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The optimal focus of transfer prices: pre-tax profitability versus tax minimization

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Abstract This paper studies transfer prices influencing managerial decisions and determining corporate taxes in a multinational firm. Common sense suggests that the transfer price decision should be made to maximize the firm's after-tax profit and thus achieve the optimal trade-off between pre-tax profitability and tax minimization. Based on a model of a decentralized firm facing asymmetric information with respect to operations, I examine why this conclusion does not hold in general. In particular, I demonstrate that a policy of negotiated transfer pricing, under which the divisions exploit their superior information but select the transfer price to maximize the firm's pre-tax profit, is the firm's optimal organizational choice if the high-tax division's productivity is high. With respect to the firm's discretion over the transfer price, I identify situations where the firm's optimal policy choice does not depend on the arm's length range and where less discretion increases the firm's profitability.

Keywords Transfer pricing · Multinational firm · Taxation · Decentralization · Management control

JEL Classification D82 · H25 · H32 · L23 · M41

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1 Introduction

Transfer prices are valuations of products and services within a firm and are widely used in managerial accounting, financial reporting, and international taxation. They serve two purposes, namely coordination and profit allocation.[1] The aim of coordination is to align delegated decisions with the goals of the divisionalized firm. The effect of coordination is a result of the fact that transfer prices determine the divisions' costs and revenues of internal trade. In terms of profit allocation, transfer prices quantify the divisions' contributions to firm-wide profits, which is important for financial reporting and the taxation and distribution of profits. This paper examines profit allocation for the purposes of international taxation.

The studies by Smith (2002b), Baldenius et al. (2004), Hyde and Choe (2005), and Shunko et al. (2014) confirm that the optimal transfer price decision in a decentralized multinational firm maximizes firm-wide profits after taxes. Therefore, it is subject to a trade-off between maximizing the firm's pre-tax profit and minimizing its taxes. This conclusion is challenged by Ernst & Young (2001, p. 6): 52 % of the responding firms compromise between "achieving management/operational objectives" and "satisfying tax requirements," whereas 21 and 26 % primarily target "management/operations" and taxes, respectively.[2] The first set of firms can be matched with firms whose transfer price decisions aim at the maximization of after-tax profits. The transfer price decisions of the second set, by contrast, seem to target pre-tax profitability and those of the third tax minimization. The question arises as to why there are firms for which transfer price decisions do not target the firm's after-tax profitability.

While tax minimization can be related with centralized firms, a first explanation for pre-tax profit maximization under decentralization is that these firms do not face differences in tax levels across their divisions. In such scenarios, the proportional taxation of divisional profits implies that the firm's pre-tax profit and after-tax profit are proportional and maximizing pre-tax profit also maximizes after-tax profit. Consequently, there is no need for tax planning in excess of tax compliance. In other words, there are no costs of introducing taxes into the optimization of transfer prices. Under differing tax levels, tax planning costs for calculating the optimal transfer price arise from the anticipation of the divisions' decisions in reaction to the transfer price and the complexity of tax laws. In the event that these costs are high relative to the resulting increase in the firm's after-tax profit, it is optimal for the firm to only maximize its pre-tax profit. This is the case if the differences in tax levels are small or there is little discretion over the transfer price.

This paper proposes, in absence of tax planning costs, a rationale for why the firm's goal of maximizing firm-wide profits after taxes is not necessarily at odds with transfer pricing decisions maximizing pre-tax profits. The keys to this result are the firm's organizational policy and information asymmetry: it may happen that the

[1] See, for example, Anthony and Govindarajan (2000, p. 201) or Tang (2002, p. 42) for the functions of (international) transfer prices and their empirical prevalence.

[2] The figures relate to those firms using the same transfer price for both management and tax purposes.

organizational policy choice maximizing the firm's after-tax profit is to delegate the transfer price decision to divisional managers whose pricing decisions are better informed but aim at the firm's pre-tax profits.

Decentralized transfer price decisions are also at the heart of the second main insight of the paper, namely that a reduction of the firm's discretion over the transfer price may be favorable for the firm if it implies a profit shift to the low-tax division. Moreover, I describe situations where the applicable arm's length range does not affect policy performance.

More precisely, the paper addresses two research questions. On the one hand, I identify and analyze organizational policies of a tax-compliant firm, under which the transfer price is set with, only with, and without regard to firm-wide taxes.[3] On the other hand, I am interested in how these policies perform from the firm's perspective. The main results are as follows.

1. As illustrated in Fig. 1, the policies are such that the higher the degree of decentralization, the greater the influence of pre-tax profit maximization on the transfer price decision (Propositions 1, 2, Lemma 3).
2. I establish the conditions of the firm's optimal policy choice in terms of the divisions' productivities and tax levels (Proposition 3, Fig. 4, Lemma 4). In particular, the policy under which the transfer price aims at maximizing the firm's pre-tax profit is optimal if (a) the high-tax division is more important for the firm's pre-tax profitability than the low-tax division and (b) the difference in tax levels is small.
3. There are situations where the firm's optimal policy choice does not depend on the degree of discretion over the transfer price (Proposition 4). Moreover, I demonstrate that arm's length ranges favoring the low-tax (high-tax) division call for the nonintegration (integration) of taxes into the transfer price decision (Proposition 5) and that the firm may benefit from less discretion (Proposition 6).

The results are derived by means of an analytical model. They are based on the three organizational policies introduced in Fig. 1. The transfer price decision and the trade decisions are delegated to the divisions under Negotiated Pransfer Pricing (NTP), whereas the firm's central office handles the transfer price decision under Administered Transfer Pricing (ATP) and all decisions under Centralized Planning (CP). The decisions of the central office aim at maximizing firm-wide profit after taxes. However, the analysis reveals that the divisions' decisions are not congruent with this goal even if performance measurement is based on divisional after-tax profits. In particular, the objective of the transfer price decision under NTP is to maximize the firm's pre-tax profit. Nevertheless, the firm may wish to increase the degree of decentralization to exploit the divisions' operational information. Consequently, the first two results are primarily the result of the trade-off between goal congruence on the one hand and the exploitation of the divisions' superior information on the other. In other words, there is no decision-maker who has both

[3] See Hyde and Choe (2005) for a model of a firm that deliberately fails to comply with the tax rules.

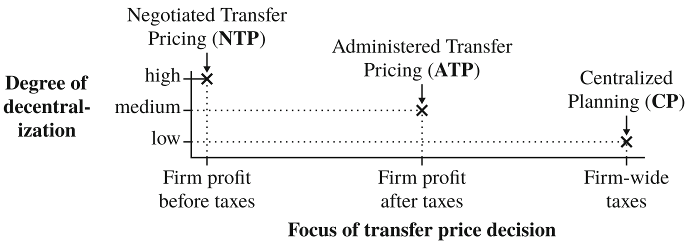

Fig. 1 Decentralization and focus of transfer price decision

the incentive to maximize firm-wide profit after taxes and the necessary information to do so. The third result relates to specific sizes and positions of the arm's length ranges and the price and quantity effects they imply under the different policies.

All results are derived under the descriptive assumption that the same transfer price is used for both coordination and taxation. This assumption of a single set of books is explained in greater detail in Sects. 2 and 6 provides a discussion of two sets of books.

Much of the literature on transfer pricing in international taxation concentrates on the effects of taxation on the decisions of centralized firms; see, for example, Horst (1971), Samuelson (1982), Sansing (1999), and Smith (2002a). This strand of literature is in line with the CP policy in this paper, which explains that the transfer price under CP is set to an extreme value from the arm's length range to minimize firm-wide taxes. The tension between maximizing pre-tax profit and minimizing taxes in setting transfer prices in decentralized firms is outlined by, among others, Elitzur and Mintz (1996), Narayanan and Smith (2000), Smith (2002b), Baldenius et al. (2004), Hyde and Choe (2005), and Shunko et al. (2014). The counterpart in this paper is the ATP policy. This policy distorts the firm's optimal pre-tax transfer price in favor of the low-tax division to save on firm-wide taxes.

Even though negotiated transfer pricing for the coordination of delegated decisions has attracted considerable attention, for example, Edlin and Reichelstein (1995), Vaysman (1998), Baldenius et al. (1999), Wielenberg (2000), Dikolli and Vaysman (2006), and Chwolka et al. (2010), tax considerations in negotiated transfer pricing have been largely neglected. Accordingly, Sansing (1999) and Smith (2002a) derive the arm's length price from negotiations between unrelated parties but do not consider decentralization and do not explain why the parties concentrate on pre-tax profits when negotiating the transfer price. By contrast, Halperin and Srinidhi (1991) find that negotiations imply the maximization of the firm's pre-tax profits, although divisional performance is measured as divisional after-tax profits. I confirm this property under more rigorous assumptions on negotiations when analyzing the NTP policy (Proposition 1). Prima facie, this contradicts the analysis of Johnson (2006), stating that the negotiated transfer price maximizes the firm's after-tax profit. However, Johnson assumes more elaborate transfer prices than this paper, as there are not only two sets of books but also a two-step internal transfer price.

The asymmetric information framework in this paper allows me to compare different organizational policies. Such comparative studies are common in the transfer pricing literature neglecting taxation; see Baldenius et al. (1999), Baldenius

(2000), and Pfeiffer et al. (2011). In this strand of literature, a policy's ability to incentivize divisional investments represents an essential driver of its performance. In my model, this driver is eliminated to place greater emphasis on tax considerations. In particular, differential taxation becomes a necessary rather than just an additional driver of the optimal policy choice.

Corresponding studies in international taxation are scarce. Johnson (2006) primarily extends the above literature by concentrating on intangible investments and allowing for differing tax levels. In contrast to my paper, Johnson concentrates on transfer pricing schemes, does not model information asymmetry between the central office and the divisions, and introduces goal congruence into divisional decision-making via a second set of books. Narayanan and Smith (2000), Nielsen et al. (2008), and Dürr and Göx (2011) analyze transfer prices as strategic commitment devices in oligopolistic markets. Although this is a different approach to explaining organizational design, Narayanan and Smith also find that the firm does not benefit from decentralization unless tax rates differ, and Nielsen et al. also demonstrate that centralization is more profitable when tax differentials are large. Dürr and Göex show that there are situations where it is not optimal to decouple transfer prices for internal and external purposes. This result supports my assumption of a single set of books.

Finally, Smith (2002a) finds that increasing the degree of discretion in setting transfer prices may mitigate investment distortions in multinational firms. This finding resembles my conclusion that reducing the degree of discretion can exert a favorable effect on firm profitability. However, Smith refers to centralized firms, takes the perspective of the tax jurisdictions, and discusses the welfare effects informally. I take the firm's perspective and formally establish the positive effect on firm-wide profits under decentralization.

The next section describes the model. The transfer price and trade decisions are derived in Sect. 3. Section 4 compares the policies, and Sect. 5 extends the analysis with respect to the arm's length range. The focus of the analysis is on decentralization, that is, NTP and ATP. The discussion of CP can be found in "Appendix 2", preceded by the benchmark case in "Appendix 1". The proofs of Propositions 1–4 and the first part of Lemma 1 can be found in "Appendix 3". The remaining proofs are integrated into the text; the proof of Lemma 3 is omitted due to the analogy to Lemma 2.

2 Model description

The model presented here forms the common basis of the following analysis, with one exception: the arm's length range specified by expression (1) only applies to Sects. 3 and 4, whereas Sect. 5 refers to a more general range.

2.1 Economic setting

There are two vertically integrated divisions of a multinational firm. The upstream division U produces an intermediate product and sells it either to the downstream division D at transfer price p or on an external market at price k. Division D purchases the intermediate product either from U at price p or on the external market at price k, finishes it, and sells the final product on an external market at a given sales price.

The firm may invest in reducing variable costs. Following Williamson (1985), this investment is specific to intra-firm trade. Hence, the cost reduction only comes into effect if the intermediate product is produced by U and delivered to D. An example of such an investment is the implementation of information technology designed to improve supply chain management, such as that deployed by Wal-Mart and Amazon.com (Chiles and Dau 2005). Other examples are the redesign of products to better match the divisions' production processes or the redesign of production processes to better match the traded products. The investment leaves the production capacity unchanged.

The outcome of the investment is random. A successful investment decreases the firm's constant unit production costs by $(\omega_u + \omega_d)I$, whereas a failure increases them by the same amount.[4] The size of the investment is given by I, and the firm-wide cost effect can be decomposed into the cost effects $\omega_u I$ for U and $\omega_d I$ for D on the divisional level. I assume $I \geq 0, \omega_u, \omega_d \geq 0, \omega_u + \omega_d > 0$, and that variable costs are nonnegative.

The probability of a successful investment leading to a cost reduction is denoted θ. It is the realization of a random variable that is uniformly distributed over $[0, 1]$.[5] For sufficiently small cost-reduction probabilities, the expected cost reduction is negative, that is, $(2\theta - 1)(\omega_u + \omega_d)I < 0$ for $\theta < 0.5$. Refraining from internal trade avoids an expected cost increase. The necessary information to make this decision is the realized cost-reduction probability θ, which is observed by the divisions, whereas the firm's central office only knows the distribution of θ; any other information is common knowledge within the firm. Without this information asymmetry, the firm would not benefit from decentralization.

In the following, a priori expected values, that is, expectations without the knowledge of the actual cost-reduction probability, are just referred to as expectations. Accordingly, I do not emphasize that a posteriori expected values are expectations.

2.2 Tax assumptions

The transfer price allocates the firm's profit to the divisions and thereby determines the incomes taxable by the two jurisdictions involved. The commonly accepted principle to evaluate the appropriateness of a transfer price is the arm's length principle as explained in the US Code of Federal Regulations (26 CFR § 1.482-1(b)) or the OECD guidelines (2010, § I). Accordingly, a transfer price is to be accepted if unrelated parties engaging in the same transaction under the same circumstances would choose the same price.

The arm's length price is not necessarily equal to the intermediate product's market price, k, as the circumstances of internal and external trade differ due to the cost-reduction investment which is specific to internal trade. Therefore, the arm's

[4] See Keuschnigg and Devereux (2013) for a similar assumption.

[5] With a slight abuse of notation, θ is used for both the random variable and its realization.

length price depends on the characteristics of external and, in particular, internal trade as represented by k, I, ω_u, ω_d, and θ, as well as on the parties' bargaining powers. The arm's length price is thus equal to the transfer price the divisions themselves agree on, provided that they deal at arm's length; see Sansing (1999) and Smith (2002a) for an equivalent approach.

The detailed information necessary to derive the arm's length price is commonly not available to the tax authorities. Hence, the practical implementation of the arm's length principle entails a range of acceptable transfer prices. Here, this so-called arm's length range, which is stipulated in 26 CFR § 1.482-1(e) and OECD (2010, § III.A.7), is assumed to be[6]

$$[k - \omega_u I, k + \omega_d I]. \tag{1}$$

This range is selected from a modeling perspective because it is ideal for studying the firm's choice of organizational policy contingent on operations and differential taxation. It is the smallest range that does not distort the arm's length dealings of the divisions and thus implies tax neutrality. However, this range is not so wide that the firm's choice of organizational policy becomes trivial due to the predominance of profit shifting. The range is endogenous in that it depends on the characteristics of internal trade; Sansing (1999) and Smith (2002a) propose similar approaches. Other arm's length ranges are considered in Sect. 5.

The incomes of divisions U and D are taxed at rates $\tau_u \in [0, 1)$ and $\tau_d \in [0, 1)$, assuming that divisional losses are fully offset against profits from the same or other tax assessment periods. For notational convenience, the index value l denotes the low-tax and h the high-tax division, that is, $\tau_l \leq \tau_h$.

2.3 Firm organization

The central office considers three decentralization policies. Under Centralized Planning (CP), the central office retains authority over both the trade decisions and the transfer price decision. Alternatively, it introduces a profit-center organization. Under the policy of Administered Transfer Pricing (ATP), the central office only delegates the trade decisions while retaining responsibility for the transfer price decision. Under Negotiated Transfer Pricing (NTP), both decisions are delegated.[7]

The central office's policy choice represents the first step in the timeline. It is followed by the determination of the cost-reduction investment, the divisions' private observation of the cost-reduction probability θ, the choice of the transfer price p, and the trade decisions. The timeline ends with the tax declarations, the financial statements, and the distribution of divisional profits to shareholders and tax authorities. Actual costs are realized only after all decisions are made.

[6] In terms of transfer pricing methods for tax purposes as described in 26 CFR § 1.482-3 or OECD (2010, § II) the assumed range matches with the comparable uncontrolled price method, the resale price method, and the cost plus method based on budgeted costs. See Ernst & Young (2010, p. 13) for the prevalence of these methods.

[7] The case study in Cools and Slagmulder (2009) suggests that firms might eliminate price negotiations to substantiate their tax compliance efforts. Here, I assume that tax compliance has no effect on the policies.

Internal trade is valued at the same transfer price per unit for management and tax purposes.[8] Durst (2002), Baldenius et al. (2004), Hyde and Choe (2005), Johnson (2006), and Shunko et al. (2014) show that the restriction to a single set of books implies the drawback that the firm, ceteris paribus, may increase its profitability by means of a second transfer price that is only used internally for coordinating the divisions. Unrelated parties would not have such decoupled transfer prices. Hence, tax authorities may doubt that the tax transfer price complies with the arm's length principle upon discovering differing internal transfer prices.[9] Accordingly, OECD (2010, § 1.5) suggests that firms with divisions that do not deal at arm's length are vulnerable to scrutiny from the tax authorities, and Chan et al. (2006) find evidence that greater divisional autonomy is accompanied by smaller adjustments to transfer prices in the event of a tax audit. Therefore, a second set of books tends to imply higher costs for the firm as a result of tax disputes, double taxation, penalties, and reputational damage in the event of litigation. The comprehensive disclosure requirements impose additional costs on the firm for concealing a second set of books from tax authorities.[10] In light of these costs, the majority of firms seem to opt for a single set of books, all the more so as it is easier to administer and to explain to divisional management.[11] In the concluding section, I comment on two-book systems in light of the paper's results.

2.4 Profit functions

All decision-makers are assumed to be risk-neutral. Hence, the firm's and thus the central office's goal is to maximize firm-wide expected profits after taxes, whereas the divisions seek to maximize their respective divisional after-tax profits. Due to the linearity of costs and revenues, it is valid to reduce the considered trade decisions to internal trade at capacity, external trade at capacity, and no trade. Given the assumption that external trade generates nonnegative divisional profits, no trade is an obsolete alternative which allows us to capture the optimal trade decisions by means of the volume of internal trade, q. Normalizing capacities to one implies $q \in \{0, 1\}$. Similar to Wagenhofer (1994), Schiller (1999), or Chwolka et al. (2010), the binary trade decision simplifies the exposition significantly, in particular with respect to the complexity of the transfer price, the arm's length range, and the investment decision. Note that this does not mean that the relevant effect of the

[8] The model refers to a constant transfer price. With such a simple contract, the central office cannot design a truth-telling mechanism to extract the divisions' knowledge.

[9] See Czechowicz et al. (1982), Davis (1994), Granfield (1995), Durst (2002), and Cools and Slagmulder (2009) for confirmation of this argument.

[10] See 26 USC §§ 1.6038A, 1.6038C of the US Internal Revenue Code and OECD (2010) for the (statutory) disclosure requirements and the associated penalties. The PATA Transfer Pricing Documentation Package (Pacific Association of Tax Administrators 2011) is suggestive of the information regularly provided to tax authorities. During tax audits, tax authorities even request access to the firm's electronic information system and operational personnel (Ernst & Young 2010, p. 14).

[11] Czechowicz et al. (1982, p. 59) report a corresponding share of firms of 84 %, Ernst & Young (2001, p. 6) of 77 %, and Ernst & Young (2003, p. 17) of 80 %.

transfer price on the trade decision is also binary because under ATP the expected trade volume varies continuously with the transfer price.

For a given cost-reduction probability θ, the firm-wide cost reduction from internal trade amounts to $(2\theta - 1)(\omega_u + \omega_d)Iq$. At the same time, this is the firm's incremental profit before investment costs and taxes relative to external trade. In the event that the firm's profit from external trade is zero, the cost reduction equates to the firm's profit before investment costs and taxes. Accordingly, $\pi(\theta)q \equiv (2\theta - 1)(\omega_u + \omega_d)Iq$ is referred to as the firm's profit before investment costs and taxes. It is allocated to the divisions by means of the transfer price, p, entailing (incremental) divisional profits $\pi_u(\theta, p)q$ and $\pi_d(\theta, p)q$ with unit profits

$$\pi_u(\theta, p) \equiv (2\theta - 1)\omega_u I + p - k \quad \text{and} \quad \pi_d(\theta, p) \equiv (2\theta - 1)\omega_d I + k - p.$$

The first summand, $(2\theta - 1)\omega_u I$ for division U and $(2\theta - 1)\omega_d I$ for D, is the cost reduction per unit incurred by the corresponding division. The second summand, $p - k$ for U and $k - p$ for D, is the division's gain per unit from profit shifting. There is no reallocation of the cost reductions for k as the transfer price. For $p > k$, part of D's cost reduction is shifted upstream, whereas $p < k$ induces a downstream shift of U's cost reduction.

If tax rates are equal, shifting a given firm profit does not influence firm-wide taxes. Differing tax rates, by contrast, place unequal weights on the pre-tax shifting gains, meaning that taxes are affected by the transfer price on the divisional level and on the firm level. To see this, let $t(\theta, p)q$ with $t(\theta, p) \equiv \sum_{i \in \{u,d\}} \tau_i \pi_i(\theta, p)$ denote firm-wide taxes and rearrange the tax per unit as follows:

$$t(\theta, p) = \sum_{i \in \{u,d\}} \tau_i (2\theta - 1)\omega_i I - (\tau_d - \tau_u)(p - k). \tag{2}$$

The tax on firm profits can thus be interpreted as the taxes on the divisions' cost reductions less the firm's after-tax gain from profit shifting.

3 Pricing and trade decisions

In this section, I derive the choices of the transfer price and the internal trade volume under the NTP and ATP policies. The analysis moves backward and therefore first derives the trade decision for a given transfer price and then the transfer price decision.

The results in this section hold for any nonnegative level of the cost-reduction investment. But the explanations refer to positive investments, only these create the opportunity for the firm to enhance its profitability through internal trade. As investment costs are sunk, they are irrelevant for both the transfer price and the trade decision and are neglected in the decision-makers' objectives. See "Appendix 1" for the benchmark situation in which the central office makes the decisions in absence of information asymmetry and "Appendix 2" for the decisions under the CP policy.

3.1 Negotiated Transfer Pricing

The profit-center organization under NTP is based on after-tax profits, and hence each division strives to maximize its own after-tax profit,

$$(1-\tau_i)\pi_i(\theta,p)q = \left\{ \begin{array}{ll} (1-\tau_u)[(2\theta-1)\omega_u I + (p-k)]q & \text{for division U} \\ (1-\tau_d)[(2\theta-1)\omega_d I + (k-p)]q & \text{for division D} \end{array} \right\}.$$

The divisions jointly make the internal trade decision. It is denoted $q_n(\theta,p)$ and depends on the transfer price the divisions previously agreed on.[12] The divisions negotiate the transfer price cooperatively with equal bargaining power; $p_n(\theta)$ denotes the negotiated transfer price. Note that both the trade decision and the choice of the transfer price depend on the cost-reduction probability because the divisions observe its realization before negotiating.

Proposition 1 *Given Negotiated Transfer Pricing (NTP), cost-reduction probability θ and transfer price p, the divisions agree to internal trade if and only if both divisions do not suffer a loss. The trade decision then becomes*

$$q_n(\theta,p) = \left\{ \begin{array}{lll} 1 & \text{if} & p \in [k-(2\theta-1)\omega_u I, k+(2\theta-1)\omega_d I] \\ 0 & \text{otherwise} & \end{array} \right\}. \quad (3)$$

The transfer price negotiated by the divisions for $\theta \geq 0.5$,

$$p_n(\theta) = k + \frac{(2\theta-1)(\omega_d-\omega_u)I}{2},$$

maximizes the firm's pre-tax profit and implies equal pre-tax profits across the divisions.

A division's consent to internal trade follows from the comparison of its after-tax profits from internal and external trade. This translates into the conditions $\pi_u(\theta,p) \geq 0$ and $\pi_d(\theta,p) \geq 0$, both of which must be satisfied for both divisions to agree. Thus, the trade decision does not depend on the tax rates. Moreover, in the case of a cost increase, $\theta < 0.5$, at least one of the divisions incurs a loss and thus does not agree to internal trade. By contrast, for a cost reduction, $\theta > 0.5$, no division shows a loss if the transfer price does not shift more profit from one division to the other than is covered by the former division's cost reduction. For example, for transfer price $p = k-(2\theta-1)\omega_u I$, U's entire cost reduction is shifted to D, and any lower transfer price implies a loss for U. Consequently, the trade decision focuses neither on the firm's after-tax profit nor on its pre-tax profit or taxes.

The trade decision $q_n(\theta,p)$ implies that, whenever internal trade is not unfavorable for the firm on a pre-tax basis, $\theta \geq 0.5$, there is a transfer price such that the divisions agree to trade. In these cases, we must consider the bargaining problem over the transfer price, which is depicted in Fig. 2 as a parametric plot of

[12] Due to the linear setting of the model, the joint trade decision can equivalently be interpreted as bilateral negotiations or as one division setting the quantity and the other accepting or rejecting this decision. The sequence of the trade decision and the transfer price agreement does not play a role either.

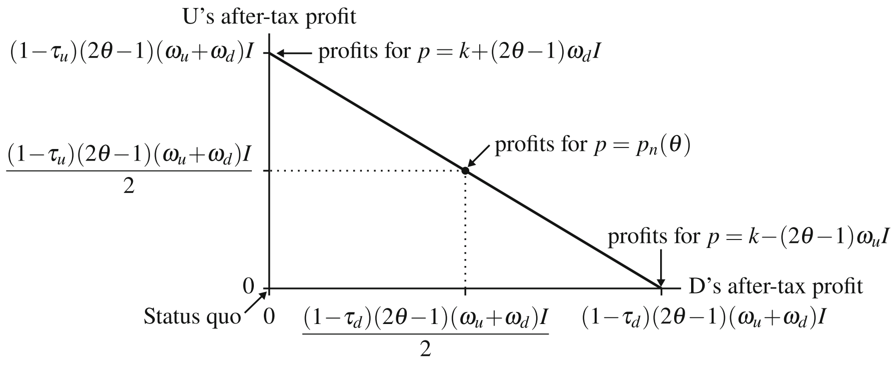

Fig. 2 Bargaining problem under NTP ($\tau_d < \tau_u$)

the divisions' after-tax profits resulting from the trade decision $q_n(\theta, p)$ and the variation of the transfer price. Both after-tax profits are zero for excessively high or low transfer prices as these preclude internal trade. By contrast, the resulting after-tax profits for intermediate transfer prices are depicted by the decreasing solid line. Negotiations are not affected by the arm's length range assumed in (1) because any transfer price for which there is internal trade is accepted, that is, $[k - (2\theta - 1)\omega_u I, k + (2\theta - 1)\omega_d I] \subseteq [k - \omega_u I, k + \omega_d I]$. The status-quo point of negotiations is zero, which corresponds to external trade.

Cooperative bargaining theory provides a unique solution to this bargaining problem, the idea of which is also illustrated by Fig. 2. The negotiated transfer price, $p_n(\theta)$, is the unique price satisfying $(1 - \tau_i)\pi_i(\theta, p) = \frac{1}{2}(1 - \tau_i)\pi(\theta)$ for both divisions, that is, both

$$(1 - \tau_u)[(2\theta - 1)\omega_u I + p_n(\theta) - k] = \frac{1}{2}(1 - \tau_u)(2\theta - 1)(\omega_u + \omega_d)I \qquad (4)$$

and

$$(1 - \tau_d)[(2\theta - 1)\omega_d I + k - p_n(\theta)] = \frac{1}{2}(1 - \tau_d)(2\theta - 1)(\omega_u + \omega_d)I \qquad (5)$$

hold. This means that the divisions agree on that transfer price for which each obtains half of its maximally feasible after-tax profit. The equality of the relative shares of the respective maximal after-tax profits is an expression of the divisions' equal bargaining power. Observe that conditions (4) and (5) do not imply equal after-tax profits across the divisions and none of the conditions is affected by the tax rates. The irrelevance of the tax rates is driven by a fundamental axiom of Nash bargaining stating that the bargaining solution, that is, the agreed payoffs, covaries with positive affine transformations of utility or, equivalently, covaries with equivalent representations of utility.

This has several consequences. First, the negotiated transfer price implies that the firm's pre-tax profit is allocated equally to the divisions. Second, the irrelevance of the tax rates for both the transfer price decision and the trade decision implies that it does not matter whether the divisional performance measures are the divisions' after-tax or pre-tax profits. Third, for any given cost-reduction probability, the divisions select a transfer price in an attempt to maximize the firm's pre-tax profit. This property would still obtain in more sophisticated economic settings than that considered here, in particular for a nonbinary quantity decision and nonlinear costs and revenues, if the transfer price included an additional lump sum payment between the divisions. It would not obtain if the firm maintained two sets of transfer prices. Fourth, whenever the firm's pre-tax profit from internal trade is nonnegative, the divisions realize this profit by agreeing on the negotiated transfer price, that is,

$$q_n[\theta, p_n(\theta)] = \begin{Bmatrix} 1 & \text{if} \quad \theta \geq 0.5 \\ 0 & \text{otherwise} \end{Bmatrix}.$$

Consequently, the firm's pre-tax profit achieves the maximally feasible level, which confirms a conclusion in Halperin and Srinidhi (1991, p. 146). Moreover, given equal tax rates, the firm's expected after-tax profit under NTP also reaches the benchmark level. To see this, realize that equal tax rates cause the firm's after-tax profit and pre-tax profit to be proportional. Thus, the firm's policy choice is trivial in absence of differential taxation.

3.2 Administered Transfer Pricing

Under ATP, the trade decisions are delegated to the divisions as under NTP, whereas the central office retains authority over the transfer price. Thus, for a given value of the transfer price p, the internal trade decision under ATP is the same as under NTP, namely $q_n(\theta, p)$ according to Proposition 1. In contrast to the trade decision, the transfer price decision under ATP does not incorporate the divisions' information. Consequently, the transfer price choice under ATP in general differs from that under NTP, leading to a distortion of the trade decision as shown below. This drawback is mitigated by the fact that the transfer price choice under ATP seeks to achieve the firm's objective of maximizing its expected profit after taxes.[13] The corresponding objective function is

$$\mathrm{E}([\pi(\theta) - t(\theta, p)]q_n(\theta, p)). \tag{6}$$

Equal tax rates imply that there is no benefit to the firm from profit shifting and the firm's pre-tax profit, its tax burden, and its after-tax profit are proportional. The optimal transfer price thus maximizes the firm's expected pre-tax profit, which makes the transfer price from the NTP policy an ideal choice. Yet, this course of action is not feasible because the NTP transfer price depends on the cost-reduction probability, which is unknown to the central office. However, the market price k is independent of the cost-reduction probability. In addition, it is an arm's length price

[13] Given internal trade, any transfer price not equal to p^* as given by (13) is inefficient because it does not minimize taxes. Therefore, one may wonder whether NTP or ATP benefit from revising or postponing the transfer price decision after the trade decision is made; see Martini (2011) for an analysis in this direction. The answer to this question is no, which is due to the adverse effect on the divisions' trade decisions.

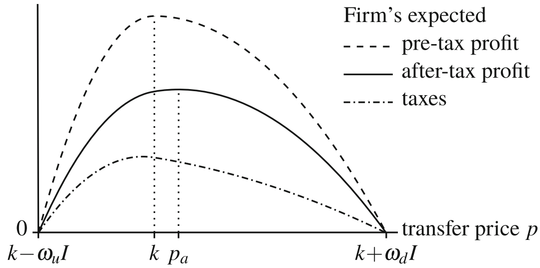

Fig. 3 Transfer price decision under ATP ($\tau_u < \tau_d, \omega_d > \omega_u > 0$)

and induces the same internal trade decision for any cost-reduction probability as the negotiated price. Thus, both ATP and NTP achieve the benchmark performance if tax rates are equal.

It is intuitive that tax rates are irrelevant to the choice of the transfer price if they are equal. For unequal tax rates, one would instead expect that, starting from k as the transfer price, it is profitable for the firm to adjust the transfer price in favor of the low-tax division. The resulting reduction of the firm's expected pre-tax profit should be overcompensated by the corresponding reduction in expected taxes. More generally, one would expect that the transfer price finds an optimal trade-off between maximizing expected pre-tax profit and minimizing expected taxes.

To be more precise about this trade-off, it is necessary to evaluate the firm's expected after-tax profit in (6):

$$\begin{aligned}&\int_{\underline{\theta}}^{1}(2\theta-1)(\omega_u+\omega_d)I-\left(\sum_{i\in\{u,d\}}\tau_i(2\theta-1)\omega_i I-(\tau_d-\tau_u)(p-k)\right)d\theta\\&=\left[\underline{\theta}(\omega_u+\omega_d)I-\left(\sum_{i\in\{u,d\}}\tau_i\underline{\theta}\omega_i I-(\tau_d-\tau_u)(p-k)\right)\right](1-\underline{\theta}).\end{aligned}\tag{7}$$

The critical cost-reduction probability $\underline{\theta}$ is defined as

$$\underline{\theta}\equiv\begin{Bmatrix}\frac{1}{2}+\frac{k-p}{2\omega_u I} & \text{if} \quad p<k\\ \frac{1}{2} & \text{if} \quad p=k\\ \frac{1}{2}+\frac{p-k}{2\omega_d I} & \text{if} \quad p>k\end{Bmatrix}.\tag{8}$$

It is derived from the divisions' internal trade decision in (3) and represents the minimal probability at which both divisions agree to internal trade at a given transfer price.

The firm's expected after-tax profit and its composition are depicted in Fig. 3 for a bilateral cost-reduction investment, that is, $\omega_u, \omega_d > 0$ and U as the low-tax division.[14] The firm's expected pre-tax profit is maximal for k as the transfer price.

[14] Figure 3 is based on the parameter setting $\omega_d/\omega_u = 2$ and $(1-\tau_d)/(1-\tau_u) = 0.824$ and thereby corresponds to scenario A from Table 1.

The more the price deviates from this value, the more the expected pre-tax profit declines, which is due to the distortion of the trade decision. This can be seen from the fact that deviating from k implies profit shifting, and hence the disadvantaged division requires a higher minimal cost-reduction probability to avoid a loss from internal trade and thus to agree to trade in the first place. The first and third case in (8) reflect this. In other words, the expected internal trade volume, $\mathrm{E}[q_n(\theta,p)] = 1-\underline{\theta}$, decreases in $|p-k|$ and reacts to even small changes in the transfer price, whereas the quantity decision $q_n(\theta,p)$ is binary. Moreover, increasing the minimal cost-reduction probability inducing internal trade, $\underline{\theta}$, raises the firm's expected pre-tax profit conditional on internal trade, $\mathrm{E}[\pi(\theta)|q_n(\theta,p)=1] = \underline{\theta}\cdot(\omega_u+\omega_d)I$. But this countervailing effect is dominated by the trade distortion.

Expected taxes amount to the expected taxes on the divisions' cost reductions, $\sum_{i\in\{u,d\}}\tau_i\underline{\theta}\omega_i I(1-\underline{\theta})$, less the firm's expected after-tax gain from profit shifting, $(\tau_d-\tau_u)(p-k)(1-\underline{\theta})$. This means that deviating from k as the transfer price has two effects on taxes. One effect is that expected taxes on the divisions' cost reductions decrease because the expected cost-reductions themselves decrease due to the trade distortion; this effect is essentially the same as for the firm's expected pre-tax profit. Yet, this cannot be the reason for deviating from maximum expected pre-tax profit, as the firm's expected cost reduction after taxes, $\sum_{i\in\{u,d\}}(1-\tau_i)\underline{\theta}\omega_i I(1-\underline{\theta})$, also suffers from the trade distortion. Therefore, the overriding force for deviating from k as the transfer price is the reduction of the firm's expected tax burden through profit shifting. For U as the low-tax division, the optimal transfer price, p_a, solves

$$(p-k)\frac{\omega_u+\omega_d}{2\omega_d^2 I} = (p-k)\frac{\tau_u\omega_u+\tau_d\omega_d}{2\omega_d^2 I} + (\tau_d-\tau_u)\left(\frac{1}{2}-\frac{p-k}{\omega_d I}\right) \tag{9}$$

and thereby equalizes the marginal reduction in the expected pre-tax profit on the left-hand side and the marginal reduction of expected taxes on the right-hand side. The following proposition provides the explicit value for the general case.

Proposition 2 *Under ATP, the transfer price is designed to maximize the firm's expected after-tax profit and is equal to*

$$p_a = k + \frac{(\tau_d-\tau_u)\omega_h^2 I}{(1-\tau_l)(\omega_u+\omega_d)+(\tau_h-\tau_l)\omega_h}. \tag{10}$$

Similar to Baldenius et al. (2004), p_a can be interpreted as a convex combination of the transfer price maximizing the firm's expected pre-tax profit, k, and the transfer price minimizing expected taxes, that is, $p = k + \omega_d I$ for U as the low-tax division and $p = k - \omega_u I$ for D as the low-tax division.

Finally, the described trade-off between pre-tax profit maximization and tax minimization degenerates if the cost reduction only affects the low-tax division, $\omega_h = 0$. In this case, there is no cost reduction to be shifted from the high-tax to the low-tax division, which is also reflected by the arm's length range that then equals

$[k - \omega_u I, k]$ for U as the low-tax division and $[k, k + \omega_d I]$ for D as the low-tax division.

4 Comparison of the policies

In this section, I compare the policies and derive the firm's optimal policy choice. See "Appendix 2" for the CP policy.

The intuition behind NTP is to allow those possessing the best information to decide, namely the divisions. The drawback is that neither the trade nor the transfer price decision aims at the firm's after-tax profit, as they do not incorporate the minimization of firm-wide taxes. Therefore, these decisions are informed but not congruent with the firm's goal.

ATP improves upon NTP in that the trade decision still uses the divisions' information, whereas the transfer price decision remains with the central office making ATP goal congruent with respect to the transfer price decision. The weakness of ATP is that the transfer price decision is not based anymore on the divisions' information.

These strengths and weaknesses imply that there is no policy that is always the firm's optimal choice. More specifically, the optimal policy choice can be put down to two ratios, the productivity ratio PR and the tax ratio TR, which I define as

$$\text{PR} \equiv \frac{\omega_h}{\omega_l} \quad \text{and} \quad \text{TR} \equiv \frac{1 - \tau_h}{1 - \tau_l}$$

with $\text{PR} \equiv \infty$ when $\omega_l = 0$. The nonnegative productivity ratio PR compares the cost reductions per unit across the divisions, that is, $(2\theta - 1)\omega_u I$ and $(2\theta - 1)\omega_d I$, or, equivalently, the productivity parameters ω_u and ω_d. The higher the value of PR, the more important the high-tax division for generating the firm's pre-tax profit relative to the low-tax division. $\text{PR} = 1$ indicates that both divisions are equally productive. The tax ratio $\text{TR} \in (0, 1]$ measures the difference in the divisions' tax levels. Tax rates are equal for $\text{TR} = 1$, and the more TR decreases, the higher the difference in the tax rates becomes.[15]

Proposition 3 *Given unequal tax rates, the firm's expected after-tax profit under NTP is higher than (equal to) that under ATP if and only if* $\text{TR} > (=) 1/\text{PR}$. *Given equal tax rates, the firm's expected after-tax profit under NTP is the same as under ATP.*

The proposition is illustrated by Fig. 4 with points A and B corresponding to the scenarios of the numerical example in Table 1.[16] The figure includes the CP policy analyzed in "Appendix 2" to confirm that NTP and ATP are optimal policies for

[15] According to OECD (2013), the tax ratio varies between 0.696 and 1.0 for the OECD member countries; see column "Combined corporate income tax rate" for 2013 in Table II.1 "Basic (non-targeted) corporate income tax rates". Concentrating on the G7 states, it varies between 0.791 and 0.967 for relations involving the United States.

[16] Numerical examples contain rounded values. The corporate tax rates in Table 1 are taken from OECD (2013).

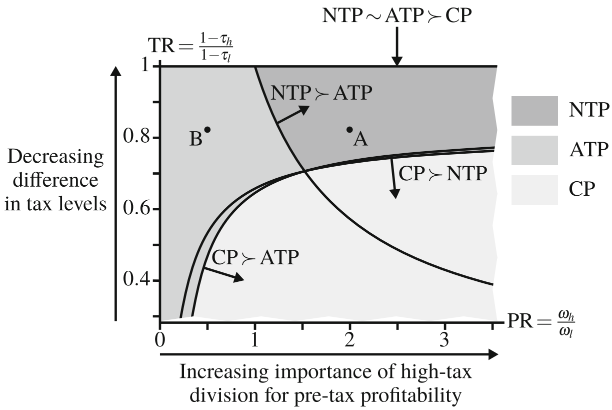

Fig. 4 Optimal policy choice

scenarios A and B or, more generally, for sufficiently small differences in the tax levels; see Lemma 4.

There are two drivers of the firm's after-tax profitability: pre-tax profitability and tax minimization through profit shifting. For small differences in the tax levels, both drivers have to be considered and the optimal choice between NTP and ATP depends on the productivity ratio PR. For example, scenario A, which is also depicted in Fig. 3, is characterized by PR $= 2$, implying that the expected cost reduction accruing in the low-tax division only amounts to half of that in the high-tax division. This entails that, before profit shifting, that is, for transfer price p equal to the market price k, two-thirds of the firm's pre-tax profit are posted by the high-tax division. This unfavorable profit allocation corresponds to the relatively high expected profit shift under ATP amounting to $9.4I$. Under NTP, the firm's pre-tax profit is allocated equally to the divisions implying an even higher profit shift to the low-tax division than under ATP, namely $12.5I$. At the same time, profit shifting under NTP does not affect the firm's pre-tax profitability, as is the case under ATP, due to the adverse effect on trade. The impairment of the firm's pre-tax profitability under ATP amounts to $0.8I$, which is the difference between the firm's expected pre-tax profit for $p = k$, $75I$, which is equal to that under NTP, and that under ATP, $74.2I$. If the central office increased the expected profit shift under ATP to the level under NTP, the firm's expected taxes would decrease by $0.7I$, but the firm's expected pre-tax profit would decrease even more, namely by $0.8I$.[17] Consequently, NTP prevails over ATP for scenario A or, more generally, when the importance of the high-tax division for the firm's pre-tax profitability is sufficiently high.

For scenario B, the divisions' productivities reverse relative to scenario A. Now, the equality of pre-tax profits under NTP implies a high profit shift in the wrong direction, namely from the more productive low-tax division to the less productive high-tax division. Moreover, the fact that, before profit shifting, two-thirds of the

[17] There are two transfer prices implying an expected profit shift of $12.5I$ under ATP. I chose the one inducing the higher expected after-tax profit.

Table 1 Numerical example

			Scenario	
			A	B
PR $= \omega_h/\omega_l$			2.0	0.5
TR $= (1-\tau_h)/(1-\tau_l)$			0.824	0.824
Firm	NTP	Exp. pre-tax profit	75.0I	75.0I
		Exp. taxes	24.5I	24.5I
		Exp. after-tax profit	50.5I	50.5I
	ATP	Exp. pre-tax profit	74.2I	74.8I
		Exp. taxes	24.6I	22.4I
		Exp. after-tax profit	49.6I	52.3I
High-tax division	Country		US	US
	Tax rate τ_h		0.391	0.391
	Productivity ω_h		200.0	100.0
	NTP	Exp. cost reduction	50.0I	25.0I
		Exp. profit shift	−12.5I	12.5I
		Exp. pre-tax profit	37.5I	37.5I
		Exp. taxes	14.7I	14.7I
		Exp. after-tax profit	22.8I	22.8I
	ATP	Exp. cost reduction	49.4I	24.9I
		Exp. profit shift	−9.4I	−2.6I
		Exp. pre-tax profit	40.1I	22.3I
		Exp. taxes	15.7I	8.7I
		Exp. after-tax profit	24.4I	13.6I
Low-tax division	Country		Canada	Canada
	Tax rate τ_l		0.261	0.261
	Productivity ω_l		100.0	200.0
	NTP	Exp. cost reduction	25.0I	50.0I
		Exp. profit shift	12.5I	−12.5I
		Exp. pre-tax profit	37.5I	37.5I
		Exp. taxes	9.8I	9.8I
		Exp. after-tax profit	27.7I	27.7I
	ATP	Exp. cost reduction	24.7I	49.8I
		Exp. profit shift	9.4I	2.6I
		Exp. pre-tax profit	34.1I	52.5I
		Exp. taxes	8.9I	13.7I
		Exp. after-tax profit	25.2I	38.7I

firm's pre-tax profit are already located in the low-tax jurisdiction makes profit shifting and the associated reduction in the firm's pre-tax profitability under ATP less pronounced. In this scenario, ATP clearly dominates NTP. More briefly, ATP outperforms NTP when the high-tax division's productivity is sufficiently low.

It is necessary to note that the policy choice of the central office is based on the firm's expected after-tax profit after investment costs. In general, this would require determining the central office's investment decisions under the different policies in anticipation of the subsequent transfer price and trade decisions from Sect. 3. Here, we may ignore the actual investment decisions because, irrespective of the policy, the firm's expected after-tax profit before investment costs is directly proportional to the investment level. More specifically, the optimal policy maximizes the firm's expected after-tax profit before investment costs either per unit of the investment or, equivalently, for a given positive investment level; both measures directly follow from Sect. 3. Essentially, this means that the ranking of the policies for a given investment level is the same as the ranking when the investment level is endogenous.

5 Other arm's length ranges and the degree of discretion

In practice, the arm's length range is typically based on observed dealings between unrelated firms engaging in transactions deemed to be sufficiently comparable to the transaction under consideration and the derivation of the range admits considerable discretion (26 CFR § 1.482-1; OECD 2010, § III.A). It is therefore not possible without further assumptions to derive the applicable arm's length range from within the model. Consequently, it is difficult to determine how the dominance relations identified in Sect. 4 change with the arm's length range in general. Nevertheless, it is possible to describe the principal effects associated with different arm's length ranges (Sect. 5.1) and to derive results concerning the absolute and relative performance of the policies (Sects. 5.2–5.4). For the CP policy, refer to "Appendix 2".

5.1 The principal effects of generalizing the arm's length range

The preceding analysis is based on the specific arm's length range given by (1), that is, $[k - \omega_u I, k + \omega_d I]$. Now, I relax this assumption and allow the arm's length range to be some interval $[\underline{p}, \overline{p}]$ of transfer prices that is not necessarily equal to or a subset of the range $[k - \omega_u I, k + \omega_d I]$.

The globally optimizing transfer price under ATP, p_a, is stated in Proposition 2. In the event that this price is not feasible because it does not lie in the arm's length range, $p_a \notin [\underline{p}, \overline{p}]$, it is optimal for the firm to choose the lowest or the highest arm's length price depending on which is nearest to p_a; see Fig. 3 for an illustration or the proof of Proposition 2. Taking $k - \omega_u I \leq \overline{p} < p_a$ as an example, the optimal transfer price is $\overline{p}$, and any decrease in it decreases after-tax profitability. The effect of the arm's length range on the performance of ATP is due to the change in the transfer price decision in combination with the implied distortion of the trade decision.

Under NTP, divisional decisions do not depend on the arm's length range if it is sufficiently wide, that is, $[\underline{p}, \overline{p}] \supseteq [k - \omega_u I, k + \omega_d I]$, as the prices in $[k - \omega_u I, k + \omega_d I]$ allow for arbitrary allocations of the firm's pre-tax profit to the divisions. Any restriction on this range, that is, $[\underline{p}, \overline{p}] \not\supseteq [k - \omega_u I, k + \omega_d I]$, involves the risk of influencing price negotiations. The effect is most evident when the negotiated transfer price from Proposition 1 is not feasible. However, even if this price remains feasible, we must acknowledge that reducing the ability of profit shifting makes utility nontransferable between the divisions. Bargaining problems with nontransferable utility (NTU) in turn entail that, in general, the bargaining solution, that is, the negotiated transfer price, depends on the specific solution concept applied by the players. Two well-known concepts are the Nash and the Kalai–Smorodinsky bargaining solutions (Nash 1950; Kalai and Smorodinsky 1975). Therefore, the effects of changing the arm's length range under NTP in general depend on the applied bargaining solution concept and are difficult to anticipate.

In addition to this price effect of the arm's length range under NTP, there is a quantity effect in the event that the arm's length range does not contain any transfer price inducing internal trade according to Proposition 1. This means that, if the arm's length range $[\underline{p}, \overline{p}]$ and the range of transfer prices inducing trade, $[k - (2\theta - 1)\omega_u I, k + (2\theta - 1)\omega_d I]$, do not overlap for a given cost-reduction probability $\theta > 0.5$, there will be no internal trade although it would be favorable for the firm.

As these conclusions hold for any given investment level, the effect on the firm's expected after-tax profit before investment costs translates into the maximal after-tax profit after investment costs. Thus, it is not necessary to consider the investment decisions explicitly here or in the rest of this section. The reasoning is the same as in Sect. 4, the only difference being that, under the generalized arm's length range, the firm's expected after-tax profit before investment costs might not be proportional in the investment level.

5.2 The irrelevance of the arm's length range

Given the discussion of the principal effects, the first step of the more detailed analysis is to identify conditions for the independence of policy performance from the arm's length range. This extends the applicability of the results from Sects. 3 and 4 to arm's length ranges other than $[k - \omega_u I, k + \omega_d I]$.

Lemma 1 *The firm's expected after-tax profit ...*

1. *... under NTP is the same as under ATP if tax rates are equal.*
2. *... under ATP is the same for any arm's length range including the transfer price p_a.*
3. *... under NTP is the same for any arm's length range including the transfer price $p_n(\theta)$ if the divisions apply the Nash bargaining solution.*

The first part speaks to the policies' relative performance and generalizes Proposition 3 by stating that the indifference between NTP and ATP holds for any arm's length range $[\underline{p}, \overline{p}]$ in absence of differential taxation. This, again, underlines that differential taxation is necessary for a nontrivial policy choice.[18]

[18] As shown in Lemma 5 in "Appendix 2", the inclusion of CP does not interfere with this conclusion.

The second property relates to the absolute performance of ATP and follows from Sect. 5.1. The idea is that the arm's length range is irrelevant if it contains the globally optimal transfer price. Refer to scenario A from Table 1 with U as the low-tax division for an example. The transfer price under ATP is $p_a = k + 21I$ for arm's length range $[k - \omega_u I, k + \omega_d I] = [k - 100I, k + 200I]$. Changing this range to any range $[\underline{p}, \overline{p}]$ containing $k + 21I$ does not influence the transfer price decision and the corresponding profits.

A similar reasoning explains the third property. The negotiated transfer price of the Nash bargaining solution maximizes the Nash product, that is, the product of the divisional pre-tax profits, $\pi_u(\theta, p) \cdot \pi_d(\theta, p)$, over the prices from the arm's length range. The Nash transfer price is that price from the arm's length range that is closest to $p_n(\theta)$ according to Proposition 1. It follows that, if $p_n(\theta)$ is feasible, there is no effect of the arm's length range on the negotiated transfer price and the corresponding profits. For instance, for scenario A from Table 1 with U as the low-tax division, the negotiated transfer price varies between $p_n(0.5) = k$ and $p_n(1) = k + 50I$ for the arm's length range $[k - \omega_u I, k + \omega_d I] = [k - 100I, k + 200I]$. Changing this range to any range covering $[k, k + 50I]$ affects neither the negotiated transfer price nor the corresponding profits.

A conclusion from the last two parts of Lemma 1 is that the firm's preference over NTP and ATP does not depend on the arm's length range if the considered ranges cover both $p_n(\theta)$ and p_a. The lemma does not apply to situations where at least one of these transfer prices is not covered. In this event, the price and quantity effects discussed in Sect. 5.1 influence policy performance. In the following proposition, I identify a class of arm's length ranges described by a triangular distribution such that the price and quantity effects induced by different arm's length ranges do not alter the relative performance of NTP and ATP.

Proposition 4 *Let the arm's length range be an interquantile range of the triangular distribution with lower limit $k - \omega_u I$, mode k, and upper limit $k + \omega_d I$ and measure the degree of the firm's discretion over the transfer price by the length of the interquantile range. Then, the firm's preference between NTP and ATP does not depend on the positive degree of discretion if the divisions apply the Nash bargaining solution.*

Before explaining the assumed arm's length range, let us take scenario A from Table 1 with U as the low-tax division as an example. The 100 % interquantile range is the arm's length range $[k - \omega_u I, k + \omega_d I] = [k - 100I, k + 200I]$ for which we know that NTP dominates ATP. Reducing discretion to the 20 % interquantile range implies the range $[k + 10.3I, k + 45.1I]$. Since this range contains $p_a = k + 21I$, the performance of ATP is unaffected. The transfer price decision under NTP, by contrast, changes from $p_n(\theta) = k + (2\theta - 1)50I$ for $\theta \geq 0.5$ to

$$p_N(\theta) = \left\{ \begin{array}{lll} k + 10.3I & \text{if} & 0.526 \leq \theta < 0.603 \\ k + 50(2\theta - 1)I & \text{if} & 0.603 \leq \theta \leq 0.951 \\ k + 45.1I & \text{if} & 0.951 < \theta \end{array} \right\}. \quad (11)$$

The unfavorable quantity effect is that there is no internal trade for $\theta < 0.526$. The price effect is twofold, as the top case in (11) implies a profit shift to the low-tax division, whereas the bottom case implies a higher profit shift to the high-tax division. In total, the change in the arm's length range reduces the firm's expected after-tax profit under NTP from 50.5I to 50.4I, which still exceeds the level under ATP.[19]

The assumed arm's length range can be motivated as follows. Let the range be derived from prices observed for uncontrolled transactions. Each transaction exhibits two unobserved characteristics, namely the value of the cost-reduction probability and the trading parties' bargaining powers. All other circumstances of the transactions are the same as under NTP or have been adjusted to be so (26 CFR § 1.482-1(d); OECD 2010, § III.A.6). In particular, differing investment levels have been adjusted to that of the firm to achieve comparability. Each pair of characteristics is the outcome of uniformly distributed and stochastically independent random variables, and the pairs are independent and identically distributed. It can be shown that the implied distribution of the price is that from Proposition 4; this is the theoretical distribution of the price. The empirical distribution is the distribution of the sample of prices actually observed. According to 26 CFR § 1.482-1(e) and OECD (2010, § 3.57) the arm's length range is an interquantile range of the empirical distribution. For a large sample, we may substitute the theoretical distribution for the empirical distribution (Glivenko–Cantelli theorem). Consequently, the arm's length range becomes the interquantile range of the above triangular distribution, and the degree of discretion is readily identified as the length of the range.

5.3 The relevance of the arm's length range

The preceding analysis identifies conditions under which the results from Sects. 3 and 4 remain valid when the arm's length range changes. Now, I deal with conditions for which the results concerning the policies' relative performance collapse. Note that the following result does without assuming a specific bargaining solution.

Proposition 5 *The firm's expected after-tax profit under NTP ...*

1. *... is the same as under ATP if the firm has no discretion over the transfer price.*
2. *... is not lower than under ATP if* $\underline{p} \geq p_a$ *for* $\tau_u < \tau_d$ *or* $\overline{p} \leq p_a$ *for* $\tau_u > \tau_d$.
3. *... is not higher than under ATP if* $\overline{p} \leq k$ *for* $\tau_u < \tau_d$ *or* $\underline{p} \geq k$ *for* $\tau_u > \tau_d$.

The first part refers to $\underline{p} = \overline{p}$. It is true because the transfer price and trade decisions under NTP and ATP coincide if the arm's length range collapses. Thus, removing discretion over the transfer price destroys any strict preference for one of these policies.

The main determinant of the second part is a price effect. A sufficiently favorable arm's length range for the low-tax division prevents the divisions under NTP from agreeing on a transfer price that is less favorable for the firm than the ATP transfer price. As an example, refer to scenario B from Table 1 with U as the low-tax

[19] According to Lemma 6 in "Appendix 2", CP does not benefit from narrowing the arm's length range. Hence, NTP also dominates CP for both considered degrees of discretion.

division. In this setting, ATP with $p_a = k + 5.5I$ is the firm's optimal policy for arm's length range $[k - \omega_u I, k + \omega_d I] = [k - 200I, k + 100I]$. Now, switch to some arm's length range $[\underline{p}, \overline{p}]$ satisfying $k + 5.5I \leq \underline{p}$. The transfer price chosen under ATP for $p_a \leq \underline{p}$ is $\underline{p}$ because it is the arm's length price nearest to p_a. By contrast, the negotiated transfer price can react to the actual cost-reduction probability θ, meaning that it is at least as high as $\underline{p}$ and implies the same trade decisions. The firm's strict preference for ATP therefore reverts into at least a weak preference for NTP. An analogous reasoning explains the third part of the proposition.

Summarizing the proposition's last two parts, one can say that NTP (ATP) prevails over ATP (NTP) if the arm's length range is sufficiently favorable for the low-tax (high-tax) division. Regarding the firm's preference for NTP or ATP from Sect. 4, we thus learn that any preference for one of the policies for arm's length range $[k - \omega_u I, k + \omega_d I]$ reverses if the new arm's length range exhibits an appropriate position.[20]

5.4 The benefit of less discretion

Common sense tells us that firms do not benefit from less discretion over the transfer price. That is, the firm's expected after-tax profit does not increase when the arm's length range $[\underline{p}, \overline{p}]$ is narrowed to a subset of it. The following proposition reveals that this is not necessarily true when the transfer price decision is decentralized.

Proposition 6 *Narrowing the arm's length range and thereby reducing the firm's discretion over the transfer price does not increase the firm's expected after-tax profit under ATP, but it may increase profitability under NTP.*

The result relating to ATP holds due to the general property that the maximum of an objective function, that is, the firm's expected after-tax profit, cannot increase if, ceteris paribus, a constraint on a decision variable, that is, the arm's length range, becomes more severe. This property does not apply to NTP as the divisions do not maximize the firm's after-tax profit.

I demonstrate the positive effect of less discretion under NTP by means of Fig. 5, which reflects scenario A from Table 1 with U as the low-tax division. We know from Fig. 4 that NTP is strictly preferred to ATP for the arm's length range $[k - \omega_u I, k + \omega_d I] = [k - 100I, k + 200I]$. The corresponding divisional pre-tax profits form the lower of the two profit lines under NTP. The dotted lines reflect that the firm's pre-tax profit and thereby the feasible combinations of divisional pre-tax profits vary with the cost-reduction probability θ. The narrower arm's length range $[k - 20I, k + 120I]$ means less discretion and restricts the divisions in dividing the firm's pre-tax profit, provided that it is higher than the level represented by the lower dotted line. This restriction would be without effect under the Nash bargaining solution. By contrast, under the Kalai–Smorodinsky bargaining solution, it leads to the upper instead of the lower of the two profit lines under NTP and thus

[20] The inclusion of CP does not make Proposition 5 obsolete as CP is not an optimal policy choice if the difference in the tax levels becomes sufficiently small. This is because the performance of CP is merely driven by profit shifting.

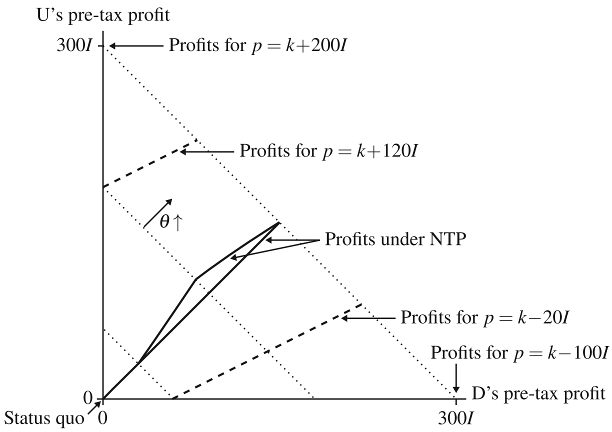

Fig. 5 Profits under NTP and ATP ($\tau_u < \tau_d$)

to more profit shifting to the low-tax division.[21] The firm's expected after-tax profit therefore increases from 50.5I to 50.8I.[22]

6 Conclusion

The analysis sheds light on the performance of organizational designs that differ in how they coordinate managerial decisions and allocate profits. The results may not only guide practitioners in choosing an appropriate transfer pricing policy, but they also contribute to the understanding of how firms react to environmental conditions, in this case, international taxation.

NTP rationalizes transfer price decisions that are tax compliant but do not target the firm's after-tax profitability. Moreover, it is the only policy that allows the firm to benefit from a reduction in the discretion over the transfer price. In fact, the firm could exploit this property to improve the performance of NTP by providing less discretion to the divisions than allowed by the tax authorities. However, such behavior conflicts with the arm's length property of the divisions' interactions, and as such it risks provoking increased scrutiny from the tax authorities; see Chan et al. (2006). Similarly, one could argue that ATP, and to an even greater extent CP, exhibits a lower degree of discretion than NTP because it deviates from the ideal of unrelated parties dealing at arm's length. The analysis suggests that such differentiated degrees of discretion will lead to NTP becoming the most, and CP the least, preferred policy.

[21] The Kalai–Smorodinsky solution goes for the Pareto-efficient profit allocation inducing equal divisional pre-tax profits relative to the divisions' maximal pre-tax profits. Accordingly, the negotiated transfer price solves $\pi_u(\theta,p)/\pi_u(\theta,\min\{\overline{p},\overline{p}_0\}) = \pi_d(\theta,p)/\pi_d(\theta,\max\{\underline{p},\underline{p}_0\})$ with $\pi_d(\theta,\overline{p}_0) = 0$ and $\pi_u(\theta,\underline{p}_0) = 0$. In this sense, the Kalai–Smorodinsky solution averages the transfer prices $\max\{\underline{p},\underline{p}_0\}$ and $\min\{\overline{p},\overline{p}_0\}$.

[22] Again, narrowing the arm's length range does not reverse the dominance of NTP over CP; see footnote 19.

In view of the simplicity of the model, there is the question of how robust the findings are. The answer refers to two aspects. First, provided a sufficiently wide arm's length range, the linearity of costs and revenues creates bargaining problems over the transfer price exhibiting transferability of utility (TU). Yet, more complex transactions between the divisions typically lead to nontransferability of utility (NTU) unless a two-step transfer pricing scheme applies, that is, there is an additional lump sum payment between the divisions; see Haake and Martini (2013). Although the NTU bargaining problems are still characterized by the irrelevance of the divisions' tax rates, the divisions generally no longer maximize the firm's pre-tax profit. For instance, under the Nash bargaining solution, the divisions maximize the product of their profits. Nevertheless, there remains a crucial analogy with the TU problems: for both types of problems, the benefit of decentralization, namely that the divisions exploit their superior information, is accompanied by the disadvantage that the divisions do not maximize the firm's after-tax profit when negotiating the transfer price. Therefore, the trade-off between the costs and benefits of decentralization remains essentially the same.

Second, although the assumption of a single set of books seems descriptive and is reflected in the exploratory studies by Cools et al. (2008) and Cools and Slagmulder (2009), it is interesting to know what changes a second set of books would bring about. As highlighted by Baldenius et al. (2004), Hyde and Choe (2005), and Shunko et al. (2014), with two sets of books, the transfer price for tax purposes is optimally set to the transfer price from the arm's length range that minimizes firm-wide taxes. This can be done without involving the divisions. The optimal internal transfer price induces operating decisions that maximize the firm's after-tax profit given the transfer price for tax purposes. It can be shown that this happens to be the case under NTP; the line of reasoning is essentially the same as that presented in the context of Proposition 1. Consequently, the firm's after-tax profit reaches the maximally feasible level, and the trade-off between goal congruence and the use of information does not occur. Yet, more sophisticated models of the divisions' dealings lead to NTU bargaining problems, and the divisions no longer maximize the firm's after-tax profit. This means that the trade-off reemerges. As explained above and exploited by Johnson (2006), this problem can be solved by means of a two-step internal transfer price.

In summary, in more involved economic settings, the trade-off between goal congruence and the use of information only disappears for two sets of books comprising a two-step internal transfer price, whereas it is similar for one-step internal transfer prices and remains unchanged for a single set of two-step transfer prices.

This paper offers fundamental insights into optimal transfer pricing and the role of discretion in the context of international taxation. Future research might investigate the optimal design of the organization and the performance measures in specific and more sophisticated settings and thereby extend existing studies such as Pfeiffer et al. (2011) to include differential taxation.

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Appendix 1: Benchmark case

The benchmark decisions maximize the firm's after-tax profit given the cost-reduction probability θ, the investment level I, and the arm's length range $[\underline{p}, \overline{p}]$. In Sects. 3 and 4, we have $[\underline{p}, \overline{p}] = [k - \omega_u I, k + \omega_d I]$; in Sect. 5, the arm's length range is some interval not necessarily equal to or a subset of $[k - \omega_u I, k + \omega_d I]$.

The decision on internal trade maximizes

$$[\pi(\theta) - t(\theta, p)]q = (2\theta - 1)(\omega_u + \omega_d)Iq - \left(\sum_{i \in \{u,d\}} \tau_i (2\theta - 1)\omega_i I - (\tau_d - \tau_u)(p - k) \right) q, \tag{12}$$

where the probability θ and the transfer price p are given and known. The expression $q^*(\theta, p)$ denotes the corresponding maximizer. The optimal transfer price p^* maximizes (12) evaluated for $q = q^*(\theta, p)$.

Lemma 2 *In the benchmark case, the decision on internal trade is*

$$q^*(\theta, p) = \left\{ \begin{array}{ll} 1 & \text{if} \quad \pi(\theta) - t(\theta, p) \geq 0 \\ 0 & \text{otherwise} \end{array} \right\}$$

and maximizes the firm's after-tax profit for a given cost-reduction probability θ and transfer price p. The transfer price choice minimizes firm-wide taxes per unit through a maximal profit shift to the low-tax division and equals

$$p^* \left\{ \begin{array}{lll} = \overline{p} & \text{if} & \tau_u < \tau_d \\ = \underline{p} & \text{if} & \tau_u > \tau_d \\ \in [\underline{p}, \overline{p}] & \text{if} & \tau_u = \tau_d \end{array} \right\}. \tag{13}$$

Internal trade is optimal for the firm if both divisions and thus the firm show a nonnegative pre-tax profit per unit. In the event that one division's pre-tax profit is positive and the other's is negative, it must be assessed whether the tax on the positive profit is offset by the firm's pre-tax profit plus the tax benefit from the negative profit. Thus, a nonnegative pre-tax profit for the firm is not necessary for the optimality of internal trade. The optimal transfer price minimizes the firm's taxes per unit, (2), by shifting the firm's pre-tax profit as much as possible to the low-tax division.

Appendix 2: Centralized Planning

In contrast to the hypothetical benchmark case, there is information asymmetry between the corporate and the divisional levels under CP, NTP, and ATP as to the cost-reduction probability θ. For CP, this is the only difference from the benchmark case.

The objective of the central office's trade decision is the firm's expected after-tax profit, that is, the expectation of (12) with respect to the random cost-reduction probability θ:

$$\mathrm{E}([\pi(\theta) - t(\theta, p)]q) = (\tau_d - \tau_u)(p - k)q. \tag{14}$$

In expectation, the firm's pre-tax profit vanishes due to the symmetric effect of the investment on production costs. In turn, this means that any expected after-tax profit is the result of profit shifting. Expression $q_c(p)$ denotes the corresponding maximizer, and the transfer price p_c maximizes (14) for $q = q_c(p)$, given the general arm's length range $[\underline{p}, \overline{p}]$.

Lemma 3 *Given Centralized Planning (CP), the decision on internal trade maximizes the firm's expected after-tax profit for a given transfer price p and is equal to*

$$q_c(p) = \begin{Bmatrix} 1 & \text{if} \quad (\tau_d - \tau_u)(p - k) \geq 0 \\ 0 & \text{otherwise} \end{Bmatrix}.$$

The transfer price choice is $p_c = p^*$ and thus minimizes firm-wide taxes per unit through a maximal profit shift to the low-tax division.

As information asymmetry is the only difference between the benchmark case and CP, the trade decision under CP is equal to the benchmark decision evaluated for the expected cost-reduction probability $\mathrm{E}(\theta) = 0.5$, that is, $q_c(p) = q^*(0.5, p)$. The link between the benchmark case and CP is even stronger with respect to the chosen transfer price, as the optimality of the benchmark transfer price p^* does not depend on the cost-reduction probability and hence also prevails under CP.

Compared to NTP and ATP, the advantage of CP is that it is congruent with the firm's goal of after-tax profit maximization with respect to both the transfer price and the trade decision. Its weakness is that it does not allow the central office to exploit the divisions' information about the cost-reduction probability θ.

Including CP in the firm's policy choice leads to an extension of Proposition 3:

Lemma 4 *Let the arm's length range $[\underline{p}, \overline{p}] = [k - \omega_u I, k + \omega_d I]$. Given unequal tax rates, the firm's expected after-tax profit ...*

1. *... under NTP is higher than (equal to) that under CP if and only if* $\mathrm{TR} > (=)\ (7\,\mathrm{PR} - 1)/(9\,\mathrm{PR} + 1)$.
2. *... under ATP is higher than (equal to) that under CP if and only if* $\mathrm{TR} > (=)\ (3 - \sqrt{2}/2 - (\sqrt{2} - 1)/(2\,\mathrm{PR})$.

Given equal tax rates, the firm's expected after-tax profit under CP does not reach the level of NTP and ATP.

The relations identified in Lemma 4 are depicted in Fig. 4 showing that the optimality of CP requires sufficiently high differences in the tax levels or, equivalently, sufficiently low values of the tax ratio TR. Tax ratios exceeding

$(3-\sqrt{2})/2 = 0.793$ even exclude CP as an optimal policy irrespective of the divisions' productivities.

In this context, it is worth noting that the tax ratio can be interpreted not only as a result of taxes but also as a result of minority shares. From the central office's perspective, both the taxes levied on the firm's shares of divisional profits and the profits distributed to minority shareholders not belonging to the firm represent charges on divisional profits. Refer to Table 1 for an example and suppose that there are minority shareholders external to the firm holding a total of 25 % of the high-tax division's shares. In conjunction with the US corporate tax rate of 39.1 %, this yields a total rate of $\tau_h = 0.25 + (1-0.25)\cdot 0.391 = 0.544$ and reduces TR from 0.824 to 0.618. Accordingly, the ranges of TR given in footnote 15 start at 0.348 and 0.395, respectively, when allowing for minority shareholders.

Returning to a general arm's length range $[\underline{p}, \overline{p}]$, we have the following addition to Lemma 1.

Lemma 5 *The firm's expected after-tax profit under CP exceeds neither that under NTP nor that under ATP if tax rates are equal.*

It is true because the performance of CP solely depends on profit shifting which becomes irrelevant if there is no differential taxation.

Finally, Proposition 6 says that ATP does not benefit from narrowing the arm's length range. This property equally applies to CP as both policies imply centralized transfer price decisions:

Lemma 6 *Narrowing the arm's length range does not increase the firm's expected after-tax profit under CP.*

Appendix 3: Proofs

Proof of Proposition 1 The proof refers to axiomatic bargaining theory, according to which any symmetric bargaining solution satisfies at least the axioms of feasibility, individual rationality, Pareto efficiency, covariance with permutations, and covariance with positive affine transformations of utility.[23] The last of these axioms allows us to concentrate on the divisions' pre-tax profits.

For $\pi(\theta) \geq 0$ or, equivalently, $\theta \geq 0.5$, the set of transfer prices inducing internal trade is $[k-(2\theta-1)\omega_u I, k+(2\theta-1)\omega_d I]$; all of these transfer prices are accepted as arm's length prices. The pairs of divisional profits corresponding to these prices are given by the set

$$\{(\pi_u(\theta,p), \pi_d(\theta,p)) : p \in [k-(2\theta-1)\omega_u I, k+(2\theta-1)\omega_d I]\}. \tag{15}$$

For any other transfer price, there is no internal trade, and profits drop to zero. Hence, the set in (15) consists of all pairs of profits, which are feasible, individually rational, and Pareto efficient.

[23] See, for example, Rosenmüller (2000, § 8) for the details.

The bargaining problem implied by (15) exhibits transferability of utility at rate 1. To see this, conclude from $\pi_u(\theta,p) + \pi_d(\theta,p) = \pi(\theta)$ that the choice of the transfer price allows the divisions to transform one unit of U's into one unit of D's pre-tax profit and vice versa. Moreover, given the range of transfer prices in (15), this transformation is feasible for any individually rational pair of pre-tax profits satisfying $\pi_u(\theta,p) + \pi_d(\theta,p) = \pi(\theta)$.

It is well known from bargaining theory that any symmetric bargaining solution satisfying the above-mentioned minimal set of axioms implies equal surpluses with respect to the players' status-quo points for both players if utility is transferable at rate 1. Because the status-quo point is zero, the negotiated transfer price, $p_n(\theta)$, is the unique solution to $\pi_u(\theta,p) = \pi_d(\theta,p)$. □

Proof of Proposition 2 The optimizer $p_a = k$ for identical tax rates is derived in the text. The same transfer price is optimal for $\tau_u \neq \tau_d$ if $I = 0$, because without the cost-reduction investment the arm's length range collapses to market price k.

For $\tau_u \neq \tau_d$ and $I > 0$, I concentrate on the case $\tau_u < \tau_d$, because the proofs for $\tau_u < \tau_d$ and $\tau_u > \tau_d$ are symmetric. The following lemma allows us to focus on the price range $[k, k + \omega_d I]$. □

Lemma 7 *The optimal transfer price under ATP, p_a, satisfies*

$$p_a \in \left\{ \begin{array}{lll} [k, k+\omega_d I] & \text{if} & \tau_u \leq \tau_d \\ [k-\omega_u I, k] & \text{if} & \tau_u \geq \tau_d \end{array} \right\}.$$

Proof The cases $\tau_u = \tau_d$ and $I = 0$ are discussed above. The proof for $\tau_u > \tau_d$ and $I > 0$ follows from that for $\tau_u < \tau_d$ and $I > 0$ by symmetry, so I concentrate on the latter case. First assume $\omega_u = 0$. Then, the arm's length range is $[k, k + \omega_d I]$, and the lemma holds. To show $p_a \geq k$ for $\omega_u > 0$, it is sufficient to verify that the firm's expected after-tax profit, (7), increases in the transfer price over $[k - \omega_u I, k]$. An inspection of the form of the profit function reveals that it can only be constant, linear, or quadratic over this range. The corresponding derivative reads

$$(k-p)\frac{\omega_u + \omega_d}{2\omega_u^2 I} - \left[(k-p)\frac{\tau_u\omega_u + \tau_d\omega_d}{2\omega_u^2 I} - (\tau_d - \tau_u)\left(\frac{1}{2} - \frac{k-p}{\omega_u I}\right)\right].$$

Consequently, the monotonicity property follows from the fact that both the derivative for $p = k - \omega_u I$, that is, $(1-\tau_d)(\omega_u + \omega_d)/(2\omega_u)$, and the derivative for $p = k$, that is, $(\tau_d - \tau_u)/2$, are positive. □

Assuming $\omega_d > 0$, an inspection of the functional form of the firm's expected after-tax profit given by (7) shows that it is quadratic and strictly concave over $[k, k + \omega_d I]$. The corresponding derivative is

$$(k-p)\frac{\omega_u + \omega_d}{2\omega_d^2 I} - \left[(k-p)\frac{\tau_u\omega_u + \tau_d\omega_d}{2\omega_d^2 I} - (\tau_d - \tau_u)\left(\frac{1}{2} - \frac{p-k}{\omega_d I}\right)\right]. \quad (16)$$

The derivative for $p = k$ is $(\tau_d - \tau_u)/2$ and thus positive, whereas the derivative for $p = k + \omega_d I$ equals $-(1-\tau_u)(\omega_u + \omega_d)/(2\omega_d)$ and is therefore negative. Hence, p_a is the unique root of (16) or, equivalently, the unique solution of (9); see (10) for the explicit value. Now assume $\omega_d = 0$. The arm's length range is then given by $[k - \omega_u I, k]$. $p_a = k$ directly follows from Lemma 7 and is also covered by (10). □

Proof of Proposition 3 and Lemma 4 The firm's expected after-tax profits under CP, NTP, and ATP read

$$(\tau_h - \tau_l)\omega_h I, \ \frac{(2 - \tau_u - \tau_d)(\omega_u + \omega_d)I}{8}, \ \text{and} \ \frac{(1 - \tau_l)^2 \omega^2 I}{4[(1 - \tau_l)(\omega_u + \omega_d) + (\tau_h - \tau_l)\omega_h]}. \tag{17}$$

Evaluating these expressions for $\tau_u = \tau_d$ reveals that the expected after-tax profits per unit of investment are identical and positive under NTP and ATP, whereas the profit under CP is zero. This implies that the central office's optimal investments and the corresponding expected after-tax profits under NTP and ATP are the same and positive. The corresponding investment and expected after-tax profit under CP are zero.

For unequal tax rates, interpret the expressions in (17) as linear functions of I and express the pairwise comparisons of their slopes in terms of PR and TR. I take the second part of Lemma 4 as an example. The firm's expected after-tax profit under ATP is higher than (equal to) that under CP if and only if

$$\left(\frac{3 + \sqrt{2}}{2} + \frac{\sqrt{2} + 1}{2\,\mathrm{PR}} - \mathrm{TR}\right)\left[\mathrm{TR} - \left(\frac{3 - \sqrt{2}}{2} - \frac{\sqrt{2} - 1}{2\,\mathrm{PR}}\right)\right] > (=)\ 0. \tag{18}$$

The factor in parentheses is positive due to $\mathrm{PR} \geq 0$ and $\mathrm{TR} \in (0, 1)$, and hence the sign of the factor in brackets determines the sign of the product. For Proposition 3, the expression corresponding to the left-hand side of (18) is $(1 - \mathrm{TR})(\mathrm{TR} - 1/\mathrm{PR})$; for the first part of Lemma 4, it is $\mathrm{TR} - (7\,\mathrm{PR} - 1)/(9\,\mathrm{PR} + 1)$. Similar to the case of equal tax rates, the dominance relations between the firm's expected after-tax profits before investment costs hold for all positive investment levels. Hence, they carry over to the firm's maximal expected after-tax profits after investment costs. □

Proof of Lemmas 1 and 5 For part 1 of Lemma 1 and for Lemma 5, realize that the firm's expected after-tax profit is nonnegative under NTP and ATP, whereas it is zero under CP for $\tau_u = \tau_d$. The equality of the profits under NTP and ATP trivially holds if no transfer price from $[k - \omega_u I, k + \omega_d I]$ is accepted or if $I = 0$ holds, because both NTP and ATP then show zero profit. For the opposite case, $\tau_u = \tau_d$ allows us to concentrate on the firm's pre-tax profit. Then, the only relevant role of the transfer price is its effect on the decentralized trade decision. Under NTP, the divisions agree on an arm's length price from $[k - (2\theta - 1)\omega_u I, k + (2\theta - 1)\omega_d I]$ for a given cost-reduction probability θ and thus maximize the firm's pre-tax profit subject to the constraint imposed by the arm's length range; confer Proposition 1. Any transfer price from this range implies the same decision on internal trade and thereby the same pre-tax profit. Under ATP, the central office induces the same trade decisions and thus the same pre-tax as well as after-tax profit as the divisions under NTP by choosing the arm's length price closest to $p_a = k$. As the relations between the firm's expected after-tax profits under CP, NTP, and ATP equally hold for all investment levels, the relations carry over to the firm's maximal expected after-tax profits after investment costs. Parts 2 and 3 of Lemma 1 follow from the discussion in the text. □

Proof of Proposition 4 The quantiles corresponding to the interquantile ranges, that is, the limits $\underline{p}$ and $\overline{p}$ of the arm's length range, are referred to as $p_{\frac{1-\delta}{2}}$ and $p_{\frac{1+\delta}{2}}$, where parameter $\delta \in [0, 1]$ reflects the degree of discretion. We shall concentrate on $I, \delta > 0$ to prevent the arm's length range from collapsing.

The case of equal tax rates is covered by part 1 of Lemma 1. The proof for unequal tax rates can be structured as follows. First, distinguish between (1) $\omega_u < \omega_d$, (2) $\omega_u = \omega_d$, and (3) $\omega_u > \omega_d$, where the third case follows from the first by symmetry. Second, divide case 1 into (a) $\mathrm{PR} > 1$ and (b) $\mathrm{PR} < 1$. Third, divide case 1.a into (i) $p_{0.5} > p_a$, (ii) $p_{0.5} = p_a$, and (iii) $p_{0.5} < p_a$. Fourth, divide case 1.a.iii into (A) $\mathrm{TR} > 1/\mathrm{PR}$, (B) $\mathrm{TR} = 1/\mathrm{PR}$, and (C) $\mathrm{TR} < 1/\mathrm{PR}$. Throughout this proof, I concentrate on cases 1.a.iii.C, 1.b, and 2, for which ATP $\succ$ NTP holds by Proposition 3. The remainder of the proof can be provided on request.

The Nash transfer price under NTP is denoted $p_N(\theta, \delta)$; it is the arm's length price closest to $p_n(\theta)$ as given in Proposition 1. Similarly, the Nash transfer price under ATP, $p_A(\delta)$, is the arm's length price closest to p_a as given in Proposition 2.

Under NTP in case 1, there are three ranges for δ. For high degrees of discretion, that is, $\delta \geq \delta_k$, negotiation outcomes are not affected according to Lemma 1, that is, $p_N(\theta, \delta) = p_n(\theta)$ for all $\theta \geq 0.5$ with δ_k solving $p_{\frac{1-\delta}{2}} = k$. For intermediate and low degrees of discretion, that is, $\delta < \delta_k$, the minimal cost-reduction probability inducing internal trade raises from 0.5 to $\theta_{1,n}(\delta)$ with $\theta_{1,n}(\delta)$ defined as the solution of $\pi_d[\theta, p_{\frac{1-\delta}{2}}] = 0$. In addition to the quantity effect, the reduction of discretion causes a price effect for success probabilities $\theta \in [\theta_{1,n}(\delta), \theta_{2,n}(\delta))$ with $\theta_{2,n}(\delta)$ defined as the solution of $p_{\frac{1-\delta}{2}} = p_n(\theta)$. In this range of the cost-reduction probability, $p_{\frac{1-\delta}{2}} > p_n(\theta)$ and thus $p_N(\theta, \delta) = p_{\frac{1-\delta}{2}}$ are true. For low degrees of discretion, that is, $\delta < \delta_1$ where δ_1 is the solution of $p_{\frac{1+\delta}{2}} = p_n(1)$, there is an additional price effect occurring for high success probabilities, that is, $\theta > \theta_{3,n}(\delta)$ where $\theta_{3,n}(\delta)$ solves $p_{\frac{1+\delta}{2}} = p_n(\theta)$. For such high cost-reduction probabilities, transfer price $p_n(\theta)$ is not feasible anymore, that is, $p_n(\theta) > p_{\frac{1+\delta}{2}}$, and thus $p_N(\theta, \delta) = p_{\frac{1+\delta}{2}}$. The relations $0 < \delta_1 < \delta_k \leq 1$ and $0.5 \leq \theta_{1,n}(\delta) < \theta_{2,n}(\delta) < \theta_{3,n}(\delta) \leq 1$ are verified easily. Consequently, the firm's expected after-tax profit for $\delta \in [\delta_1, \delta_k]$ is $\int_{\theta_{1,n}(\delta)}^{\theta_{2,n}(\delta)} \sum_{i \in \{u,d\}} (1 - \tau_i)\pi_i(\theta, p_{\frac{1-\delta}{2}}) d\theta + \int_{\theta_{2,n}(\delta)}^{1} \sum_{i \in \{u,d\}} (1 - \tau_i)\pi_i[\theta, p_n(\theta)] d\theta$. For $\delta \leq \delta_1$, the second summand of the firm's expected after-tax profit becomes $\int_{\theta_{2,n}(\delta)}^{\theta_{3,n}(\delta)} \sum_{i \in \{u,d\}} (1 - \tau_i)\pi_i[\theta, p_n(\theta)] d\theta + \int_{\theta_{3,n}(\delta)}^{1} \sum_{i \in \{u,d\}} (1 - \tau_i)\pi_i(\theta, p_{\frac{1+\delta}{2}}) d\theta$.

Under ATP in case 1.a.iii, the restrictions imposed by the arm's length range do not bear on the transfer price if discretion is high, that is, $p_A(\delta) = p_a$ for $\delta \geq \delta_a$. The threshold $\delta_a > 0$ is the lowest degree of discretion for which p_a is at arm's length and solves $p_{\frac{1+\delta}{2}} = p_a$; this is an application of Lemma 1. For low degrees of discretion, the highest arm's length price restricts the optimal transfer price choice, that is, $p_A(\delta) = p_{\frac{1+\delta}{2}}$ for $\delta \leq \delta_a$. The firm's expected after-tax profit for $\delta \leq \delta_a$ therefore amounts to $\int_{\theta_{1,a}(\delta)}^{1} \sum_{i \in \{u,d\}} (1-\tau_i)\pi_i[\theta, p_{\frac{1+\delta}{2}}]d\theta$ with $\theta_{1,a}(\delta)$ as the minimal cost-reduction probability inducing internal trade, that is, $\pi_d[\theta_{1,a}(\delta), p_{\frac{1+\delta}{2}}] = 0$.

Regarding the comparison of NTP and ATP in case 1.a.iii.C, we have ATP $\succ$ NTP for $\delta \geq \delta_k$ because $\delta_a < \delta_k$ holds in case 1.a.iii. A further reduction of discretion does not increase the firm's expected after-tax profit under ATP; see Proposition 6. Yet, according to the following lemma, profitability under NTP increases in case 1.a.iii.C until the degree of discretion falls to δ_1.

Lemma 8 *Given (1) the arm's length range defined as the interquantile range of the triangular distribution with lower limit $k - \omega_u I$, mode k, and upper limit $k + \omega_d I$, (2) NTP and the Nash bargaining solution, and (3)* TR $< 1/$PR < 1, *the firm's expected after-tax profit decreases in δ over the range $[\delta_1, \delta_k]$. The thresholds δ_1 and δ_k are defined as the solutions of $p_{\frac{1+\delta}{2}} = p_n(1)$ and $p_{\frac{1-\delta}{2}} = k$ for $\omega_u < \omega_d$ and of $p_{\frac{1-\delta}{2}} = p_n(1)$ and $p_{\frac{1+\delta}{2}} = k$ for $\omega_u > \omega_d$, respectively.*

Proof The proof focuses on case 1; case 3 follows by symmetry. The firm's expected after-tax profit for $\delta \in [\delta_1, \delta_k]$ is defined above. The sign of its derivative with respect to δ is the sign of $(1-\tau_d)/(1-\tau_u) - \omega_u/\omega_d$. For $\omega_u < \omega_d$, the sign is negative if and only if TR $< 1/$PR. □

Given these monotonicity properties, ATP $\succ$ NTP equally holds for $\delta \in [\delta_1, \delta_k]$, because the difference in the firm's expected after-tax profits under ATP and NTP is positive for $\delta = \delta_1$. The difference is still positive for $\delta \in (0, \delta_1]$ as it is zero for $\delta = 0$, see Proposition 5, and is strictly convex over $[0, \delta_1]$.

In case 1.b, D becomes the low-tax division, implying $p_a \leq k < p_{0.5}$ and $p_A(\delta) = p_{\frac{1-\delta}{2}}$ for $\delta \leq \delta_a$, where δ_a now solves $p_{\frac{1-\delta}{2}} = p_a$ and satisfies $\delta_a \geq \delta_k$. ATP $\succ$ NTP holds for $\delta \geq \delta_k$, because the firm's expected after-tax profit for transfer price $p_A(\delta)$ is not lower than for price k, see Proposition 2, which in turn is higher than for price $p_n(\theta)$. For $\delta \in (0, \delta_k]$, the minimal success probabilities inducing internal trade under ATP and NTP coincide, $p_A(\delta) = p_N(\theta, \delta)$ for $\theta \in [\theta_{1,n}(\delta), \theta_{2,n}(\delta)]$ and $p_A(\delta) < p_N(\theta, \delta)$ for $\theta \in [\theta_{2,n}(\delta), 1]$. Consequently, ATP $\succ$ NTP for $\delta \in (0, \delta_k]$, which at the same time confirms part 3 of Proposition 5.

Case 2 is a limiting case of cases 1.a.iii.C and 1.b: $p_n(\theta) = p_N(\theta, \delta) = p_{0.5} = k, p_A(\delta) = \min\{p_a, p_{\frac{1+\delta}{2}}\}$ for $\tau_u < \tau_d$, and $p_A(\delta) = \max\{p_a, p_{\frac{1-\delta}{2}}\}$ for $\tau_u > \tau_d$. Moreover, $p_A(\delta)$ is the unique maximizer of the firm's expected after-tax profit over all (constant) transfer prices from the arm's length range; see Proposition 2. ATP $\succ$ NTP then holds as $p_A(\delta) \neq k$ for $\delta > 0$.

As the relation between the firm's expected after-tax profits under NTP and ATP equally holds for all positive investment levels and no investment means no profits, the relations carry over to the firm's maximal expected after-tax profits after investment costs. □

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