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Abstract

Recent empirical research documents a tendency of affiliates of multinational enterprises to bunch around zero reported profit. Setting up a model that allows for profitable and loss-making affiliates of multinationals, we show that profit shifting to a low-tax country as well as a loss-related, inverted-type of transfer pricing from the low-tax to the high-tax country induces bunching. Such bunching promotes investment incentives in the low-tax as well as the high-tax country. In equilibrium, affiliates might over-invest and the bunching-related investment effects generate a tendency for too high profit taxes in equilibrium. The finding contrasts existing literature where transfer pricing incentives are insulated from investment incentives and transfer pricing induces inefficiently low taxes.

JEL-Codes: H250, D210, H870.

Keywords: tax competition, profit shifting, corporate losses, bunching, investment.

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1 Introduction

Profit shifting of multinational enterprises (MNEs) has recurrently been subject to policy discussions in Europe and the U.S. alike. Compared to domestic firms, MNEs have the possibility to exploit cross-country difference in corporate tax rates to reduce their global tax bill. A frequently used strategy for that purpose is the strategic adjustment of transfer prices at which goods and services such as the use of intellectual property rights (e.g., patents and trade marks) are traded between affiliates of MNEs (Keen and Konrad, 2013; Dharmapala, 2014).[1] Recent empirical evidence has shown that transfer pricing induces MNEs to bunch their affiliates' reported profits around zero (Grubert et al., 1993; Johannesen et al., 2017; Habu, 2017; Dharmapala and Hebous, 2018). Generally, bunching occurs because MNEs shift both profits out of profitable affiliates in high-tax countries and from profitable into loss-making affiliates, potentially residing in high-tax countries (Hopland et al., forthcoming; DeSimone et al., 2017).

Most notably, existing theoretical work struggles in accommodating these relevant empirical findings in a unified model of profit shifting behavior because either affiliates do not incur losses or because MNEs are unconstrained in their transfer pricing choices, thereby ruling out the possibility that transfer pricing induces bunching.[2] Accounting for the relevant empirical findings, we set up a model of transfer pricing and analyze whether bunching has real effects on MNE behavior, that is on MNEs' investment incentives. The issue whether transfer pricing affects MNE investment is of long-standing interest in international taxation, but is notoriously difficult to analyze in the canonical model of transfer pricing. This particularly applies to the investment implications of

[1] The issue of tax-induced transfer pricing has not long since gained momentum in the Base Erosion and Profit Shifting (BEPS) initiative of the OECD (OECD, 2013). Despite various attempts to regulate transfer pricing (OECD, 2010), limiting this type of tax avoidance behavior continues to be a 'taxing task' for tax authorities. The notion of arm's-length pricing, which underlies most of the transfer pricing regulation, is difficult to implement with, e.g., intellectual property rights due to the highly idiosyncratic nature of this service and the associated difficulty in finding comparable transactions that are not influenced by tax-savings considerations. See Schön and Konrad (2012), for instance.

[2] Theoretical contributions on corporate losses and profit shifting are scarce. Two exceptions are Kalamov and Runkel (2016) and Mardan and Stimmelmayr (2018). Both studies rely on interior solutions to characterize transfer pricing incentives. As detailed below, investment behavior and transfer pricing incentives do not intertwine in this environment.

bunching.

Our set-up deviates from the existing approach of modeling transfer pricing in two ways. First, we allow affiliates to incur losses. Losses are quantitatively important and corporate tax codes typically offer provisions that allow MNEs to use losses for tax purposes.[3] However, losses do not immediately generate tax rebates and the tax codes in most countries impose time limits on the availability of loss offset provisions and do not allow losses to be offset across countries. The intention of restricting the use of tax losses is to reduce tax fraud and excessive use of tax deductions (Altshuler et al., 2009). Despite these attempts to protect the domestic corporate tax base, MNEs have the potential to bypass these 'waiting' rules through the strategic use of transfer pricing in order to immediately use losses for tax purposes and to allow shifted profits to be taxed at a zero rate (Hopland et al., forthcoming; DeSimone et al., 2017).

As a second deviation of our model from existing theory, we allow MNEs to be constrained in their transfer pricing behavior. In the canonical model of transfer pricing, the MNE trades off the marginal tax savings against the marginal concealment cost (Haufler and Schjelderup, 2000; Gresik, 2001). The implicit assumption is that, with profitable affiliates, the amount of profits in the high-tax country does not fall below the unconstrained level of shifted profits. In our setting, we allow for the possibility of constrained profit shifting behavior due to insufficient profits. Moreover, with losses in an affiliate that is located in high-tax country, the MNE might also be constrained in the choice of the transfer price. This is the case when losses are fully absorbed by the shifted profits.

The combination of shifting profits out of profitable affiliates into loss-making affiliates and constraints in transfer-price setting gives MNEs the opportunity to bunch their affiliates' reported profits around zero, an implication that is in line with empirical research (Grubert et al., 1993; Johannesen et al., 2017; Habu, 2017; Dharmapala and

[3] Altshuler et al. (2009) and Dwenger (2009) document the increase in corporate tax losses over time for the U.S., respectively, Germany. The number of loss-making firms or affiliates of MNEs is quite sizeable. For instance, Cooper and Knittel (2006) find that roughly 50% of U.S. C corporations report losses in the period 1993-2003. Overesch (2009) finds a similar magnitude for affiliates of German MNEs. For a more general overview of the quantitative relevance of corporate losses, see OECD (2011).

Hebous, 2018).[4] Such a situation is consistent with highly-publicized cases of aggressive transfer pricing behavior by very large MNEs like Apple, Google or Starbucks, leaving almost zero taxable profits in high-tax countries (Levin and McCain, 2013). The predominance of very large MNEs engaging in international tax avoidance is also consistent with the most recent empirical evidence on transfer pricing (Davies et al., forthcoming). Similarly, political concerns about the aggressive transfer pricing behavior of larger MNEs underlies the OECD's Base Erosion and Profit Shifting (BEPS) initiative (OECD, 2013) and the recent European Union's investigations against Ireland and Luxemburg.[5]

We show that the tendency of affiliates to bunch around zero reported profits has real effects for MNE behavior. Intuitively, when the profitability of an affiliate is too low, the optimal profit shifting level falls below the optimal unconstrained level of profit shifting. Increasing the investment level in the respective affiliate implies that the marginal return on investment will be shifted to the other affiliate, where it is taxed at a lower rate. Similarly, when the 'absorptive capacity' in the loss-making affiliate is too low, an increase in investment in the loss-making affiliate relaxes the constraint by increasing the 'absorptive capacity' which, in turn, allows the MNE to increase its profit shifting. In this setting, transfer pricing increases investments in the affiliate in the high-tax country as well as in the low-tax country. Thereby, our model provides a micro-foundation for investment effects resulting from transfer pricing that are hitherto undocumented. Although an investment link also exists in the context of profit shifting via internal debt rather than transfer pricing, the channel only promotes investments in high-tax affiliates (Mintz and Smart, 2004).

Moreover, the interrelatedness between profit shifting and investment decisions has also implications for the efficiency of government policy. The typical positive externality

[4] The loss-induced tendency to bunch from below zero gives rise to 'two-sided' bunching incentives. This is different to frequently-analyzed bunching incentives at kinks or notches in income tax codes where bunching occurs only from one side, typically by households that otherwise operate above the threshold (Kleven, 2016).

[5] The European Commission has initiated investigations against Ireland and Luxemburg due to tax privileges that have been granted to Apple and Amazon, respectively and the resistance of the Irish government to recover tax benefits from Apple (European Commission, 2017).

caused by governments when they reduce their tax rate to attract profits, sufficiently characterizes the efficiency of government policy only when affiliates are profitable and the MNE is unconstrained in its profit shifting strategy. Instead, whenever the MNE is constrained in its transfer-pricing, there also exists a negative investment externality running in the opposite direction, which generates a tendency for too high tax rates in equilibrium. Since the two externalities are differently rooted in the behavior of the MNE (one operates with an unconstrained choice, while the other follows from a constrained choice), the investment externality does not deduce from the transfer pricing response underlying the standard positive externality. It is thereby of first-order importance.

From our analysis, we can derive several implications. First, in empirical analyses on transfer pricing, loss-making affiliates are frequently dropped from the analysis (Klassen et al., 1993; Dharmapala, 2014), presumably reflecting the prior that loss-making affiliates induce a bias from reversed transfer pricing incentives. Our analysis shows that the disregard of loss-making affiliates does not nullify the impact of losses on transfer pricing in data with profitable affiliates only. The existence of losses in the disregarded affiliates reduces the reported profit in otherwise profitable affiliates (close) to zero and thereby makes taxable profits in profitable affiliates (almost) insensitive to corporate taxes.[6] In a situation where only the tax sensitivity of reported profits among profitable affiliates is of interest, the cross-affiliate effect of losses likely results in an underestimation of the tax sensitivity of reported profits.

Second, a change in the corporate tax rate in the location where affiliates report close to zero taxable profits has, most likely, no impact on local investment incentives because MNEs can escape the taxation of the marginal return on investment by shifting the respective profit to a loss-making affiliate abroad. Differently, investment incentives of affiliates with no loss-making counterparts, to which profits can be shifted, are affected by corporate taxation. If the omission of loss-making affiliates is intended

[6]This finding is consistent with Habu (2017) who shows that a cut in the UK corporate tax rate did not have a differentiated effect on the ratio of taxable profits to total assets of foreign multinational subsidiaries vs. domestic stand-alone firms. She explains this result to be consistent with the fact that subsidiaries reporting zero taxable profits may be inelastic to changes in the corporate tax rates as they already report zero taxable profits.

to nullify the role of losses and to get estimates that apply to unconstrained profit shifting among profitable affiliates (the scenario generally assumed in theoretical work), then the empirical estimate of investment responses to corporate taxation is downward biased.[7]

Third, from a policy point of view, our analysis offers a more nuanced perspective on the effectiveness of policies to curb tax-induced transfer pricing. Policies that increase concealment cost due to more stringent auditing and documentation requirements are part of the OECD's strategy to curb profit shifting (OECD, 2010). Our analysis shows that such a strategy becomes ineffective when the choice of the transfer price is constrained. The constraint insulates the choice of the transfer price from concealment cost considerations. The reasoning does not apply to formula apportionment, an alternative frequently-applied and discussed policy measure to reduce profit shifting of MNEs.

The paper is organized as follows. In Section 2, we introduce a model with profitable and loss-making MNE affiliates. In Section 3, we analyze the MNE's transfer pricing and investment choices and, in Section 4, we turn to government policy and characterize the efficiency of tax policy. Various assumptions made in the basic model are discussed in Section 5, while a summary of the results and some concluding policy remarks are provided in Section 6.

2 The basic framework

We consider a multinational enterprise (MNE) with two affiliates, each of them located in a small country which levies a source-based profit tax rate t_i, $i = 1, 2$. Although tax rates are determined endogenously, we assume, without loss of generality, that country

[7] The two aforementioned biases still exist when comparing the findings to the full sample, including loss-making affiliates. Taxable profits of loss-making affiliates that bunch from below zero do not respond to taxes, yielding an overestimation of the tax sensitivity of taxable profits when eliminating these from the data set. Differently, the tax induced investment response might continue to be underestimated since investments in loss-making affiliates might well decrease in the own corporate tax rate. The latter finding is in line with empirical estimates of the user cost elasticity of investment in Dwenger and Walch (2014), which increases in absolute value from 0.37 to 0.52 when accounting for tax losses.

2 is the high-tax country.[8] Affiliates employ capital, k_i, to produce a final good, y_i, and use a standard production technology, $y_i = f(k_i)$, with $f'(k_i) > 0 > f''(k_i)$. Capital, k_i, can be borrowed at the world market at an interest rate r.

The price levels of the final goods are stochastic and drawn from a cumulative distribution function, $H_i(p_i)$, and density, $h_i(p_i)$, with support on $[p_i^-, p_i^+]$. The uncertainty of the price level in country 1 affects the profitability of affiliate 1, but we assume that ex post the affiliate is always profitable even if the realization of the price takes the lower bound p_1^-.[9] Instead, the realization of the output price in country 2 may imply losses in affiliate 2 ex post.[10] Moreover, we denote $\hat{p}_i = \int_{p_i^-}^{p_i^+} p_i h_i(p_i) dp_i$ as the average price in country i.

Each affiliate additionally requires one unit of an essential intangible input g for production. The input could, for instance, be a patent. The legal rights for using the intangible input good are located in the affiliate in country 1. The arm's-length price for g is normalized to zero. Any deviation from the arm's-length price results in convex concealment costs of the form $C(g) = \gamma g^2/2$, $\gamma > 0$.[11] Furthermore, we assume that the MNE has sufficient flexibility to determine the transfer price ex post, i.e., after the realization of the output price in each of the two countries.[12]

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[8] One reason for this could be that country 2 hosts a larger number of purely national firms and therefore derives comparably more corporate tax revenues from this additional source.

[9] This assumption reduces complexity without qualitatively affecting our results. When affiliate 1 is also allowed to incur losses, the induced bunching and investment effects are similar to those that we report below when affiliate 2 incurs losses.

[10] In general, the MNE might close down a permanently loss-making affiliate. However, at least in the short run it might well be that the MNE continues the operation even though it temporarily incurs losses in expectation. Loss-making affiliates might be valuable in order to gain access to a new market or to show strategic presence in a relevant market. The reasoning is consistent with the persistence of losses, as reported in Auerbach and Poterba (1987) and Dwenger and Walch (2014), for instance.

[11] We could also include size-related determinants of the concealment cost, like affiliate assets (Soerensen, 2004; Riedel and Runkel, 2007). Such an extension allows corporate investments to influence transfer pricing and vice versa. Instead, our modelling approach conditions the concealment cost only on the deviation from the arm's-length price to provide a micro-foundation for the link between transfer pricing and investment incentives that builds on transfer pricing constraints.

[12] The ex-post use of tax losses for transfer pricing requires some form of flexibility in setting transfer prices and/or some persistency of tax losses. See Hopland et al. (forthcoming) for evidence that the use of intangible assets gives MNEs the opportunity to shift income ex post. Johannesen et al. (2017) and Dharmapala and Hebous (2018) show that MNE affiliates' profits are centered around zero, consistent with the idea that, to some extent, transfer prices can be flexibly adjusted to eliminate positive taxable profits. Auerbach and Poterba (1987) and Dwenger and Walch (2014) find that tax losses for US and

The before-tax profit of each affiliate is given by (expected) sales revenue less the user cost of capital adjusted by the payment/income from the intangible asset,

$$\begin{aligned}\pi_1^e &= \int_{p_1^-}^{p_1^+} p_1 h_1(p_1) dp_1 \, y_1 - rk_1 + g, \\ \pi_2^e &= \int_{p_2^-}^{p_2^+} p_2 h_2(p_2) dp_2 \, y_2 - rk_2 - g. \end{aligned} \tag{1}$$

The timing of decisions is as follows. First, the two governments non-cooperatively set tax rates. Then, the MNE determines the optimal investment levels (before the realization of affiliates' output prices) and thereafter (after the realization of affiliates' output prices) it chooses the optimal transfer price. Alternative sequences of decision making are discussed in Section 5. We solve by backward induction.

3 The firm

3.1 Ex-post period

Taxable profits differ from pre-tax profits in that only a share $\delta < 1$ of the capital costs is deductible in case taxable profits are positive. The restriction on the deductibility of the cost of capital reflects the observation that real-world tax systems only offer delayed expensing of investment outlays and no deductibility of the cost of equity capital.

Non-negative taxable profits in country 2

If the output price in country 2 is sufficiently large, i.e., $p_2 y_2 - \delta r k_2 > 0$ and, depending on the choice of g, taxable profits of both affiliates are given by

$$\begin{aligned}\pi_1^t &= p_1 y_1 - \delta r k_1 + g, \\ \pi_2^t &= \begin{cases} p_2 y_2 - \delta r k_2 - g & \text{if} \quad p_2 y_2 - \delta r k_2 - g \geq 0, \\ 0 & \text{otherwise.} \end{cases}\end{aligned} \tag{2}$$

The formulation in (2) accounts for the fact that $g > 0$, given that country 2 levies the higher tax rate, $t_2 > t_1$. We distinguish two scenarios: in the first case, the realization

German firms appear to be quite persistent over time.

of the output price in country 2 is sufficiently high and the MNE is not restricted in setting its transfer price. In the second case, the output price is still sufficiently high and the MNE generates positive taxable profits in affiliate 2 in the absence of profit shifting. The MNE is now however able to shift all profits earned in affiliate 2 into the low-tax country 1, leading to a zero tax base in country 2, i.e., $\pi_2^t = 0$.

Assuming for the moment that the MNE is unrestricted in its profit shifting possibilities, total profits of the MNE amount to[13]

$$\Pi^{UP} = (1 - t_1)p_1 y_1 - (1 - \delta t_1)rk_1 + (1 - t_2)p_2 y_2 - (1 - \delta t_2)rk_2 + (t_2 - t_1)g - \gamma\frac{g^2}{2}. \tag{3}$$

The optimal transfer price is determined by

$$g^{UP} = \frac{t_2 - t_1}{\gamma}, \tag{4}$$

where the superscript denotes that the MNE is <u>u</u>nconstrained and taxable profits in country 2 are <u>p</u>ositive. Optimal profit shifting behaviour implies that the marginal cost of shifting profits has to equal the marginal benefit of profit shifting, that is, the tax savings. Since $t_2 > t_1$, the MNE shifts profits from the high-tax country 2 to the low-tax country 1. The transfer price is positive, $g^{UP} > 0$.

The realization of the output price in country 2 might not be sufficiently high to ensure that the MNE is unconstrained in its optimal profit shifting behaviour. Denoting p_2^0 as the price at which taxable profits of affiliate 2 are zero in the absence of profit shifting, i.e. $p_2^0 \equiv \frac{\delta rk_2}{y_2}$, and p_2^{UP} as the price at which taxable profits evaluated at the transfer price (4) are zero, the MNE is constrained in the choice of the transfer price if

$$p_2^0 \leq p_2 < \frac{\delta rk_2}{y_2} + \frac{t_2 - t_1}{\gamma y_2} \equiv p_2^{UP}. \tag{5}$$

For the price range defined in (5), affiliate 2 is still profitable and the MNE shifts profits from the high-tax country 2 to the low-tax country 1, but to a smaller extent. Due to

[13]For simplicity, we assign the concealment cost to the net-of-tax profit stream of the headquarters. Assigning the concealment cost to the affiliates and making the cost tax deductible (partly or fully) changes the endogenous probability of the different scenarios that we consider in our analysis, but does not change our findings qualitatively.

the lower output price and thus the lower profitability of affiliate 2, the MNE sets the transfer price in a way that reduces taxable profits in country 2 to zero. Thus,

$$g^0 = p_2 y_2 - \delta r k_2 > 0, \tag{6}$$

where the superscript 0 denotes that taxable profits in country 2 are zero. The constraint of the MNE's profit shifting behavior originates from the insufficient profitability of affiliate 2. Thus, we refer to this scenario as the *profit constraint* in country 2.

Non-positive taxable profits in country 2

If the realization of the final goods price in country 2 is too low ($p_2 < p_2^0$), the affiliate in country 2 incurs losses and the tax bases in the two countries are given by[14]

$$\begin{aligned}
\pi_1^t &= \begin{cases} p_1 y_1 - \delta r k_1 + g & \text{if} \quad p_1 y_1 - \delta r k_1 + g \geq 0, \\ 0 & \text{otherwise.} \end{cases} \\
\pi_2^t &= \begin{cases} 0 & \text{if} \quad p_2 y_2 - \delta r k_2 - g \leq 0, \\ p_2 y_2 - \delta r k_2 - g & \text{otherwise.} \end{cases}
\end{aligned} \tag{7}$$

The specification in (7) accounts for the fact that g might be negative, as shown below. The tax base of affiliate 2 is non-positive in the absence of profit shifting and, thus, the MNE has an incentive to shift profits from the low-tax country 1 to the high-tax country 2, given that the effective tax rate in country 2 is zero for non-positive taxable profit levels.

We distinguish three scenarios depending on the realization of the price levels p_1 and p_2. In the first case, none of the conditions in equation (7) are binding. Taxable profits in country 1 and losses in country 2 are sufficiently large and the MNE is unrestricted in setting its transfer price. In the second case, optimal MNE behavior is constrained

[14]We abstract from tax provisions to offset losses against positive profits across time or across affiliates, either because they do not eliminate incentives to engage in transfer pricing into loss-making affiliates or they are not commonly available in national tax codes (or both). Different to 'shifting into loss-making affiliates', loss carry forwards entail a cost of forgone interest and can only be used over a limited time span. Loss carry backs are by far less generous than loss carry-forwards. Only a small number of countries offer loss carry backs and the period in which this is possible is very short (at most three years). Many countries do not grant loss carry backs at all. Even more restricted is the possibility of cross-border loss offset. Only four countries (Austria, Denmark, France and Italy) currently allow for cross-border loss offsets (see OECD, 2011).

by the size of taxable profits in country 1. The MNE is forced to shift less profits from country 1 to country 2 because profits of the affiliate in the low-tax country 1 are insufficient to fully offset the loss incurred by the affiliate in country 2. We refer to this scenario as the *profit constraint* in country 1. In the third case, the MNE is constrained by the limited amount of losses in country 2. Given that the statutory tax rate in country 2 is larger than in country 1, $t_2 > t_1$, the MNE never chooses a transfer price which would result in positive taxable profits in country 2. Therefore, the optimal amount of profits shifted from the low-tax country 1 to the high-tax country 2 is confined by the size of affiliate 2's losses and we refer to this scenario as the *loss constraint* in country 2.

Suppose scenario one holds and the MNE is unconstrained in determining its profit shifting behavior. Then, total profits of the MNE are given by

$$\Pi^{UN} = (1 - t_1)p_1 y_1 - (1 - \delta t_1) r k_1 + p_2 y_2 - r k_2 - t_1 g - \gamma \frac{g^2}{2} \tag{8}$$

and the optimal transfer price is

$$g^{UN} = -\frac{t_1}{\gamma}. \tag{9}$$

The superscript indicates that the MNE is <u>u</u>nconstrained and taxable profits in country 2 are <u>n</u>egative. In this scenario, the MNE sets a negative transfer price that shifts profits out of the low-tax country 1 into the high-tax country 2, where the effective profit tax rate is zero. Thereby, the transfer price (9) only depends on the level of country 1's tax rate. In contrast to the scenario where the affiliate in country 2 is profitable, both price levels determine whether the MNE is unconstrained in setting the transfer price. Denoting p_1^{UN} (p_2^{UN}) as the price at which taxable profits π_1^t (π_2^t) evaluated at the transfer price (9) are zero, the MNE is unconstrained if

$$p_1 \geq \frac{\delta r k_1}{y_1} + \frac{t_1}{\gamma y_1} \equiv p_1^{UN} \qquad \text{and} \qquad p_2 \leq \frac{\delta r k_2}{y_2} - \frac{t_1}{\gamma y_2} \equiv p_2^{UN}, \tag{10}$$

which means that the price in country 1 must be sufficiently high whereas the price in country 2 needs to be sufficiently low. Intuitively, to implement the transfer price (9), profits in country 1 and losses in country 2 need to be large enough.

One of the two conditions in (10) might, however, be binding. Either the price in country 1 might be too low ($p_1 < p_1^{UN}$), implying that the affiliate in country 1 is profit constrained, or the price level realized in country 2 might not be sufficiently low ($p_2^{UN} < p_2 < p_2^0$), implying that the affiliate in country 2 is loss constrained. Using (7), we can determine the thresholds under which both constraints are binding. This is the case when the tax bases in both countries reduce to zero, i.e.

$$p_1 y_1 - \delta r k_1 + g = 0 \qquad \text{and} \qquad p_2 y_2 - \delta r k_2 - g = 0. \tag{11}$$

Combining the two equations

$$p_1 y_1 - \delta r k_1 + p_2 y_2 - \delta r k_2 = 0, \tag{12}$$

yields the critical threshold for p_2

$$p_2 \geq \frac{\delta r(k_1 + k_2)}{y_2} - \frac{p_1 y_1}{y_2} \equiv p_2^{PC}. \tag{13}$$

The threshold in (13) depends on the realization of the output price p_1. The higher the output price in country 1 the lower has to be the output price in country 2 to ensure that the MNE is still profit constrained in the affiliate country 1. This implies that for price realizations of $p_2^{UN} < p_2 < p_2^{PC}$, the MNE is profit constrained in the affiliate in country 1.

The optimal transfer price choice depends on which constraint is binding. If the MNE is profit constrained in affiliate in country 1, all profits in country 1 are shifted to country 2 and the optimal transfer price is

$$g^{PC} = -(p_1 y_1 - \delta r k_1) < 0. \tag{14}$$

Instead, if the MNE is loss constrained in the affiliate in country 2, losses are used to accommodate profits of country 1 until taxable profits in country 2 are zero. The associated optimal transfer price is

$$g^{LC} = p_2 y_2 - \delta r k_2 < 0. \tag{15}$$

The superscript of the two transfer prices indicates whether the MNE is profit constrained or loss constrained. Interestingly, the transfer pricing strategies depend on the level of investments in the two countries. Investments possibly relax the constraint either by generating more profits in country 1 or by expanding the amount of losses in country 2. We return to this issue in the subsequent section.

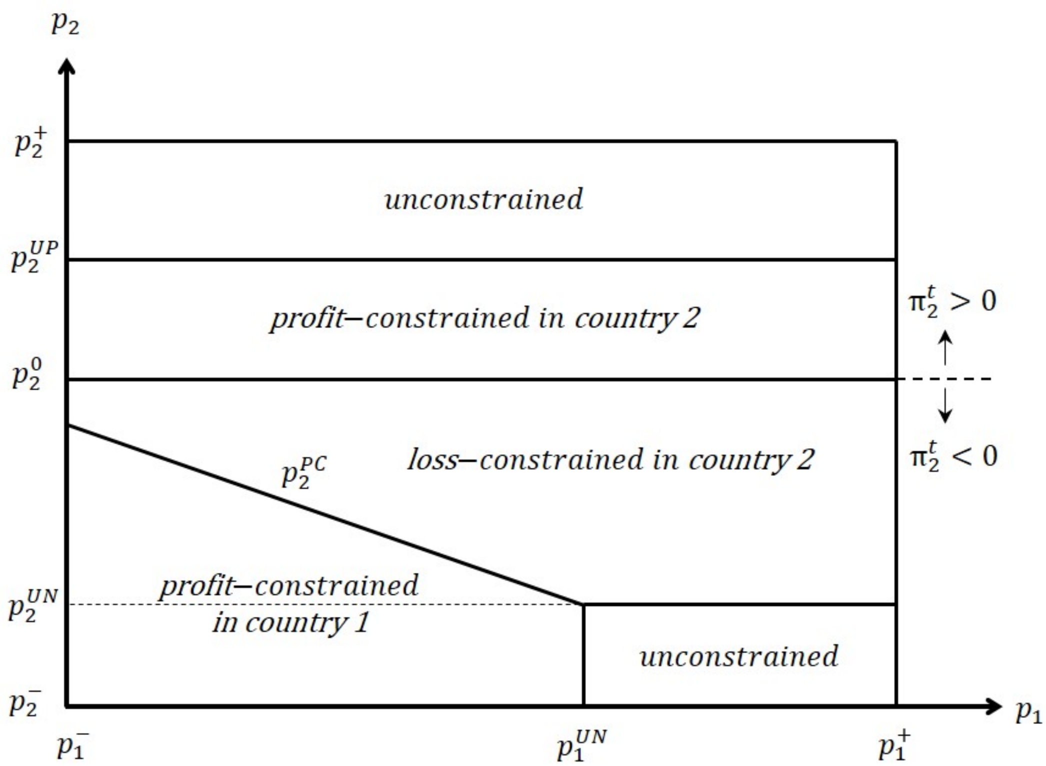

Figure 1: Price-dependent profit shifting regimes.

Finally, Figure 1 summarizes our findings on the critical price levels which constrain the MNE's profit shifting behavior. For instance, for $p_1 \in \{p_1^-, p_1^{UN}\}$, the realization of a very low price p_2 implies that the affiliate in country 2 incurs losses, $\pi_2^t < 0$. The losses are relatively large compared to the profits that are generated in the affiliate in country 1 when the price p_1 is low. Some of the losses of the affiliate in country 2 remain "unused" given the low profitability of the affiliate in country 1. For a price realization of $p_2 \in \{p_2^{PC}, p_2^0\}$, the losses of the affiliate in country 2 are too small to absorb all the profits earned in the affiliate in country 1. Only a portion of the profits generate in country 1 can be shifted into the loss-making affiliate in country 2. For even higher price realizations in country 2, i.e., $p_2 > p_2^0$, the affiliate in country 2 becomes profitable and profits are shifted from the high-tax country 2 to the low-tax country 1. Within the price range $p_2 \in \{p_2^0, p_2^{UP}\}$, profit of the affiliate in country 2 are too small to satisfy the interior solution for the MNE's optimal profit shifting behavior. The latter is only satisfied for $p_2 > p_2^{UP}$, which allows a transfer price volume that coincides with the standard profit shifting equation (4).

One should note that, in Figure 1, the p_2^{PC} threshold cuts the p_2-axis below the value of p_2^0. The explanation for this result originates from the assumption that the affiliate in country 1 is always profitable. Therefore, the p_2^{PC} and p_2^0 lines intersect to the left of p_1^- and the associated value on the p_1-axis would be a price at which taxable profits in country 1 are zero in the absence of profit shifting.

3.2 Ex-ante period

In this section, we analyze the optimal investment decisions of the MNE conditional on the set of constraints the MNE faces in expectation. Taking all possible scenarios together, the MNE's expected profit is given by

$$\begin{aligned} E(\Pi) &= \int_{p_1^-}^{p_1^+}\int_{p_2^{UP}}^{p_2^+} \Pi^{UP} h_2(p_2)h_1(p_1)dp_2dp_1 + \int_{p_1^-}^{p_1^+}\int_{p_2^0}^{p_2^{UP}} \Pi^0 h_2(p_2)h_1(p_1)dp_2dp_1 \\ &+ \int_{p_1^{UN}}^{p_1^+}\int_{p_2^-}^{p_2^{UN}} \Pi^{UN} h_2(p_2)h_1(p_1)dp_2dp_1 + \int_{p_1^-}^{p_1^{UN}}\int_{p_2^-}^{p_2^{PC}} \Pi^{PC} h_2(p_2)h_1(p_1)dp_2dp_1 \\ &+ \int_{p_1^-}^{p_1^{UN}}\int_{p_2^{PC}}^{p_2^0} \Pi^{LC} h_2(p_2)h_1(p_1)dp_2dp_1 + \int_{p_1^{UN}}^{p_1^+}\int_{p_2^{UN}}^{p_2^0} \Pi^{LC} h_2(p_2)h_1(p_1)dp_2dp_1. \quad (16) \end{aligned}$$

To simplify the exposition of the subsequent analysis, it proves useful to impose the assumption that taxable profits slope positively with investment, $p_i f'(k_i) - \delta r > 0$. While this assumption is a simplification, it does not restrict the analysis in important ways, as discussed below.[15]

Differentiating the MNE's expected profit (16) with respect to k_2, Appendix A.1 shows

[15] Straightforwardly, the assumption will be satisfied when δ is not too large. Most importantly, the finding that transfer pricing and investment decisions are interrelated is general in nature and not dependent on this assumption. The finding that profit shifting increases investment and potentially leads to over-investment extends to environments in which $p_i f'(k_i) - \delta r > 0$ does not hold universally. We will return to this issue below.

that the optimal investment level in country 2 is given by

$$
\begin{aligned}
&(1-t_2)\hat{p}_2 f'(k_2) = (1-\delta t_2)r \\
&-\int_{p_1^{UN}}^{p_1^+}\int_{p_2^-}^{p_2^{UN}} t_2[p_2 f'(k_2)-\delta r]h_1(p_1)h_2(p_2)dp_1dp_2 \\
&-\int_{p_1^-}^{p_1^{UN}}\int_{p_2^-}^{p_2^{PC}} t_2[p_2 f'(k_2)-\delta r]h_1(p_1)h_2(p_2)dp_1dp_2 \\
&-\int_{p_1^-}^{p_1^{UN}}\int_{p_2^{PC}}^{p_2^0} \gamma(g^{UP}-g^0)[p_2 f'(k_2)-\delta r]h_1(p_1)h_2(p_2)dp_1dp_2 \\
&-\int_{p_1^{UN}}^{p_1^+}\int_{p_2^{UN}}^{p_2^0} \gamma(g^{UP}-g^0)[p_2 f'(k_2)-\delta r]h_1(p_1)h_2(p_2)dp_1dp_2 \\
&-\int_{p_1^-}^{p_1^+}\int_{p_2^0}^{p_2^{UP}} \gamma(g^{UP}-g^0)[p_2 f'(k_2)-\delta r]h_1(p_1)h_2(p_2)dp_1dp_2 \\
&-\int_{p_1^-}^{p_1^{UN}} \gamma[p_2^{PC} f'(k_2)-\delta r][p_2^{PC}y_2-\delta r k_2+t_1/\gamma]h_2(p_2^{PC})\frac{\partial p_2^{PC}}{\partial k_2}h_1(p_1)dp_1. \qquad (17)
\end{aligned}
$$

The first line in (17) represents the standard first-order condition for the capital stock k_2 given that the two affiliates are profitable and the transfer price coincides with the interior solution derived in (4). In this case, capital investment is distorted by taxation in country 2 because only the portion δ of investment costs are deductible from the tax base. Multiple effects amend the first-order condition when losses and deviations from an interior choice of the transfer price are accounted for. First, the existence of losses in the affiliate in country 2 implies that country 2's tax rate does not affect domestic investment. That is, the terms in the second and third line of (17) cancel the tax effect depicted in the first line of (17) if the choice of the transfer price is either unconstrained or the MNE is profit-constrained in the affiliate in country 1. Second, country 2's tax rate influences investment incentives whenever the MNE is loss-constrained in the affiliate in country 2. The MNE shifts profits from the low-tax affiliate in country 1 to the high-tax affiliate in country 2 and any increase in the investment level in the affiliate in country 2 relaxes the constraint on the absorptive capacity of the affiliate in country 2. The investment effect is summarized in the fourth and fifth line of (17). The terms are positive because $g^{UP} > g^0$.[16]

[16]Note, the unconstrained transfer price g^{UP} necessarily exceeds the constrained price g^0.

Similarly, in the case the MNE is profit-constrained in country 2, the marginal return to investment can be shifted to the affiliate in country 1, thereby taking advantage of the lower tax rate in country 1. The lower tax burden increases investment incentives in the affiliate in country 2. The effect is depicted in the sixth line of (17). As before, the term is positive because $g^{UP} > g^0$. The last term of (17) captures the change in the likelihood of the MNE being profit-constrained in country 1 due to an increase in the capital investment in country 2. As it states, the MNE's profit shifting behavior impacts the investment incentives in the high-tax country by lowering the cost of capital and, thereby, increasing investment levels in country 2.

Differentiating (16) with respect to k_1, Appendix A.1 shows that the optimal investment level in country 1 is given by

$$\begin{aligned}
&(1-t_1)\hat{p}_1 f'(k_1) = (1-\delta t_1)r \\
&- \int_{p_1^-}^{p_1^{UN}}\int_{p_2^-}^{p_2^{PC}} \gamma[p_1 f'(k_1) - \delta r](g^{PC} - g^{UN}) h_1(p_1) h_2(p_2) dp_1 dp_2 \\
&- \int_{p_1^-}^{p_1^{UN}} \gamma[p_1 f'(k_1) - \delta r](g^{PC} - g^{UN}) h_2(p_2^{PC}) \frac{\partial p_2^{PC}}{\partial k_1} h_1(p_1) dp_1. \qquad (18)
\end{aligned}$$

The interpretation of the first effect on the right side of (18) is the same as in the case of (17). It states that investment in country 1 are insulated from profit shifting if both affiliates earn sufficiently high profits. Although the affiliate in country 1 does not incur losses, the possibility of losses in the affiliate in country 2 affects the MNE's investment behavior in country 1. This is captured by the second line of (18). Since $g^{PC} > g^{UN}$, the latter term is negative and thus, profit shifting exerts a positive effect on optimal investment in country 1 if the MNE is profit-constrained in country 1. The MNE has an incentive to increase its investment in country 1 to relax the profit constraint. Additional profits earned through the increase in investment in affiliate 1 are shifted to the loss-making affiliate in country 2 without triggering additional tax payments. Similarly to (17), the terms in the last line of (18) determine how the MNE's probability of being profit-constrained in country 1 is affected by a marginal increase of capital investment in country 1. Therefore, our results highlight the novel finding that profit shifting may also exert a positive impact on investment levels in the low-tax country. This sums up to the following:

Proposition 1 *If MNEs are constrained in their profit shifting activity, the possibility of profit shifting exerts a positive effect on investment. The investment effect might appear in the high-tax country as well as in the low-tax country.*

Proposition 1 provides a micro-foundation for the interdependence between profit shifting and MNE's investment behavior. In existing research, this type of investment response is frequently ignored due to the commonly used assumption that transfer pricing satisfies an interior solution which is determined by the marginal concealment cost and the statutory tax differential, c.f. (4).

Two additional comments are in order at this point. Previous studies show that investment effects may emerge in the context of profit shifting via internal debt rather than transfer pricing (Mintz and Smart, 2004). Therein, the investment effect arises in the high-tax country because of the reduction in capital costs due to interest deductibility. When the MNE uses license payments to shift profits, our results suggest that the investment effect can occur in the high-tax country (but for different reasons) and also in the low-tax country.

Moreover, the model provides an underpinning to the empirically-observed bunching of MNE affiliates in two different ways. The model unravels economic incentives to bunch around zero profits from above as well as from below. When the MNE is profit-constrained in country 1, profits of the affiliate in country 1 are reduced to zero, providing a tendency to bunch from above. Differently, when the affiliate in country 2 does not have enough absorbing capacity and, thereby, is loss-constrained, its profit level will be increased to a zero level. Bunching occurs from below. Investment effects reinforce the tendency to bunch. For instance, when the affiliate in country 1 is profit constrained, the marginal return to investment in the affiliate in country 1 is shifted to the affiliate in country 2. As shown above, this promotes investment incentives in the affiliate in country 1 and, at the same time, reinforces bunching from below in the loss-making affiliate in country 2, since more profits are shifted to that affiliate. Similarly, when the affiliate in country 2 is loss constrained, a rise in its investment level more likely induces the affiliate in country 1 to bunch around zero just because it can shift more profits to the affiliate in country 2.

Multiple issues are noteworthy at this point. First, a necessary (and mild) condition for the investment effects to arise is that the cumulative distribution function $H_i(p_i)$ places some positive mass on the scenarios that entail transfer pricing related investment effects. Strict monotonicity of $H_i(p_i)$ satisfies this requirement. Second, the two first-order conditions (17) and (18) imply that the positive investment effect of transfer pricing continues to hold when the assumption $p_i f'(k_i) - \delta r > 0$ does not hold universally (as assumed so far), but over a sufficiently large set of the relevant price intervals. These are represented by the price intervals governing the terms in the fourth to sixth line of (17) and in the second line of (18).

The impact of profit shifting on capital investment possibly implies over-investment in the two countries, i.e. $\hat{p}_i f'(k_i) < r$. When the MNE is profit-constrained in one of the two countries, the marginal return of the investment is shifted to the other country where it faces a lower tax burden. For instance, if the MNE is profit-constrained in country 1, the marginal return of the investment in country 1 is shifted to the loss-making affiliate in country 2 and is subject to an effective tax rate of zero. At the same time, the amount of shifted profits is tax deductible in country 1. Hence, the marginal return on investment is subsidized at rate $t_1 > 0$ and falls short of the capital costs r. An analogous argument applies when the MNE is profit constrained in country 2, in which case the marginal return on investment in country 2 will be subsidized at rate $t_2 - t_1 > 0$. Importantly, the invoked assumption that taxable profits slope positively with respect to investment, $p_i f'(k_i) - \delta r > 0$, runs against the possibility of over-investment. Over-investment would straightforwardly follow if we assumed $p_i f'(k_i) - \delta r < 0$. We summarize this observation as follows:

Proposition 2 *If MNEs are constrained in their profit shifting activity, the possibility of profit shifting might lead to over-investment in the low-tax as well as in the high-tax country.*

From the first-order conditions (17) and (18), we can infer the effect of taxes on optimal capital investment. In general, these effects are ambiguous because taxes additionally affect the probabilities of being in the one or the other scenario. However, when prices are e.g. uniformly distributed on a large support, the probability of being at a specific point in the price distribution becomes negligible. In the following, we resort to this assumption which allows us to establish (see Appendix A.2)

$$\frac{\partial k_1}{\partial t_1} < 0, \quad \frac{\partial k_2}{\partial t_2} < 0, \quad \frac{\partial k_2}{\partial t_1} < 0, \quad \frac{\partial k_1}{\partial t_2} = 0. \tag{19}$$

Similar to the standard model with only profitable affiliates, taxes in the host country have a negative impact on investment incentives. However, and in contrast to the standard model, the tax rate in country 1 has a negative effects on investment incentives in country 2. A higher tax rate in country 1 reduces the incentives to shift profits when the MNE is profit- or loss-constrained in the affiliate in country 2 and this mitigates the necessity to relax the respective constraint via increased capital investment in country 2. The explanation why country 2's tax rate has no effect on capital investment in country 1 is twofold. First, when the MNE is profit constrained in country 1, the statutory tax rate t_2 is irrelevant for the MNE's profit shifting incentives because the effective tax rate in country 2 is zero due to the loss position of the affiliate in country 2. Second, and more generally, the finding hinges on the assumption that the affiliate in country 1 is always profitable. In a setting where the affiliate in country 1 may as well incurs losses, cross-tax effects on capital investment similar to those in country 2 would also occur in country 1. We summarize our results as follows:

Proposition 3 *If MNEs are constrained in their profit shifting activity, local taxes negatively affect foreign investments via reduced profit shifting.*

The MNE's profit shifting and investment decisions are not insulated from each other when the MNE is constrained in its profit shifting strategy. As implied by Proposition 3, taxes influence this relationship and generate own-country and cross-country tax effects. A tax increase in country 1 spills over to country 2. In fact, it generates a co-movement in capital investments across affiliates of the MNE, an observation that is in line with empirical findings in Desai et al. (2005, 2009) and Becker and Riedel (2011). The predictions reflect the insight that a MNE structure gives rise to interdependencies of investment choices in different countries which, as in this case, are mediated by tax savings considerations.

4 The government

In this section, we analyze the implications of our results derived in the previous section for the efficiency of governments' tax policies. We assume that each government sets its corporate income tax rate to maximize corporate tax revenues.[17] The tax base in both countries consists of expected taxable profits generated by the local affiliate. In addition, country 2 collects additional tax revenues by taxing purely national firms. These revenues are denoted by $t_2G(t_2)$, $G'(t_2) \leq 0$.[18] Expected tax revenues in each country are given by

$$\begin{aligned}
T_1 &= t_1 \int_{p_1^-}^{p_1^+}\int_{p_2^{UP}}^{p_2^+} \left(p_1y_1 - \delta rk_1 + \frac{t_2 - t_1}{\gamma}\right) h_2(p_2)h_1(p_1)dp_2dp_1 \\
&+ t_1 \int_{p_1^-}^{p_1^+}\int_{p_2^0}^{p_2^{UP}} \left(p_1y_1 - \delta rk_1 + p_2y_2 - \delta rk_2\right) h_2(p_2)h_1(p_1)dp_2dp_1 \\
&+ t_1 \int_{p_1^{UN}}^{p_1^+}\int_{p_2^-}^{p_2^{UN}} \left(p_1y_1 - \delta rk_1 - \frac{t_1}{\gamma}\right) h_2(p_2)h_1(p_1)dp_2dp_1 \\
&+ t_1 \int_{p_1^-}^{p_1^{UN}}\int_{p_2^{PC}}^{p_2^0} \left(p_1y_1 - \delta rk_1 + p_2y_2 - \delta rk_2\right) h_2(p_2)h_1(p_1)dp_2dp_1 \\
&+ t_1 \int_{p_1^{UN}}^{p_1^+}\int_{p_2^{UN}}^{p_2^0} \left(p_1y_1 - \delta rk_1 + p_2y_2 - \delta rk_2\right) h_2(p_2)h_1(p_1)dp_2dp_1, \qquad (20)
\end{aligned}$$

$$\begin{aligned}
T_2 &= t_2G(t_2) \\
&+ t_2 \int_{p_1^-}^{p_1^+}\int_{p_2^{UP}}^{p_2^+} \left(p_2y_2 - \delta rk_2 - \frac{t_2 - t_1}{\gamma}\right) h_2(p_2)h_1(p_1)dp_2dp_1. \qquad (21)
\end{aligned}$$

We analyze the efficiency of the governments' tax policies by deriving tax externalities, i.e. the influence of one country's corporate tax rate on the other country's tax revenues. Differentiating T_i with respect to t_j ($i \neq j$), Appendix A.3 shows that the tax

[17] The use of tax revenues as a welfare metric is sufficient to unravel the implications of investment effects on tax externalities. Since investment choices are interior, the investment effect of a higher tax on dividend distributions to shareholders of the MNE nullify, which follows from the application of the envelope theorem. Externalities of domestic tax policy on foreign shareholders, as analyzed in Huizinga and Nielsen (1997), are not qualitatively changed by the investment effects.

[18] We assume that the tax base of national firms is sufficiently large to ensure $t_2 > t_1$ in equilibrium.

externalities take the following form

$$
\begin{aligned}
\frac{\partial T_1}{\partial t_2} &= t_1 \int_{p_1^-}^{p_1^+} \int_{p_2^{UP}}^{p_2^+} \frac{1}{\gamma} h_2(p_2) h_1(p_1) dp_2 dp_1 \\
&+ t_1 \int_{p_1^-}^{p_1^+} \int_{p_2^0}^{p_2^{UP}} [p_2 f'(k_2) - \delta r] \frac{\partial k_2}{\partial t_2} h_2(p_2) h_1(p_1) dp_2 dp_1 \\
&+ t_1 \int_{p_1^-}^{p_1^{UN}} \int_{p_2^{PC}}^{p_2^0} [p_2 f'(k_2) - \delta r] \frac{\partial k_2}{\partial t_2} h_2(p_2) h_1(p_1) dp_2 dp_1 \\
&+ t_1 \int_{p_1^{UN}}^{p_1^+} \int_{p_2^{UN}}^{p_2^0} [p_2 f'(k_2) - \delta r] \frac{\partial k_2}{\partial t_2} h_2(p_2) h_1(p_1) dp_2 dp_1, \qquad (22) \\
\frac{\partial T_2}{\partial t_1} &= t_2 \int_{p_1^-}^{p_1^+} \int_{p_2^{UP}}^{p_2^+} \left(\frac{1}{\gamma} + [p_2 f'(k_2) - \delta r] \frac{\partial k_2}{\partial t_1} \right) h_2(p_2) h_1(p_1) dp_2 dp_1. \qquad (23)
\end{aligned}
$$

In case both affiliates are sufficiently profitable, our model replicates the well-established result of standard tax competition analyses, namely a positive tax externality. Specifically, the tax externality generated by each country is given by the tax-induced adjustment in the MNE's profit shifting behavior yielding a positive tax externality of $1/\gamma$ (first effect in (22) and (23)). In this situation, a country's tax rate has no effect on the level of capital investments.

Results, however, differ when the MNE is constrained in its profit shifting strategy. Then, a higher tax rate in one country generates investments effects and thereby influences the other country's tax revenues. Interestingly, the negative own-investment effect of a higher tax t_2 creates a tax externality for country 1 when affiliate 2 is either profit- or loss-constrained, as depicted by the terms in the second to fourth line of (22). Precisely, when the MNE is profit constrained in country 2, all profits of the affiliate in country 2 are shifted to the affiliate in country 1. Given that a higher tax rate t_2 lowers the capital stock k_2, the amount of profits is reduced as well which can be shifted into the affiliate in country 1. Hence, the tax base in country 1 is subject to a negative tax externality exerted by country 2. Similarly, if the MNE is loss constrained in country 2, a higher tax rate in country 2 lowers investment in country 2 and, hence, the respective affiliate's capacity to absorb profits from the affiliate in country 1. In turn, less profits are shifted out of country 1, leaving country 1 with a higher tax base. Thus, the overall tax externality is ambiguous in sign. It might be lower in magnitude, as compared to standard analysis, possibly negative in sign.

Besides the standard positive tax externality, the externality of country 1 on country 2's tax revenues is influenced by the cross-investment effect when affiliate 2 is sufficiently profitable implying that the MNE is unconstrained in its profit shifting behavior, c.f. (23). The cross-investment effect runs counter the standard profit shifting externality because a higher tax rate t_1 reduces capital investment in country 2 and thus the tax base in country 2.[19] Depending on the relative size of the two spill-overs, the tax externality on country 2 might become negative. Hence:

Proposition 4 *The sign of the tax externalities is ambiguous and depends on the relative sizes of the standard profit shifting and the investment externality. If the (negative) investment externality is sufficiently strong, tax competition leads to excessively high tax rates.*

Proposition 4 shows that in addition to the standard positive profit shifting externality our model gives rise to an additional, *negative* externality of profit shifting. The latter externality has been absent in the literature so far due to the assumption of unconstrained profit shifting behavior of MNEs. If the profit shifting strategy of MNEs is subject to constraints, tax effects on investment impact the tax externality and this happens in the high-tax as well as in the low-tax country. We also note that the positive transfer pricing externality operates with an unconstrained choice of the transfer price, while the investment externality influences the efficiency of tax policy when the transfer pricing choice is constrained. Thereby, the investment externality does not deduce from the transfer pricing response underlying the standard externality and is of first-order importance.

Similar to our results summarized in Proposition 1, a necessary (and mild) condition for the investment externality to arise is that the cumulative distribution function

[19] Interestingly, the constraints the profit levels in the two affiliates impose on profit shifting behavior give rise to investment effects. But the investment changes generate tax revenue consequences for country 2 just when the MNE is unconstrained in its profit shifting strategy. In this situation, inframarginal profits are shifted to country 1 and country 2 is the residual claimant of any tax revenue changes generated by investments k_2.

$H_i(p_i)$ places some positive mass on the scenarios that entail transfer pricing related investment effects which again in granted by assuming strict monotonicity of $H_i(p_i)$. A final question is whether the negative externality might overcompensate the standard positive externality. Analytically, this will be the case if the probability mass on cases that entail transfer pricing related investment effects is sufficiently high. Empirically, this might indeed be the case because the lion's share of tax avoidance is done by the very large MNEs (see, Davies et al., 2018) and the extent of profit shifting can almost entirely be explained by affiliates reporting zero taxable profits (Habu, 2017). Moreover, anecdotal evidence suggests that it is the very large MNEs which can reduce their effective tax payments in high-tax countries close to zero (Levin and McCain, 2013). This suggests that the negative investment externality might indeed overcompensate the standard positive externality. Our analytical results can be related to Becker and Riedel (2011) who show that investment effects compensate a substantial fraction of the standard positive externality. Although their analysis abstracts from bunching of reported profits of affiliates and, instead, attributes the cross-border tax effect on investment to a common input like patents, our results are in line with their empirical finding and complement their analysis.

5 Discussion

Ex-ante transfer pricing In analyzing the role of transfer pricing for corporate investment incentives, we have assumed that transfer prices are set ex post, that is, after the output price (shock) has been revealed. In this set-up, the MNEs excessively report profits around zero, an implication consistent with the recent evidence on profit shifting. Moreover, the existing empirical findings suggest that MNEs have enough flexibility at their disposal to fine-tune transfer prices such that reported profits become slightly positive or negative.[20]

Against this background, the question arises whether the impact of transfer pricing on

[20] The view that MNEs have sufficient flexibility in setting transfer prices is also in line with evidence reported in Johannesen et al. (2017) where MNE affiliates in developing countries with presumably less tax enforcement capacity bunch to a greater extent around zero reported profit levels.

the MNE's investment behavior vanishes when the MNE losses its flexibility in setting transfer prices ex post. Thus, in the following we take the opposite view and derive the implications for MNE behavior when the MNE has to choose the transfer price ex ante, that is, before output prices are realized. In this situation, the MNE bases its optimal transfer pricing strategy on the expected price levels $\hat{p}_1$ and $\hat{p}_2$. The major difference compared to the ex-post transfer pricing analysis becomes manifest in the fact that the MNE now anticipates (in expectation) in which of the five different scenarios it will end up (cf. footnote 10). Thus, the MNE maximizes a simplified version of equation (16) where profits in only one specific scenario are maximized. For example, when the expected price level in country 2 is such that $p_2^0 < \hat{p}_2 < p_2^{UP}$, the MNE maximizes Π^0. Thus, with ex-ante transfer pricing, our finding that capital investments are affected by profit shifting, when the MNE is constrained in its tax-planning strategies, remains valid. However, one difference emerges compared to the previous analysis. Provided the MNE is profit constrained (either in country 1 or 2), the possibility of profit shifting definitely results in over-investment in the country where the constraint is binding.

To see whether the tax externality is affected by the modified timing of the profit shifting choice, we first consider the scenario in which the affiliate in country 2 is highly profitable and transfer prices are set ex ante. Under these conditions, the MNE is unconstrained in its profit shifting strategy and capital investments in each of the two countries are not affected by the tax rate of the other country. Thus, the tax externality comprises only the standard profit shifting effect and is given by

$$\frac{\partial T_i}{\partial t_j} = \frac{t_i}{\gamma} > 0. \tag{24}$$

Turning to the remaining scenarios in which the affiliate in country 2 has only a low profitability or even incurs losses, a change in country 1's tax rate may affect capital investment in country 2. This has, however, no impact on the tax revenues of country 2 because the tax base of affiliate 2 is always zero in each of the remaining scenarios. Contrary to that, the tax rate setting of country 2 has an effect on the tax revenues in country 1. Intuitively, the externality emerges because the tax rate t_2 affects investment in country 2 and thus the amount of profits shifted out of or into country 2, but not due to a direct effect of the tax rate t_2 on capital investment in country 1. Hence and similar to the case of ex-post profit shifting, the own-investment effect of a higher tax t_2 generates a tax externality for country 1. The spillover exists when the MNE is profit-constrained in country 2. In this situation, the MNE saves on tax payments in country 2 by shifting the marginal return on investment to country 1.

Ex-post investment choice So far, investment levels are chosen ex-ante, that is, prior to the price resolution. Empirical evidence shows that losses are quantitatively important and, in fact, might be quite persistent (Auerbach and Poterba, 1987; Dwenger and Walch, 2014). This suggests that investment choices might be made even after the profit or loss position is known to the firm. To analyze the implications of this scenario for our main findings, we modify the sequence of events and assume that the MNE determines the optimal investment levels after the realization of the affiliates' output prices, followed by the choice of the transfer price. The sequence of decision making still reflects the view that investment choices are more long term as compared to transfer pricing choices. As before, governments choose tax rates non-cooperatively prior to the realization of output prices.

Solving backwards, transfer prices continue to be given by the choices that apply in the main analysis. Different to the main analysis, the investment choice is now contingent on the scenario the MNE faces. When the MNE is unconstrained in its choice of the transfer price, the investment behavior is insulated from transfer pricing. Investments become sensitive to transfer pricing only when the transfer pricing choice is constrained by insufficiently low profits or losses. As depicted by the constrained transfer prices in (6), (14), and (15), transfer prices depend on investment levels. Higher investment levels relax the associated constraints and introduce a tendency to over-invest, as in the main analysis with an ex-ante choice of investment.[21] Possibly surprisingly, even though transfer pricing promotes investments, the related investment effects do not give rise to inefficiencies in tax policy choices. For instance, when the MNE has two profitable affiliates, but is profit constrained in the high-tax country 2, investments k_2 depend on the tax rate in country 1 due to transfer pricing, c.f. (6). The investment

[21] For simplicity, we continue to assume that $p_i f'(k_i) - \delta r > 0$.

effect does not generate a tax externality of t_1 on tax revenues in country 2 since the latter are zero as a result of profit shifting. Similarly, losses in country 2 imply that the MNE might be profit constrained in country 1 or loss constrained in country 2. In the former case, the transfer price (14) depends on k_1 but taxes do not influence investment policy because all profits end up in the loss-making affiliate facing a zero effective tax rate. Tax externalities do not arise. In the latter case, it is k_2 that influences the transfer price (15). The dependence has no tax implications since k_2 is independent of taxes and is not a source of tax spill-overs. As such, with an ex-post choice of investments, transfer pricing has investment effects and these are possibly mediated by taxes, but the effects are neutral for welfare as proxied by tax revenues.[22]

Asymmetric concealment cost The use of losses for tax savings may imply unexpected directions in which transfer payments are channeled. In particular, profits may flow to loss-making affiliates in otherwise high-tax countries, which are not susceptible of being the host country of transfer income and hence 'inflated' reported profits. Moreover, the fiscal authorities in low-tax countries, from where the profit flows may originate, presumably do not place much monitoring effort on transfer payment of domestic affiliates to these otherwise high-tax countries. Therefore, MNEs may face only low cost for preparing the documents which justify the transfer payments and for restructuring the intra-firm transactions to masquerade the tax-savings strategy. All this suggest that concealment costs might be asymmetric with respect to deviations from the true price and that the asymmetry implies excessive deviations from the true price in the unexpected way with severe fiscal implications. Given the formal analysis above, the concern turns out to have less validity than possibly conjectured.

Precisely, in the context of our model, the concealment cost function might take the form

$$C(g) \quad = \quad \begin{cases} \overline{\gamma} g^2/2 & \text{if } g \geq 0, \\ \underline{\gamma} g^2/2 & \text{otherwise,} \end{cases} \tag{25}$$

[22]As before, using an extended welfare metric that also includes private income of shareholders will not change the conclusion. A formal analysis is available upon request.

where $\overline{\gamma} > \underline{\gamma} > 0$. Overpricing of the internal service, $g > 0$, is more costly to the MNE as compared to tax-induced underpricing, $g < 0$. The parameter $\underline{\gamma}$ becomes relevant for MNE behavior when the affiliate in country 2 is making losses, but is unconstrained in the choice of the transfer price. In this case, (9) governs the choice of the transfer price and a lower value of γ magnifies profit shifting from the low-tax country 1 to the high-tax country 2. In all other cases, in which we observe an inverted transfer pricing, the asymmetry in concealment cost capitalizes in the firm value, but does not influence MNE behavior.[23]

6 Conclusion

This paper analyzes the incentives of MNE affiliates to bunch around zero profits and how this behavior intertwines with investment incentives resulting from profit shifting. We deviate from the traditional analyses of MNE behavior, which neither allows for bunching nor investment effects, by accounting for affiliates that are in a loss position and constrained in the choice of the transfer price. Our results highlight that profit shifting results in bunching of reported profits around zero (from above and below) and that profit shifting impacts capital investments in both the high-tax and the low-tax country, when MNEs are constrained in their profit shifting strategy. Moreover, and different to standard models of profit shifting, the existence of investment effects resulting from profit shifting alters the efficiency of governments' tax policies. In the standard model, the possibility of profit shifting only creates an incentive to lower tax rates to attract mobile profits. However, when profit shifting stimulates investments, the tax-induced investment effects create an additional negative externality, possibly leading to too high tax rates in equilibrium.

Overall, our results suggest that focussing only on the direct effect of profit shifting is insufficient to derive implications for international tax policy. Unlike existing rationales

[23]The capitalization effect occurs because the equilibrium is inherently asymmetric in nature and the equilibrium level of profit shifting will be non-zero. Of course, the described limited scope of asymmetric concealment cost to influence MNE behavior should be understood in a qualitative manner. When the price distribution is such that the scenario of an unconstrained transfer pricing choice in the presence of losses in the affiliate in country 2 gets a sufficiently high probability mass, then the quantitative implications are important.

for controlling tax-induced transfer pricing, such policies might have real implications for MNE behavior. In situations in which corporations over-invest, anti-transfer pricing policies potentially curb the over-investment tendency, thereby promoting welfare above and beyond the direct tax revenue effects profit shifting has. However, the paper likewise shows that not all policy measures that are frequently discussed in public debate are appropriate in this context. For instance, policies that aim at changing the concealment cost of MNEs due to stricter documentation requirements or tax auditing, which are part of the OECD strategy to curb profit shifting (OECD, 2010), might be ineffective in changing MNE behavior. Different to standard analysis, higher concealment cost do not affect transfer pricing when the choice of the transfer price is constrained and thereby insulated from concealment cost changes. In contrast, policies such as formula apportionment, which is applied, e.g., in the U.S. and recurrently discussed in the European Union, are still effective in curbing transfer pricing. The policy nets out financial flows between affiliates of a MNE and the netting out applies independently of whether the transfer price choice is constrained or unconstrained. In this case, the investment effects of transfer pricing become relevant and need to be included in the assessment of such a policy. The paper provides a micro-founded underpinning for such an assessment.

A Appendix

A.1 Deriving the first-order conditions for capital investment

Differentiating (16) with respect to k_2 yields

$$\begin{aligned}
\frac{\partial E(\Pi)}{\partial k_2} &= \int_{p_1^-}^{p_1^+}\int_{p_2^{UP}}^{p_2^+}\{(1-t_2)p_2 f'(k_2) - (1-\delta t_2)r\}h_1(p_1)h_2(p_2)dp_2dp_1 \\
&+ \int_{p_1^-}^{p_1^+}\int_{p_2^0}^{p_2^{UP}}\{(1-t_1)p_2 f'(k_2) - \gamma(p_2y_2 - \delta rk_2)[p_2 f'(k_2) - \delta r] - (1-\delta t_1)r\}h_1(p_1)h_2(p_2)dp_2dp_1 \\
&+ \int_{p_1^{UN}}^{p_1^+}\int_{p_2^-}^{p_2^{UN}}\{p_2 f'(k_2) - r\}h_1(p_1)h_2(p_2)dp_2dp_1 \\
&+ \int_{p_1^-}^{p_1^{UN}}\int_{p_2^-}^{p_2^{PC}}\{p_2 f'(k_2) - r\}h_1(p_1)h_2(p_2)dp_1dp_2 \\
&+ \int_{p_1^-}^{p_1^{UN}}\int_{p_2^{PC}}^{p_2^0}\{(1-t_1)p_2 f'(k_2) - \gamma(p_2y_2 - \delta rk_2)[p_2 f'(k_2) - \delta r] - (1-\delta t_1)r\}h_1(p_1)h_2(p_2)dp_1dp_2 \\
&+ \int_{p_1^{UN}}^{p_1^+}\int_{p_2^{UN}}^{p_2^0}\{(1-t_1)p_2 f'(k_2) - \gamma(p_2y_2 - \delta rk_2)[p_2 f'(k_2) - \delta r] - (1-\delta t_1)r\}h_1(p_1)h_2(p_2)dp_1dp_2 \\
&- \int_{p_1^-}^{p_1^+}\{(1-t_2)p_2^{UP} f'(k_2) - (1-\delta t_2)r\}h_2(p_2^{UP})\frac{\partial p_2^{UP}}{\partial k_2}h_1(p_1)dp_1 \\
&+ \int_{p_1^-}^{p_1^+}\{(1-t_1)p_2^{UP} f'(k_2) - \gamma(p_2^{UP}y_2 - \delta rk_2)[p_2^{UP} f'(k_2) - \delta r] - (1-\delta t_1)r\}h_2(p_2^{UP})\frac{\partial p_2^{UP}}{\partial k_2}h_1(p_1)dp_1 \\
&- \int_{p_1^-}^{p_1^+}\{(1-t_1)p_2^0 f'(k_2) - \gamma(p_2^0y_2 - \delta rk_2)[p_2^0 f'(k_2) - \delta r] - (1-\delta t_1)r\}h_2(p_2^0)\frac{\partial p_2^0}{\partial k_2}h_1(p_1)dp_1 \\
&+ \int_{p_1^{UN}}^{p_1^+}\{p_2^{UN} f'(k_2) - r\}h_1(p_1)h_2(p_2^{UN})\frac{\partial p_2^{UN}}{\partial k_2}dp_1 \\
&+ \int_{p_1^-}^{p_1^{UN}}\{p_2^{PC} f'(k_2) - r\}h_2(p_2^{PC})\frac{\partial p_2^{PC}}{\partial k_2}h_1(p_1)dp_1 \\
&+ \int_{p_1^-}^{p_1^{UN}}\{(1-t_1)p_2^0 f'(k_2) - \gamma(p_2^0y_2 - \delta rk_2)[p_2^0 f'(k_2) - \delta r] - (1-\delta t_1)r\}h_2(p_2^0)\frac{\partial p_2^0}{\partial k_2}h_1(p_1)dp_1 \\
&- \int_{p_1^-}^{p_1^{UN}}\{(1-t_1)p_2^{PC} f'(k_2) - \gamma(p_2^{PC}y_2 - \delta rk_2)[p_2^{PC} f'(k_2) - \delta r] - (1-\delta t_1)r\}h_2(p_2^{PC})\frac{\partial p_2^{PC}}{\partial k_2}h_1(p_1)dp_1 \\
&- \int_{p_1^{UN}}^{p_1^+}\{(1-t_1)p_2^{UN} f'(k_2) - \gamma(p_2^{UN}y_2 - \delta rk_2)[p_2^{UN} f'(k_2) - \delta r] - (1-\delta t_1)r\}h_2(p_2^{UN})\frac{\partial p_2^{UN}}{\partial k_2}h_1(p_1)dp_1 \\
&+ \int_{p_1^{UN}}^{p_1^+}\{(1-t_1)p_2^0 f'(k_2) - \gamma(p_2^0y_2 - \delta rk_2)[p_2^0 f'(k_2) - \delta r] - (1-\delta t_1)r\}h_2(p_2^0)\frac{\partial p_2^0}{\partial k_2}h_1(p_1)dp_1 = 0
\end{aligned} \tag{A.1}$$

Rearranging the terms containing single integrals yields

$$\frac{\partial E(\Pi)}{\partial k_2} = \int_{p_1^-}^{p_1^+}\int_{p_2^{UP}}^{p_2^+}\{(1-t_2)p_2f'(k_2)-(1-\delta t_2)r\}h_1(p_1)h_2(p_2)dp_2dp_1$$

$$+ \int_{p_1^-}^{p_1^+}\int_{p_2^0}^{p_2^{UP}}\{(1-t_1)p_2f'(k_2)-\gamma(p_2y_2-\delta rk_2)[p_2f'(k_2)-\delta r]-(1-\delta t_1)r\}h_1(p_1)h_2(p_2)dp_2dp_1$$

$$+ \int_{p_1^{UN}}^{p_1^+}\int_{p_2^-}^{p_2^{UN}}\{p_2f'(k_2)-r\}h_1(p_1)h_2(p_2)dp_2dp_1$$

$$+ \int_{p_1^-}^{p_1^{UN}}\int_{p_2^-}^{p_2^{PC}}\{p_2f'(k_2)-r\}h_1(p_1)h_2(p_2)dp_1dp_2$$

$$+ \int_{p_1^-}^{p_1^{UN}}\int_{p_2^{PC}}^{p_2^0}\{(1-t_1)p_2f'(k_2)-\gamma(p_2y_2-\delta rk_2)[p_2f'(k_2)-\delta r]-(1-\delta t_1)r\}h_1(p_1)h_2(p_2)dp_1dp_2$$

$$+ \int_{p_1^{UN}}^{p_1^+}\int_{p_2^{UN}}^{p_2^0}\{(1-t_1)p_2f'(k_2)-\gamma(p_2y_2-\delta rk_2)[p_2f'(k_2)-\delta r]-(1-\delta t_1)r\}h_1(p_1)h_2(p_2)dp_1dp_2$$

$$+ \int_{p_1^-}^{p_1^{UN}}\gamma[p_2^{PC}f'(k_2)-\delta r][p_2^{PC}y_2-\delta rk_2+t_1/\gamma]h_2(p_2^{PC})\frac{\partial p_2^{PC}}{\partial k_2}h_1(p_1)dp_1$$

$$- \int_{p_1^-}^{p_1^+}\gamma[p_2^{UP}f'(k_2)-\delta r][p_2^{UP}y_2-\delta rk_2-(t_2-t_1)/\gamma]h_2(p_2^{UP})\frac{\partial p_2^{UP}}{\partial k_2}h_1(p_1)dp_1$$

$$+ \int_{p_1^{UN}}^{p_1^+}\gamma[p_2^{UN}f'(k_2)-\delta r][p_2^{UN}y_2-\delta rk_2+t_1/\gamma]h_2(p_2^{UN})\frac{\partial p_2^{UN}}{\partial k_2}h_1(p_1)dp_1 = 0. \tag{A.2}$$

Because $p_2^{UP} = \frac{\delta rk_2}{y_2}+\frac{t_2-t_1}{\gamma y_2}$ and $p_2^{UN} = \frac{\delta rk_2}{y_2}-\frac{t_1}{\gamma y_2}$, the last two terms vanish. Rearranging the second to the fifth terms as if taxes at a rate t_2 have to be paid and capital costs can be deducted at this rate, we get

$$\begin{aligned}
\frac{\partial E(\Pi)}{\partial k_2} &= \int_{p_2^-}^{p_2^+} [(1-t_2)p_2 f'(k_2) - (1-\delta t_2)r] h_2(p_2) dp_2 \\
&+ \int_{p_1^{UN}}^{p_1^+}\int_{p_2^-}^{p_2^{UN}} t_2[p_2 f'(k_2) - \delta r] h_1(p_1)h_2(p_2) dp_2 dp_1 \\
&+ \int_{p_1^-}^{p_1^{UN}}\int_{p_2^-}^{p_2^{PC}} t_2[p_2 f'(k_2) - \delta r] h_1(p_1)h_2(p_2) dp_1 dp_2 \\
&+ \int_{p_1^-}^{p_1^+}\int_{p_2^0}^{p_2^{UP}} \gamma[p_2 f'(k_2) - \delta r][(t_2-t_1)/\gamma - (p_2 y_2 - \delta r k_2)] h_1(p_1)h_2(p_2) dp_2 dp_1 \\
&+ \int_{p_1^-}^{p_1^{UN}}\int_{p_2^{PC}}^{p_2^0} \gamma[p_2 f'(k_2) - \delta r][(t_2-t_1)/\gamma - (p_2 y_2 - \delta r k_2)] h_1(p_1)h_2(p_2) dp_1 dp_2 \\
&+ \int_{p_1^{UN}}^{p_1^+}\int_{p_2^{UN}}^{p_2^0} \gamma[p_2 f'(k_2) - \delta r][(t_2-t_1)/\gamma - (p_2 y_2 - \delta r k_2)] h_1(p_1)h_2(p_2) dp_1 dp_2 \\
&+ \int_{p_1^-}^{p_1^{UN}} \gamma[p_2^{PC} f'(k_2) - \delta r][p_2^{PC} y_2 - \delta r k_2 + t_1/\gamma] h_2(p_2^{PC}) \frac{\partial p_2^{PC}}{\partial k_2} h_1(p_1) dp_1 = 0. \quad \text{(A.3)}
\end{aligned}$$

Substituting $g^{UP} = (t_2 - t_1)/\gamma$ and $g^0 = p_2 y_2 - \delta r k_2$ solving the integral and rearranging the terms leads to first-order condition as given in (17)

$$\begin{aligned}
&(1-t_2)\hat{p}_2 f'(k_2) = (1-\delta t_2)r \\
&- \int_{p_1^{UN}}^{p_1^+}\int_{p_2^-}^{p_2^{UN}} t_2[p_2 f'(k_2) - \delta r] h_1(p_1)h_2(p_2) dp_2 dp_1 \\
&- \int_{p_1^-}^{p_1^{UN}}\int_{p_2^-}^{p_2^{PC}} t_2[p_2 f'(k_2) - \delta r] h_1(p_1)h_2(p_2) dp_1 dp_2 \\
&- \int_{p_1^-}^{p_1^+}\int_{p_2^0}^{p_2^{UP}} \gamma(g^{UP} - g^0)[p_2 f'(k_2) - \delta r] h_1(p_1)h_2(p_2) dp_2 dp_1 \\
&- \int_{p_1^-}^{p_1^{UN}}\int_{p_2^{PC}}^{p_2^0} \gamma(g^{UP} - g^0)[p_2 f'(k_2) - \delta r] h_1(p_1)h_2(p_2) dp_1 dp_2 \\
&- \int_{p_1^{UN}}^{p_1^+}\int_{p_2^{UN}}^{p_2^0} \gamma(g^{UP} - g^0)[p_2 f'(k_2) - \delta r] h_1(p_1)h_2(p_2) dp_1 dp_2 \\
&- \int_{p_1^-}^{p_1^{UN}} \gamma[p_2^{PC} f'(k_2) - \delta r][p_2^{PC} y_2 - \delta r k_2 + t_1/\gamma] h_2(p_2^{PC}) \frac{\partial p_2^{PC}}{\partial k_2} h_1(p_1) dp_1. \qquad \text{(A.4)}
\end{aligned}$$

Differentiating (16) with respect to k_1 yields

$$\frac{\partial E(\Pi)}{\partial k_1} = \int_{p_1^-}^{p_1^+}\int_{p_2^{UP}}^{p_2^+}[(1-t_1)p_1 f'(k_1) - (1-\delta t_1)r]h_1(p_1)h_2(p_2)dp_2dp_1$$
$$+ \int_{p_1^-}^{p_1^+}\int_{p_2^0}^{p_2^{UP}}[(1-t_1)p_1 f'(k_1) - (1-\delta t_1)r]h_1(p_1)h_2(p_2)dp_2dp_1$$
$$+ \int_{p_1^{UN}}^{p_1^+}\int_{p_2^-}^{p_2^{UN}}[(1-t_1)p_1 f'(k_1) - (1-\delta t_1)r]h_1(p_1)h_2(p_2)dp_2dp_1$$
$$+ \int_{p_1^-}^{p_1^{UN}}\int_{p_2^-}^{p_2^{PC}}\{p_1 f'(k_1) - r - \gamma(p_1 y_1 - \delta r k_1)[p_1 f'(k_1) - \delta r]\}h_1(p_1)h_2(p_2)dp_2dp_1$$
$$+ \int_{p_1^-}^{p_1^{UN}}\int_{p_2^{PC}}^{p_2^0}[(1-t_1)p_1 f'(k_1) - (1-\delta t_1)r]h_2(p_2)h_1(p_1)dp_2dp_1$$
$$+ \int_{p_1^{UN}}^{p_1^+}\int_{p_2^{UN}}^{p_2^0}[(1-t_1)p_1 f'(k_1) - (1-\delta t_1)r]h_2(p_2)h_1(p_1)dp_2dp_1$$
$$- \int_{p_2^-}^{p_2^{UN}}[(1-t_1)p_1^{UN} f'(k_1) - (1-\delta t_1)r]h_1(p_1^{UN})\frac{\partial p_1^{UN}}{\partial k_1}h_2(p_2)dp_2$$
$$+ \int_{p_2^-}^{p_2^{PC}}\{p_1^{UN} f'(k_1) - r - \gamma(p_1^{UN} y_1 - \delta r k_1)[p_1^{UN} f'(k_1) - \delta r]\}h_1(p_1^{UN})\frac{\partial p_1^{UN}}{\partial k_1}h_2(p_2)dp_2$$
$$+ \int_{p_1^-}^{p_1^{UN}}\{p_1 f'(k_1) - r - \gamma(p_1 y_1 - \delta r k_1)[p_1 f'(k_1) - \delta r]\}h_2(p_2^{PC})\frac{\partial p_2^{PC}}{\partial k_1}h_1(p_1)dp_1$$
$$+ \int_{p_2^{PC}}^{p_2^0}[(1-t_1)p_1^{UN} f'(k_1) - (1-\delta t_1)r]h_1(p_1^{UN})\frac{\partial p_1^{UN}}{\partial k_1}h_2(p_2)dp_2$$
$$- \int_{p_1^-}^{p_1^{UN}}[(1-t_1)p_1 f'(k_1) - (1-\delta t_1)r]h_2(p_2^{PC})\frac{\partial p_2^{PC}}{\partial k_1}h_1(p_1)dp_1$$
$$- \int_{p_2^{UN}}^{p_2^0}[(1-t_1)p_1^{UN} f'(k_1) - (1-\delta t_1)r]h_1(p_1^{UN})\frac{\partial p_1^{UN}}{\partial k_1}h_2(p_2)dp_2 = 0. \qquad \text{(A.5)}$$

Rearranging the terms containing single integrals, taking into account that $p_1^{UN} y_1 - \delta r k_1 - t_1/\gamma = 0$, yields

$$
\begin{aligned}
\frac{\partial E(\Pi)}{\partial k_1} &= \int_{p_1^-}^{p_1^+}\int_{p_2^{UP}}^{p_2^+}[(1-t_1)p_1 f'(k_1) - (1-\delta t_1)r]h_1(p_1)h_2(p_2)dp_2dp_1 \\
+ & \int_{p_1^-}^{p_1^+}\int_{p_2^0}^{p_2^{UP}}[(1-t_1)p_1 f'(k_1) - (1-\delta t_1)r]h_1(p_1)h_2(p_2)dp_2dp_1 \\
+ & \int_{p_1^{UN}}^{p_1^+}\int_{p_2^-}^{p_2^{UN}}[(1-t_1)p_1 f'(k_1) - (1-\delta t_1)r]h_1(p_1)h_2(p_2)dp_2dp_1 \\
+ & \int_{p_1^-}^{p_1^{UN}}\int_{p_2^-}^{p_2^{PC}}\{p_1 f'(k_1) - r - \gamma(p_1y_1 - \delta r k_1)[p_1 f'(k_1) - \delta r]\}h_1(p_1)h_2(p_2)dp_2dp_1 \\
+ & \int_{p_1^-}^{p_1^{UN}}\int_{p_2^{PC}}^{p_2^0}[(1-t_1)p_1 f'(k_1) - (1-\delta t_1)r]h_2(p_2)h_1(p_1)dp_2dp_1 \\
+ & \int_{p_1^{UN}}^{p_1^+}\int_{p_2^{UN}}^{p_2^0}[(1-t_1)p_1 f'(k_1) - (1-\delta t_1)r]h_2(p_2)h_1(p_1)dp_2dp_1 \\
- & \int_{p_1^-}^{p_1^{UN}}\gamma[p_1 f'(k_1) - \delta r][p_1y_1 - \delta r k_1 - t_1/\gamma]h_2(p_2^{PC})\frac{\partial p_2^{PC}}{\partial k_1}h_1(p_1)dp_1 = 0. \qquad \text{(A.6)}
\end{aligned}
$$

Rearranging the terms containing double integrals yields

$$
\begin{aligned}
\frac{\partial E(\Pi)}{\partial k_1} &= \int_{p_1^-}^{p_1^+}\int_{p_2^-}^{p_2^+}[(1-t_1)p_1 f'(k_1) - (1-\delta t_1)r]h_1(p_1)h_2(p_2)dp_2dp_1 \\
+ & \int_{p_1^-}^{p_1^{UN}}\int_{p_2^-}^{p_2^{PC}}\gamma[p_1 f'(k_1) - \delta r][t_1/\gamma - (p_1y_1 - \delta r k_1)]h_1(p_1)h_2(p_2)dp_2dp_1 \\
- & \int_{p_1^-}^{p_1^{UN}}\gamma[p_1 f'(k_1) - \delta r][p_1y_1 - \delta r k_1 - t_1/\gamma]h_2(p_2^{PC})\frac{\partial p_2^{PC}}{\partial k_1}h_1(p_1)dp_1 = 0. \ \text{(A.7)}
\end{aligned}
$$

Replacing $t_1/\gamma = -g^{UN}$ and $(p_1y_1 - \delta r k_1) = -g^{PC}$, solving the double integral and putting terms on the right side of the derivation delivers the first order conditions as in equation (18)

$$
\begin{aligned}
&(1-t_1)\hat{p}_1 f'(k_1) = (1-\delta t_1)r \\
&- \int_{p_1^-}^{p_1^{UN}}\int_{p_2^-}^{p_2^{PC}}\gamma[p_1 f'(k_1) - \delta r](g^{PC} - g^{UN})h_1(p_1)h_2(p_2)dp_1dp_2 \\
&- \int_{p_1^-}^{p_1^{UN}}\gamma[p_1 f'(k_1) - \delta r](g^{PC} - g^{UN})h_2(p_2^{PC})\frac{\partial p_2^{PC}}{\partial k_1}h_1(p_1)dp_1 = 0. \qquad \text{(A.8)}
\end{aligned}
$$

A.2 The effects of taxes on capital investment

From the first-order conditions of capital investment, we can derive the effects of taxes on capital investment. Applying the implicit function theorem with respect to t_j, $j = 1, 2$, on equation (17), we get

$$\frac{\partial k_2}{\partial t_j} = \frac{\phi_j}{SOC_{k_2}}, \tag{A.9}$$

where SOC_{k_2} is the second-order condition for capital investment in country 2 and is supposed to be negative for a maximum. Moreover,

$$\begin{aligned}
\phi_1 \; = & \\
+ & \int_{p_2^-}^{p_2^{UN}} t_2[p_2 f'(k_2) - \delta r] h_1(p_1^{UN}) \frac{\partial p_1^{UN}}{\partial t_1} h_2(p_2) dp_2 \\
- & \int_{p_1^{UN}}^{p_1^+} t_2[p_2^{UN} f'(k_2) - \delta r] h_2(p_2^{UN}) \frac{\partial p_2^{UN}}{\partial t_1} h_1(p_1) dp_1 \\
- & \int_{p_2^-}^{p_2^{PC}} t_2[p_2 f'(k_2) - \delta r] h_1(p_1^{UN}) \frac{\partial p_1^{UN}}{\partial t_1} h_2(p_2) dp_2 \\
- & \int_{p_1^-}^{p_1^+} \int_{p_2^0}^{p_2^{UP}} \gamma \frac{\partial g^{UP}}{\partial t_1} [p_2 f'(k_2) - \delta r] h_1(p_1) h_2(p_2) dp_2 dp_1 \\
- & \int_{p_1^-}^{p_1^+} \gamma(g^{UP} - g^0)[p_2^{UP} f'(k_2) - \delta r] h_2(p_2^{UP}) \frac{\partial p_2^{UP}}{\partial t_1} h_1(p_1) dp_1 \\
- & \int_{p_2^{PC}}^{p_2^0} \gamma(g^{UP} - g^0)[p_2 f'(k_2) - \delta r] h_1(p_1^{UN}) \frac{\partial p_1^{UN}}{\partial t_1} h_2(p_2) dp_2 \\
- & \int_{p_1^-}^{p_1^{UN}} \int_{p_2^{PC}}^{p_2^0} \gamma \frac{\partial g^{UP}}{\partial t_1} [p_2 f'(k_2) - \delta r] h_1(p_1) h_2(p_2) dp_1 dp_2 \\
+ & \int_{p_2^{UN}}^{p_2^0} \gamma(g^{UP} - g^0)[p_2 f'(k_2) - \delta r] h_1(p_1^{UN}) \frac{\partial p_1^{UN}}{\partial t_1} h_2(p_2) dp_2 \\
+ & \int_{p_1^{UN}}^{p_1^+} \gamma(g^{UP} - g^0)[p_2^{UN} f'(k_2) - \delta r] h_2(p_2^{UN}) \frac{\partial p_2^{UN}}{\partial t_1} h_1(p_1) dp_1 \\
- & \int_{p_1^{UN}}^{p_1^+} \int_{p_2^{UN}}^{p_2^0} \gamma \frac{\partial g^{UP}}{\partial t_1} [p_2 f'(k_2) - \delta r] h_1(p_1) h_2(p_2) dp_1 dp_2 \\
- & \int_{p_1^-}^{p_1^{UN}} [p_2^{PC} f'(k_2) - \delta r] h_2(p_2^{PC}) \frac{\partial p_2^{PC}}{\partial k_2} h_1(p_1) dp_1 \\
- & \gamma[p_2^{PC} f'(k_2) - \delta r][p_2^{PC} y_2 - \delta r k_2 + t_1/\gamma] h_1(p_1^{UN}) h_2(p_2^{PC}) \frac{\partial p_2^{PC}}{\partial k_2} \frac{\partial p_1^{UN}}{\partial t_1}
\end{aligned} \tag{A.10}$$

In general ϕ_1 has an ambiguous sign. However, for the specific case of a uniform distribution with a large support, i.e. $(p_i^+ - p_i^-)$ is large, the density at a specific point is small so that

$$\begin{aligned}\phi_1 &= -\int_{p_1^-}^{p_1^+}\int_{p_2^0}^{p_2^{UP}} \gamma\frac{\partial g^{UP}}{\partial t_1}[p_2 f'(k_2) - \delta r]h_1(p_1)h_2(p_2)dp_2dp_1 \\ &- \int_{p_1^-}^{p_1^{UN}}\int_{p_2^{PC}}^{p_2^0} \gamma\frac{\partial g^{UP}}{\partial t_1}[p_2 f'(k_2) - \delta r]h_1(p_1)h_2(p_2)dp_1dp_2 \\ &- \int_{p_1^{UN}}^{p_1^+}\int_{p_2^{UN}}^{p_2^0} \gamma\frac{\partial g^{UP}}{\partial t_1}[p_2 f'(k_2) - \delta r]h_1(p_1)h_2(p_2)dp_1dp_2 > 0. \qquad (A.11)\end{aligned}$$

Because we assume δ to be not too high, the term $p_2 f'(k_2) - \delta r$ is larger than zero and thus $\frac{\partial k_2}{\partial t_1} < 0$.

For ϕ_2, we get

$$\begin{aligned}\phi_2 &= \int_{p_1^-}^{p_1^+}\int_{p_2^-}^{p_2^+}[p_2 f'(k_2) - \delta r]h_1(p_1)h_2(p_2)dp_1dp_2 \\ &- \int_{p_1^{UN}}^{p_1^+}\int_{p_2^-}^{p_2^{UN}}[p_2 f'(k_2) - \delta r]h_1(p_1)h_2(p_2)dp_2dp_1 \\ &- \int_{p_1^-}^{p_1^{UN}}\int_{p_2^-}^{p_2^{PC}}[p_2 f'(k_2) - \delta r]h_1(p_1)h_2(p_2)dp_1dp_2 \\ &- \int_{p_1^-}^{p_1^+}\int_{p_2^0}^{p_2^{UP}}[p_2 f'(k_2) - \delta r]h_1(p_1)h_2(p_2)dp_2dp_1 \\ &- \int_{p_1^-}^{p_1^+}\gamma(g^{UP} - g^0)[p_2^{UP} f'(k_2) - \delta r]h_2(p_2^{UP})\frac{\partial p_2^{UP}}{\partial t_2}h_1(p_1)dp_1 \\ &- \int_{p_1^-}^{p_1^{UN}}\int_{p_2^{PC}}^{p_2^0}[p_2 f'(k_2) - \delta r]h_1(p_1)h_2(p_2)dp_1dp_2 \\ &- \int_{p_1^{UN}}^{p_1^+}\int_{p_2^{UN}}^{p_2^0}[p_2 f'(k_2) - \delta r]h_1(p_1)h_2(p_2)dp_1dp_2 \qquad (A.12)\end{aligned}$$

Using again a uniform distribution such that we can neglect the fifth term, delivers after rearranging terms

$$\phi_2 = \int_{p_1^-}^{p_1^+}\int_{p_2^{UP}}^{p_2^+}[p_2 f'(k_2) - \delta r]h_1(p_1)h_2(p_2)dp_1dp_2 > 0. \qquad (A.13)$$

Again, because we assume δ is not too large, we get that $\frac{\partial k_2}{\partial t_2} < 0$.

Similarly, we can apply the implicit function theorem to the first-order condition for capital investment in country 1 to arrive at

$$\frac{\partial k_1}{\partial t_j} = \frac{\psi_j}{SOC_{k_1}}, \tag{A.14}$$

where SOC_{k_1} is the second-order condition for capital investment in country 1 and is supposed to be negative for a maximum.

The effect of the local tax rate on capital investment will be determined by ψ_1 which is given by

$$\begin{aligned}
\psi_1 &= \int_{p_1^-}^{p_1^+}\int_{p_2^-}^{p_2^+}[p_1 f'(k_1) - \delta r]h_1(p_1)h_2(p_2)dp_1dp_2 \\
&- \int_{p_2^-}^{p_2^{PC}} \gamma(g^{PC} - g^{UN})[p_1^{UN} f'(k_1) - \delta r]h_1(p_1^{UN})h_2(p_2)\frac{\partial p_1^{UN}}{\partial t_1}dp_2 \\
&- \int_{p_1^-}^{p_1^{UN}} \gamma(g^{PC} - g^{UN})[p_1 f'(k_1) - \delta r]h_1(p_1)h_2(p_2^{PC})\frac{\partial p_2^{PC}}{\partial t_1}dp_1 \\
&- \int_{p_1^-}^{p_1^{UN}}\int_{p_2^-}^{p_2^{PC}} \gamma[p_1 f'(k_1) - \delta r]\left(\frac{\partial g^{PC}}{\partial t_1} - \frac{\partial g^{UN}}{\partial t_1}\right)h_1(p_1)h_2(p_2)dp_1dp_2 \\
&- \gamma[p_1^{UN} f'(k_1) - \delta r](g^{PC} - g^{UN})h_2(p_2^{PC})\frac{\partial p_2^{PC}}{\partial k_1}h_1(p_1^{UN})\frac{\partial p_1^{UN}}{\partial t_1} \\
&- \int_{p_1^-}^{p_1^{UN}} \gamma[p_1 f'(k_1) - \delta r](g^{PC} - g^{UN})\left[\frac{\partial h_2(p_2^{PC})}{\partial p_2^{PC}}\frac{\partial p_2^{PC}}{\partial t_1}\frac{\partial p_2^{PC}}{\partial k_1} + h_2(p_2^{PC})\frac{\partial^2 p_2^{PC}}{\partial k_1 \partial t_1}\right]h_1(p_1)dp_1 \\
&- \int_{p_1^-}^{p_1^{UN}} \gamma[p_1 f'(k_1) - \delta r]\left(\frac{\partial g^{PC}}{\partial t_1} - \frac{\partial g^{UN}}{\partial t_1}\right)h_2(p_2^{PC})\frac{\partial p_2^{PC}}{\partial k_1}h_1(p_1)dp_1.
\end{aligned} \tag{A.15}$$

In general ψ_1 has an ambiguous sign. However, for the specific case of a uniform distribution with a large support and using $\frac{\partial g^{PC}}{\partial t_1} = 0$ and $\frac{\partial g^{UN}}{\partial t_1} = -1/\gamma$, we get

$$\begin{aligned}
\psi_1 &= \int_{p_1^-}^{p_1^+}\int_{p_2^-}^{p_2^+}[p_1 f'(k_1) - \delta r]h_1(p_1)h_2(p_2)dp_1dp_2 \\
&- \int_{p_1^-}^{p_1^{UN}}\int_{p_2^-}^{p_2^{PC}}[p_1 f'(k_1) - \delta r]h_1(p_1)h_2(p_2)dp_1dp_2 > 0.
\end{aligned} \tag{A.16}$$

Thus, we get that $\frac{\partial k_1}{\partial t_1} < 0$.

Moreover, because t_2 does not affect p_1^{UN}, p_2^{PC}, g^{UN} and g^{PC}, we get that

$$\frac{\partial k_1}{\partial t_2} = 0. \tag{A.17}$$

A.3 Deriving the tax externalities

In this section, we derive the tax externalities, i.e. the effect of one countries tax rate on the other countries tax revenues. To do so, we differentiate T_i with respect to $t_j, j \neq i$. Because t_2 does not affect k_1 and p_1^{UN}, the tax externality country 2 exerts on country 1 is given by

$$\begin{aligned}
\frac{\partial T_1}{\partial t_2} &= t_1 \int_{p_1^-}^{p_1^+}\int_{p_2^{UP}}^{p_2^+} \frac{1}{\gamma} h_2(p_2)h_1(p_1)dp_2dp_1 \\
&- t_1 \int_{p_1^-}^{p_1^+} \left(p_1y_1 - \delta r k_1 + \frac{t_2-t_1}{\gamma}\right) h_2(p_2^{UP})\frac{\partial p_2^{UP}}{\partial t_2} h_1(p_1)dp_1 \\
&+ t_1 \int_{p_1^-}^{p_1^+}\int_{p_2^0}^{p_2^{UP}} \left[p_2 f'(k_2) - \delta r\right] \frac{\partial k_2}{\partial t_2} h_2(p_2)h_1(p_1)dp_2dp_1 \\
&+ t_1 \int_{p_1^-}^{p_1^+} \left(p_1y_1 - \delta r k_1 + p_2^{UP}y_2 - \delta r k_2\right) h_2(p_2^{UP})\frac{\partial p_2^{UP}}{\partial t_2} h_1(p_1)dp_1 \\
&- t_1 \int_{p_1^-}^{p_1^+} \left(p_1y_1 - \delta r k_1 + p_2^0 y_2 - \delta r k_2\right) h_2(p_2^0)\frac{\partial p_2^0}{\partial t_2} h_1(p_1)dp_1 \\
&+ t_1 \int_{p_1^{UN}}^{p_1^+} \left(p_1y_1 - \delta r k_1 - \frac{t_1}{\gamma}\right) h_2(p_2^{UN})\frac{\partial p_2^{UN}}{\partial t_2} h_1(p_1)dp_1 \\
&+ t_1 \int_{p_1^-}^{p_1^{UN}}\int_{p_2^{PC}}^{p_2^0} \left[p_2 f'(k_2) - \delta r\right] \frac{\partial k_2}{\partial t_2} h_2(p_2)h_1(p_1)dp_2dp_1 \\
&+ t_1 \int_{p_1^-}^{p_1^{UN}} \left(p_1y_1 - \delta r k_1 + p_2^0 y_2 - \delta r k_2\right) h_2(p_2^0)\frac{\partial p_2^0}{\partial t_2} h_1(p_1)dp_1 \\
&- t_1 \int_{p_1^-}^{p_1^{UN}} \left(p_1y_1 - \delta r k_1 + p_2^{PC} y_2 - \delta r k_2\right) h_2(p_2^{PC})\frac{\partial p_2^{PC}}{\partial t_2} h_1(p_1)dp_1 \\
&+ t_1 \int_{p_1^{UN}}^{p_1^+}\int_{p_2^{UN}}^{p_2^0} \left[p_2 f'(k_2) - \delta r\right] \frac{\partial k_2}{\partial t_2} h_2(p_2)h_1(p_1)dp_2dp_1 \\
&+ t_1 \int_{p_1^{UN}}^{p_1^+} \left(p_1y_1 - \delta r k_1 + p_2^0 y_2 - \delta r k_2\right) h_2(p_2^0)\frac{\partial p_2^0}{\partial t_2} h_1(p_1)dp_1 \\
&- t_1 \int_{p_1^{UN}}^{p_1^+} \left(p_1y_1 - \delta r k_1 + p_2^{UN} y_2 - \delta r k_2\right) h_2(p_2^{UN})\frac{\partial p_2^{UN}}{\partial t_2} h_1(p_1)dp_1 \qquad (A.18)
\end{aligned}$$

Using the uniform distribution the tax externality simplifies to

$$\begin{aligned}\frac{\partial T_1}{\partial t_2} &= t_1 \int_{p_1^-}^{p_1^+}\int_{p_2^{UP}}^{p_2^+} \frac{1}{\gamma} h_2(p_2)h_1(p_1)dp_2dp_1 \\ &+ t_1 \int_{p_1^-}^{p_1^+}\int_{p_2^0}^{p_2^{UP}} [p_2 f'(k_2) - \delta r] \frac{\partial k_2}{\partial t_2} h_2(p_2)h_1(p_1)dp_2dp_1 \\ &+ t_1 \int_{p_1^-}^{p_1^{UN}}\int_{p_2^{PC}}^{p_2^0} [p_2 f'(k_2) - \delta r] \frac{\partial k_2}{\partial t_2} h_2(p_2)h_1(p_1)dp_2dp_1 \\ &+ t_1 \int_{p_1^{UN}}^{p_1^+}\int_{p_2^{UN}}^{p_2^0} [p_2 f'(k_2) - \delta r] \frac{\partial k_2}{\partial t_2} h_2(p_2)h_1(p_1)dp_2dp_1. \end{aligned} \tag{A.19}$$

The tax externality country 1 exerts on country 2 is given by

$$\begin{aligned}\frac{\partial T_2}{\partial t_1} &= t_2 \int_{p_1^-}^{p_1^+}\int_{p_2^{UP}}^{p_2^+} \frac{1}{\gamma} h_2(p_2)h_1(p_1)dp_2dp_1 \\ &+ t_2 \int_{p_1^-}^{p_1^+}\int_{p_2^{UP}}^{p_2^+} [p_2 f'(k_2) - \delta r] \frac{\partial k_2}{\partial t_1} h_2(p_2)h_1(p_1)dp_2dp_1 \\ &- t_2 \int_{p_1^-}^{p_1^+} \left(p_2^{UP} y_2 - \delta r k_2 - \frac{t_2 - t_1}{\gamma}\right) h_2(p_2^{UP}) \frac{\partial p_2^{UP}}{\partial t_1} h_1(p_1)dp_1. \end{aligned} \tag{A.20}$$

Using again the assumption of a uniform distribution yields

$$\frac{\partial T_2}{\partial t_1} = t_2 \int_{p_1^-}^{p_1^+}\int_{p_2^{UP}}^{p_2^+} \left(\frac{1}{\gamma} + [p_2 f'(k_2) - \delta r] \frac{\partial k_2}{\partial t_1}\right) h_2(p_2)h_1(p_1)dp_2dp_1. \tag{A.21}$$

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