\left(d_A-\alpha_Ac_T\right)\\&-\left(1-\tau_A\right)\left(1-\tau_B\right)c_T\left(2d_A-\alpha_Ac_T\right)\\&+\alpha_B^2\left(1-\tau_B\right)^2\left(d_A-c_A\right)\left(c_A+c_T\right)\end{aligned}$$

and

$$\begin{aligned}\theta=&\,c_A\left[\alpha_A^2\left(1-\tau_A\right)^2-\left(2-\alpha_A-\alpha_A\alpha_B\right)\left(1-\tau_A\right)\left(1-\tau_B\right)-\alpha_B\left(1-\tau_B\right)^2\right]\\&+c_T\left(1-\tau_B\right)\left(\alpha_A\left(1-\tau_A\right)-\alpha_B\left(1-\tau_B\right)\right)\end{aligned}$$

As shown in (82), the MNE has incentives to increase its transfer price as long as country A unilaterally applies minimum taxation. Therefore, a potential optimum could be a situation where a transfer price $t = p_B - c_T$ is chosen,which would be accepted by country A because it represents the highest price within the allowed interval. However, (84) shows that a transfer price of $p_B - c_T$ is not accepted by country B since its taxable income would be zero. Therefore, for any positive sales quantities s_B country B is better off when it applies the sales formula. The sales formula is thus always applied in both countries for $\tau_A > \tau_B$ if the condition in (95) is fulfilled.

2. If $\tau_A < \tau_B$, the optimal transfer price under corporate income taxation is $t^* = p_B - c_T$ and optimal sales quantities follow from (29) and (30). Since for the applied tax rate differential the reported profit in country B is zero $\Pi_B^{no} = 0$ (as shown in (85)), country B would always apply minimum taxation. The profit of the MNE strictly decreases in the transfer price if unilateral minimum taxation is applied in country B (see (88)). Thus, as shown for $\alpha_A = \alpha_B = 0$, one potential optimum could be reached by setting $t = c_A$. Country B always accepts that transfer price. By comparing the reported profit in country A under $t = c_A$ with the profit allocated to country A according to the formula we test whether country A would accept such a solution. We thereby insert the optimal sales quantities for $t = c_A$ known from (27) and (28). As shown in (95), country A accepts the transfer price and does not apply the formula as long as d_B is below or equal to the threshold $\frac{\eta}{\theta}$. In this case, the implementation of minimum taxation results in an adjustment of both the transfer price and the sales quantities. Under corporate taxation, the optimal sales quantities were given by (29) and (30). After the implementation of minimum taxation they are given by (27) and (28). This adaptation in sales quantities is unique for a setting with complementarities in sales (i.e. $\alpha_A > 0$ and $\alpha_B > 0$). If the condition of (95) is fulfilled, the sales based formula is applied in both countries.

A.6. Proof of Section 3.3

To show that the tax revenue $\mathcal{T}_A$ can both increase or decrease under minimum taxation compared to a corporate taxation regime we assume $\tau_A < \tau_B$ and $\alpha_A = \alpha_B = \alpha$. Moreover, c_B is supposed to be sufficiently high to warrant centralized production under both a corporate tax and and a minimum taxation regime. Specifically, we assume the following parameter setting:

$$d_A \to 2,000; c_A \to 11; c_T \to 30; \tau_A \to 0.15; \tau_B \to 0.3; \alpha \to 0.5$$

To calculate the tax revenue $\mathcal{T}_A$ under a corporate income taxation regime, we insert the optimal transfer price $t^* = p_B - c_T$ and the optimal sales quantities s_A^* (see (29)) and s_B^* (see ((30)).

$$\begin{aligned} \mathcal{T}_A &= \tau_A \left(p_A^* s_A^* + t^* s_B^* - c_A \left(s_A^* + s_B^* \right) \right) \\ &= 0.05 d_B^2 + 95.35 d_B + 193,813 \end{aligned} \tag{96}$$

Equivalently, for a minimum taxation regime we insert the optimal transfer price $t^* = c_A$ and the optimal sales quantities s_A^* and s_B^* from equations (35) and (36). The tax revenue $\mathcal{T}_A$ yields as:

$$\begin{aligned} \mathcal{T}_A &= \tau_A \left(p_A^* s_A^* + t^* s_B^* - c_A \left(s_A^* + s_B^* \right) \right) \\ &= 0.0013 d_B^2 + 52.7429 d_B + 20,2749 \end{aligned} \tag{97}$$

Equalizing (96) and (97) shows that tax revenues in A under the minimum tax regime are equal to the ones under a corporate income tax regime if $d_B = 174.828$. If $d_B < 174.828$ ($d_B > 174.828$), tax revenues $\mathcal{T}_A$ decrease (increase) under a minimum taxation regime compared to a corporate income tax regime. The condition in Lemma 6 is fulfilled as long as $d_B < 10,475$. Thus, both an increase or a decrease of $\mathcal{T}_A$ are possible depending on the specific parameter setting.

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Impressum:
Arbeitskreis Quantitative Steuerlehre, arqus, e.V.
Vorstand: Prof. Dr. Ralf Maiterth (Vorsitzender),
Prof. Dr. Kay Blaufus, Prof. Dr. Dr. Andreas Löffler
Sitz des Vereins: Berlin

Herausgeber: Kay Blaufus, Jochen Hundsdoerfer,
Martin Jacob, Dirk Kiesewetter, Rolf J. König,
Lutz Kruschwitz, Andreas Löffler, Ralf Maiterth,
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ISSN 1861-8944