Transfer Pricing for Coordination and Profit Determination: An Analysis of Alternative Schemes

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February 2005

Discussion Paper No. 534

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February 2005

Abstract. Transfer pricing is a well-known instrument in decentralized firms. We focus on the common situation of a ‘single book’ where the same transfer price is employed to coordinate divisions and to determine their profits. Assuming that a transfer price has to satisfy the arm’s length principle, we first argue that such a transfer price is either negotiated between the divisions before (ex ante) or set by headquarters after (ex post) divisional activities have been decided. Based on a model of a firm with two divisions, the paper analytically derives the corresponding divisional profits. Thereby, we account for exogenously as well as endogenously determined transfer pricing schemes. It is shown that the resulting divisional profits strongly depend on the different settings: For instance, under negotiated transfer prices, divisional profits are always Pareto efficient but substantially vary with the scheme, whereas there may occur Pareto-inefficient divisional profits that are invariant with the scheme when transfer prices are administered by headquarters. In the latter case, an advance pricing agreement may serve as an effective remedy. The results clarify the effects of alternative transfer pricing schemes and of the choice between them.

Keywords: Transfer Pricing, Coordination, Profit Determination, Arm’s Length Principle, Taxation, Financial Reporting

The author thanks Hermann Jahnke for helpful comments on an earlier version of the paper.
1 Introduction

Transfer prices are valuations of (intermediate) products within a firm or a group of firms. They constitute a common instrument of management accounting, taxation, and financial reporting. Consequently, transfer prices serve multiple functions the most important of which are coordination and profit determination.

For coordinational purposes transfer prices affect performance measures which are connected with the (nonmonetary) compensation of divisional managements in decentralized firms. In accordance with the transfer pricing literature and empirical evidence, we base our argumentation on profit-center organizations so that the above performance measures are divisional profits. Note that absolute or relative levels of divisional profits are not a condition of transfer prices having an incentive effect. It is rather individual maximization of divisional profit which—by virtue of the profit-center organization—guides divisional decisions. Nevertheless, for the purposes of profit determination transfer prices are explicitly employed to quantify a division’s ‘fair’ or ‘appropriate’ share in corporate profit. This information may be used by headquarters when evaluating divisional managements or deciding on the allocation of resources. Moreover, divisional profits are important for the purposes of taxation and financial reporting. Thus there are several stakeholders such as headquarters, divisional managements, employees, creditors, (potential) shareholders and investors, or tax authorities having a vital interest in the level of divisional profits.

As early as 1909, Schmalenbach (1909) describes these two basic functions of transfer prices and argues that both functions cannot be fully served by a single transfer price unless there is a perfect external market for the intermediate product. The tension between coordination and profit determination bases on the fact that a (single) transfer

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1 Atkinson (1987, 50) reports that 82 percent of 186 public Canadian companies use transfer prices. Accordingly, Tang (1993, 68) and Tang (2002, 32) document shares of almost 92 percent (143 Fortune-500 companies) and 88 percent (95 Fortune-1000 companies), respectively.


3 We use the term ‘division’ for units subordinated to headquarters regardless of their legal form or the (legal) basis of subordination. Accordingly, ‘headquarters’ designates central management or the management of the parent company.

4 For consolidated financial statements, transfer prices are relevant as to segment reporting and partial consolidation. The latter occurs under the parent company concept (US-GAAP). Under the entity concept (IFRS), it is found for proportionate consolidation (IAS 31) and equity method (IAS 28).
price couples both functions and ‘good’ coordination typically goes along with extreme divisional profits, vice versa. Hirshleifer (1956) provides early evidence of this conflict: In absence of a market for the intermediate product, optimal coordination is achieved by a transfer price based on marginal cost. However, in the presence of fixed costs such a transfer price causes the upstream division to incur a loss unless its cost function is sufficiently convex. Further complications arise because a) there is typically discretion over the fairness of divisional profits, b) transfer prices affect the level of corporate profit, and c) coordinative and distributional effects usually depend on the employed transfer pricing scheme.

There are mainly two approaches to ‘solve’ the conflict induced by the dual role of transfer prices: separation of functions or doing without transfer prices. For instance, two-step transfer prices where coordination is achieved by setting a price per unit, whereas a lump-sum payment adjusts the levels of divisional profits, may disentangle the functions. Besides the fact that two-step transfer prices are empirically negligible, they prove problematic with regard to the justification and coordination neutrality of the adjustment. Following the idea of two-step transfer prices, headquarters may use ‘two sets of books’ so that there is a transfer price for each of the functions. Although headquarters may benefit from such separation, there is empirical evidence that many firms adhere to one set of books. Presumably, costs of maintaining two sets of books and problems to justify their existence towards external stakeholders, especially tax authorities, contribute to this fact. Additionally, even with more than one set of books it is not possible to entirely decouple functions since from headquarters’ perspective coordination optimally respects the distribution of divisional profits. Finally, from taxation we know formula apportionment which derives divisional profits from consolidated profit on the basis of divisional sales, assets, payroll, and other

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5 Like Schmalenbach (1909), Hirshleifer (1956) focuses on aspects of managerial accounting.  
7 Tang (1993, 71) reports that for both national and international transfers only 1 percent of the companies use two-step transfer prices.  
8 A distinction between taxation and financial reporting might even call for three sets of books.  
9 According to Ernst & Young (2001, 6), 77 percent of 638 multinational parent companies report using the same set of transfer prices for both tax and management purposes. Czechowicz et al. (1982, 59) also substantiates a significant use of a single set of books.  
10 See also the discussion in Smith (2002b).  
Depending on the formula, this type of profit determination may do without transfer prices. However, since transfer prices used for coordination typically affect (at least some of) these factors, profit determination indirectly depends on transfer prices and thus on coordination. Consequently, doing without any transfer price does not resolve the relation between coordination and profit determination.

Related literature is mainly found in the context of transfer pricing for international taxation, where a considerable literature examines distortions of production, pricing, or investment decisions induced by differential tax rates, tariffs, or regulations mainly from an economics or public finance perspective. The majority of the models assumes a centralized firm and thereby abstracts from coordinational aspects. Papers pertaining to this strand comprise Horst (1971), Samuelson (1982), Halperin & Srinidhi (1987), Kant (1988, 1990), Harris & Sansing (1998), Sansing (1999), and Smith (2002a). The idea of a comparative analysis of (divisional) profits and transfer-pricing schemes found in (some of) these papers is common to our analysis.

There are also papers assuming decentralization. Schjelderup & Sorgard (1997), Narayanan & Smith (2000), and Nielsen, Raimondos-Møller & Schjelderup (2003) concentrate on transfer prices as strategic devices in oligopolistic markets. Halperin & Srinidhi (1991) analyze the resale-price and the cost-plus method when arm’s length prices are uniquely determined by “most similar products” traded with uncontrolled parties. Thus arm’s length prices are derived from internal and direct comparisons. Modeling decentralization as a special form of cooperative negotiations between the divisions over all operative decision variables such that after-tax consolidated profit is maximized, Halperin & Srinidhi identify inefficiencies induced by decentralization and taxation. Finally, Balachandran & Li (1996) propose a mechanism-design approach under dual transfer prices, and Elitzur & Mintz (1996), Smith (2002b), Bädenius et al. (2004), and Hyde & Choe (2005) analyze the approach of two sets of books.

In this paper, we assume that for both internal and external purposes the same one-step transfer price is applied. Our analysis is based on a formal model of a decentralized, vertically integrated firm trading a proprietary product and focuses on the following aspects: 1) What are admissible transfer prices? 2) By whom and when is the transfer price set? 3) How do transfer prices affect coordination, and how does coordination

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14Cf. Smith (2002b) for a model on performance measures independent of transfer prices.
15For strategic transfer prices see also Alles & Datar (1998) and Gök (2000).
depend on alternative pricing schemes? 4) What are the stakeholders’ preferences over these schemes? 5) What inefficiencies occur? 6) What is the effect of an endogenous choice of scheme?

On the basis of the arm’s length principle, we first argue that transfer prices are either negotiated by the divisions before (ex ante) or set by headquarters after (ex post) operational divisional decisions. An analytical derivation of divisional profits enables us to identify a strong influence of the transfer pricing scheme for negotiated transfer prices so that a stakeholder’s preference over the schemes depends on his type. This result does not necessarily carry over to administered transfer prices. Depending on the way external stakeholders deal with the discretion over arm’s length prices, there may be no difference between the schemes. Furthermore, in contrast to negotiated transfer prices, administration potentially induces divisional profits which are inefficient for any stakeholder from an ex-ante perspective. We argue that an advance commitment, especially in form of an advance transfer pricing agreement, may protect stakeholders from such inefficiency. Analogously, we demonstrate that an endogenous choice of the scheme may be harmful, too.

The main contributions of our paper are 1) the inclusion of different stakeholders’ perspectives, 2) the presentation of various approaches to the arm’s length principle, and 3) the consequent analysis of a single set of transfer prices in a decentralized organization. Furthermore, to the best of our knowledge, the analysis of an endogenous choice of the scheme is innovative.

The remainder of the paper is organized as follows. The model is formulated and motivated in Section 2. Sections 3 and 4 analyze the cases of ex-ante resp. ex-post determination of transfer prices. We discuss implication of an endogenous choice of the transfer pricing scheme in Section 5 and conclude in Section 6.

2 The model

We consider interactions of two divisions $D_i, i \in \{1, 2\}$, of a (possibly multinational) firm organized by functions. Internally, the divisions are set up as profit centers. Division 1 ($D_1$) is responsible for the production of a product, which is marketed externally by the downstream division 2 ($D_2$). Central management (HQ) pursues the interests of the

\[16\] Such an organizational structure is not uncommon in business practice. Examples are given by the Schüco International KG in Bielefeld (Germany) or the divisions of the Whirlpool Corporation (U.S.) as described by Tang (2002, 47–70).
firm as a whole.

D1 disposes of a long-term production capacity, which has been determined in earlier periods. The capacity consists of facilities acquired or rented on a long-term basis and of permanent employees. Whereas this long-term capacity as well as its costs are given, D1 has the possibility to determine capacity \( \bar{x} \geq 0 \) which is actually effective for the current period. This short-term capacity has to be interpreted in terms of a bottleneck and depends among others on the start-up and maintenance of production facilities, production factors rented on a short-term basis, e.g. telecommunication lines, temporarily employed staff, or the acquisition of licenses. In the following, we assume the long-term capacity sufficiently large such that it may be ignored when determining the short-term capacity \( \bar{x} \).

D2 markets the product. The revenue \( p(x) \cdot x \) corresponding to the considered period depends on a multiplicative (inverse) demand function

\[
p(x) := \frac{a}{x^b},
\]

and thus reads \( a \cdot x^{1-b} \), where \( x \in [0, \bar{x}] \) denotes the production and sales volume.\(^{17}\) The constants \( a > 0 \) and \( b \in (0,1) \) characterize market conditions.\(^{18}\) Parameter \( a \) can be interpreted as the market volume, whereas \( b \) denotes the constant price elasticity of demand. Both parameters result from exogenous factors such as the economic situation as well as from activities of the divisions and do not represent decision variables. The choice of the sales volume \( x \) is delegated to \( D2 \).\(^{19}\) In accordance with the divisions’ independence, \( D1 \) is allowed to deny delivery.

Figure 1 summarizes the relation between the divisions on the basis of the product flow and the payments. The functional organization of the firm becomes evident because all costs associated to production accrue in \( D1 \). These costs consist of capacity costs \( k \cdot \bar{x} \), \( k > 0 \), and variable product costs \( v \cdot x \), \( v > 0 \).\(^{20}\) The parameter \( f_i > 0 \), \( i \in \{1, 2\} \), denotes costs, which are fixed in relation to the capacity \( \bar{x} \) and the sales volume \( x \).

\(^{17}\)The technical problem that \( p(x) \) is not defined for \( x = 0 \) has no effect on the following derivations because it is the revenue and not the sales price which is relevant.

\(^{18}\)The choice of the multiplicative demand function facilitates the following exposition without predetermining the structural ideas and results.

\(^{19}\)The alternative specification of the sales price as \( D2 \)'s decision variable has no relevance to the model. However, the uniform choice of quantities as decision variables eases the presentation.

\(^{20}\)A deviation from the assumption of a functional organization would necessitate to account for (variable) product costs and a capacity decision on the part of \( D2 \). Especially the latter extension would call for a more involved (game-theoretic) analysis, while the main ideas of the paper would remain.
Internally, each unit of the product is valued at transfer price $t$. According to the well-known classification of cost- and market-based transfer prices, we distinguish between two schemes $j \in \{C, R\}$. We model the cost-based scheme $C$ as variable unit costs plus markup. The resulting transfer price is constant since $v$ is a constant and reads $t = \tau_C$, $\tau_C \geq 0$. The market-based scheme $R$ is derived from the external sales market and equals the share $\tau_R \in [0, 1]$ of the sales price $p(\cdot)$, i.e., $t = \tau_R \cdot p(x)$. With regard to taxation, scheme $C$ can be matched with the cost plus method (CPM) and scheme $R$ with the resale price method (RPM). Alternatively, scheme $C$ can be interpreted in terms of the comparable uncontrolled price method (CUP), which is again a market-based method. However, for clarity of exposition we stick to declare scheme $C$ a cost-based scheme.

Given transfer price $t$, the profit of division $i \in \{1, 2\}$ before divisional compensations, taxes, and appropriation of profit is $P_i(\cdot)$ with

\[
P_1(t, \bar{x}, x) = (t-v) \cdot x - k \cdot \bar{x} = \begin{cases} 
(\tau_C - v) \cdot x - k \cdot \bar{x} & \text{if } t = \tau_C \\
\tau_R \cdot a \cdot x^{1-b} - v \cdot x - k \cdot \bar{x} & \text{if } t = \tau_R \cdot p(x) 
\end{cases}
\]

\[
P_2(t, x) = (p(x) - t) \cdot x = \begin{cases} 
\tau_C \cdot x & \text{if } t = \tau_C \\
(1 - \tau_R) \cdot a \cdot x^{1-b} & \text{if } t = \tau_R \cdot p(x) 
\end{cases}
\]

Fixed costs $f_i$ are not reflected by $P_i$ because they are irrelevant for divisional decisions.

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21 Cf. among others Horngren, Datar & Foster (2003, 759).

22 In our context, it is not important whether the markup is additive or multiplicative. Furthermore, in contrast to our approach, Baldenius et al. (2004) model, inter alia, a transfer price based on full costs as a multiplicative markup on $v + f_1/x$. Note that such a transfer price depends on the sales volume and actually results in a two-step scheme.

and are not affected by transfer prices. In accordance with the modeled situation of a single set of books, we assume that divisional compensation incites $Di$ to maximize its respective profit $P_i(\cdot)$. Thus in terms of divisional profits, the interdependence of decentral decisions is reflected by the transfer payment $t\cdot x$. Let $i=0$ denote $HQ$. Then, corporate profit before compensation, taxes, and appropriation of profits, $P_0(\cdot)$, is given by the sum of divisional profits and does not (directly) depend on the transfer price, i.e., $P_0(\bar{x}, x) = (p(x) - v)\cdot x - k\cdot \bar{x}$.

As the firm relies on a single set of books, transfer prices are assumed to be in accordance with the arm’s length principle which is fundamental to both financial reporting and taxation. For instance, IAS 18 defines the ‘fair value’ as “the amount for which an asset could be exchanged, or a liability settled, between knowledgeable, willing parties in an arm’s length transaction”. The arm’s length principle has also become the standard of international taxation and is stated in Article 9(1) of the OECD Model Tax Convention. Accordingly, a transfer price satisfies the principle if it would occur or would have occurred in a transaction between or with uncontrolled parties under identical or comparable circumstances. However, since a (direct) comparison with uncontrolled transactions characterized by identical circumstances is an exception when dealing with proprietary products, the arm’s length principle typically has to be operationalized.

The first approach are administered transfer prices where $HQ$ fixes a transfer price which is considered adequate from relevant stakeholders’ perspectives. Note that a well-founded judgement concerning the adequacy of a transfer price and the induced profit allocation requires information about the divisions’ and uncontrolled parties’ cost and revenue situations. It is realistic that this information is distributed asymmetrically between internal and external stakeholders ex ante and that it becomes at best common knowledge ex post. Fixing a transfer price in advance is also complicated by the necessity to estimate its coordinative effect on divisional decisions and hence its effect on their profits. A further problem of advance pricing is that $HQ$ has an incentive to deviate ex post from a transfer price fixed ex ante. Hence, in accordance with common business practice, we focus on $HQ$ setting the transfer price ex post.

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24For our model it is irrelevant whether divisional compensation is based on divisional profit before or after taxation and appropriation of profits.


26We assume that $HQ$ does not consider to risk a penalty for deviating from arm’s length prices.

27An exception to this practice are advance pricing agreements and transfer pricing guidelines. See below for further remarks on these instruments.
The second approach are transfer prices negotiated by the divisions. The idea is that negotiations between profit or investment centers resemble those between independent parties because each of these entities pursues the maximization of its own profit. However, negotiations subsequent to the divisions’ operational decisions are problematic since for given capacity $\bar{x}$ and quantity $x$ $D2$ has no interest in a positive transfer payment $tx > 0$ as its divisional profit $P_2(t, x)$ decreases in $t$. Put differently: The status-quo point of ex-post negotiations about a transfer payment is $(P_1, P_2) = (\bar{v} \cdot x - \bar{k} \cdot \bar{x}, p(x) \cdot x)$ and is Pareto-efficient. Hence, for $D2$ it is individual rational not to enter into or to break down negotiations. Consequently, in the following analysis we disregard subsequent negotiations.

The timing of the model is exhibited in Figure 2. Given the transfer price is specified ex ante at date 1 (scenario $\alpha$), $D1$ determines capacity $\bar{x}$ at date 2 in anticipation of $D2$‘s subsequent decision on sales volume $x$. The equilibrium decisions depend on the transfer price. Finally, production, sales, profit determination, compensation, taxation, and appropriation of profits take place. Otherwise, i.e., if the transfer price is specified ex post at date 5 (scenario $\beta$), $D1$ and $D2$ anticipate the transfer payment when deciding at dates 2 and 3. $D1$‘s decision at date 4 whether to deliver the quantity $x$ is implicitly captured by the equivalent condition that the transfer payment $t \cdot x$ does not fall short of the variable product costs $v \cdot x$.

For the time being, we proceed on the assumption that the pricing scheme $j \in \{C, R\}$ is given, which can be justified by (at least) two arguments. First, the decision on the scheme is generally taken less frequently than the one on the amount of the transfer price. This circumstance grounds on the existence of implementation costs, the existence of a recommended method of transfer pricing for taxation, the existence of an intrafirm guideline or an advance pricing agreement, or the fact that a (frequent) change of schemes may be hard to justify towards (external) stakeholders, especially towards tax authorities. Moreover, in scenario $\beta$ the availability and quality of data on compara-

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28We refer to OECD (1995, I-2) saying: “It should not be assumed that the conditions established in the commercial and financial relations between associated enterprises will invariably deviate from what the open market would demand. Associated enterprises in MNEs commonly have a considerable amount of autonomy and often bargain with each other as though they were independent enterprises. For example, local managers may be interested in establishing good profit records and therefore would not want to establish prices that would reduce the profit of their own company.” See also Eden (1998, 596–597) for the “affiliate bargaining approach”.

29Considering a different status-quo point –probably set by HQ– does not change the problem and ultimately comes to the first approach.
ble transactions for the justification of an arm’s length price may vary with the scheme. Second, as a result of the following analysis, there actually may be no choice of scheme or the choice may be irrelevant (scenarios $\beta_2$ and $\beta_3$). Nevertheless, we make detailed comments on the decision on the pricing scheme in Section 5.

In order to model different stakeholders’ preferences over divisional profits $P_i(\cdot)$, we introduce the weights $w_i \geq 0$, $i \in \{1, 2\}$, $w_1 + w_2 = 1$. These weights can be interpreted as a stakeholder’s type and are explained by an example focusing on HQ and an U.S.-like approach of international taxation.\(^{30}\) Let HQ and D1 both be incorporated in the U.S., whereas D2 is a controlled foreign corporation, i.e., D2 is incorporated in the foreign country and U.S. shareholders own more than 50 percent of its shares. The weight $a_i \in (1/2, 1]$ denotes HQ’s share in $D_i$. The compensation of divisional management $i$ is determined by $c_i \in (0, 1)$ representing a proportional share of divisional profit before taxation and appropriation of profits. The corporate income tax rate applicable to D1 and HQ is $s_1$, whereas the foreign division’s income is taxed at $s_2$.\(^{31}\) Let $s_1 \in (0, 1)$, $s_2 \in [0, 1)$, and $s_1 > s_2$. The repatriated share of D2’s profit is denoted by $r \in [0, 1]$ and takes the form of dividends. HQ’s (world) income is taxed according to the residence principle with deferred taxation until repatriation of profits. Hence, HQ is interested in maximizing the following weighted sum of divisional profits $P_i$:

$$a_1 \cdot (1-c_1) \cdot (1-s_1) \cdot P_1 + r \cdot a_2 \cdot (1-c_2) \cdot (1-s_1) \cdot P_2 + (1-r) \cdot a_2 \cdot (1-c_2) \cdot (1-s_2) \cdot P_2.$$ (2)

Standardization of the above weights yields weights $w_i^0$, $i \in \{1, 2\}$, defined by

$$w_1^0 := \frac{a_1 \cdot (1-c_1) \cdot (1-s_1)}{a_1 \cdot (1-c_1) \cdot (1-s_1) + a_2 \cdot (1-c_2) \cdot (r \cdot (1-s_1) + (1-r) \cdot (1-s_2))}, \quad w_2^0 = 1-w_1^0$$


\(^{31}\)Note that the assumption of proportional divisional compensation and taxation typically is an abstraction of reality.
so that \( \sum_{i=1}^{2} w^0_i \cdot P_i \) is an equivalent representation of HQ’s objective function (2). Its level curves in the \((P_1, P_2)\)-plane are straight lines with nonpositive slopes. The form of the objective function can be transferred to all stakeholders by an appropriate choice of the weight \( w_1 \) (resp. \( w_2 \)). For example, we have \( w_1 = 1 \) for \( D1 \) or \( w_1 = 0 \) for \( D2 \).

### 3 Transfer prices determined ex ante (scenario \( \alpha \))

In scenario \( \alpha \), the transfer price, i.e., the parameter \( \tau_C \) or \( \tau_R \), is determined by way of negotiation between \( D1 \) and \( D2 \) at date 1.\(^{32}\) The bargaining result is not modified subsequently. At the time of negotiation, \( D1 \) and \( D2 \) anticipate their decisions on capacity \( \bar{x} \) and sales volume \( x \) at dates 2 and 3. They form a subgame-perfect equilibrium for given scheme \( j \) and parameter \( \tau_j \). First, we concentrate on coordination when computing and analyzing this equilibrium. Then we derive and describe equilibrium divisional profits. Finally, we apply the above preference model to evaluate stakeholders’ preferences over the pricing schemes.

#### 3.1 Coordination under cost-based transfer pricing

Under scheme \( C \), \( D2 \) decides at date 3 for given transfer price \( t = \tau_C \) and given capacity \( \bar{x} \) on the sales volume \( x \). The corresponding objective function follows from (1), so that the optimization problem is

\[
P_2(\tau_C, x) = a \cdot x^{1-b} - \tau_C \cdot x \to \max_{x \in [0, \bar{x}]} .
\]  

(3)

Note that (3) is based on the assumption, that \( D1 \) agrees to deliver quantity \( x \). Hence, we require the transfer price not to fall short of the variable unit costs, i.e., \( \tau_C \geq v \). The result of this calculation is the function \( \tilde{x}^\alpha_C : [v, \infty) \times \mathbb{R}_+ \to \mathbb{R}_+ \), which maps transfer price \( \tau_C \) and capacity \( \bar{x} \) to \( D2 \)’s optimal quantity decision. Anticipating quantity decision \( \tilde{x}^\alpha_C(\tau_C, \bar{x}) \), \( D1 \) maximizes (1) as to capacity, i.e.,

\[
P_1(\tau_C, \bar{x}, \tilde{x}^\alpha_C(\tau_C, \bar{x})) \to \max_{\bar{x} \geq 0},
\]  

(4)

and obtains the function \( \tilde{x}^\alpha_C : [v, \infty) \to \mathbb{R}_+ \) as the equilibrium capacity. Proposition 1 computes the equilibrium in divisional decisions.

\(^{32}\)In contrast to Halperin & Srinidhi (1991), divisions do not negotiate for decisions which have been delegated to each of them.
Proposition 1. In scenario $\alpha$, the equilibrium capacity $\bar{x}^C_C(\tau_C)$ and sales volume $x^C_C(\tau_C)$ for given scheme $C$ and transfer price $\tau_C \geq 0$ are

$$\bar{x}^C_C(\tau_C) = x^C_C(\tau_C) = \begin{cases} \left( \frac{a \cdot (1-b)}{\tau_C} \right)^{1/b} & \text{if } \tau_C \geq v + k \\ 0 & \text{otherwise} \end{cases} .$$

(5)

Proof. $D^2$’s reaction function for $\tau_C \geq v$ is $\tilde{x}^C_C(\tau_C, \bar{x}) = \min \left\{ \bar{x}, (a \cdot (1-b) / \tau_C)^{1/b} \right\}$. Thus $D^1$ maximizes

$$P_1(\tau_C, \bar{x}, \tilde{x}^C_C(\tau_C, \bar{x})) = \begin{cases} (\tau_C - (v+k)) \cdot \bar{x} & \text{if } \bar{x} \leq (a \cdot (1-b) / \tau_C)^{1/b} \\ (\tau_C - v) \cdot (a \cdot (1-b) / \tau_C)^{1/b} - k \cdot \bar{x} & \text{otherwise} \end{cases}$$

as to $\bar{x} \geq 0$. Assuming that $D^1$ chooses $\bar{x} = (a \cdot (1-b) / \tau_C)^{1/b}$ in case of indifference ($\tau_C = v + k$), the equilibrium capacity is $\bar{x}^C_C(\tau_C)$ which entails the equilibrium sales volume $x^C_C(\tau_C) = \tilde{x}^C_C(\tau_C; \bar{x}^C_C(\tau_C))$.

In case $\tau_C < v$, $D^1$ denies delivery and does not set up any capacity. As a consequence, the bottom case in (5) applies.

For $\tau_C \geq v + k$, the equilibrium in Proposition 1 is governed by the marketing division, because the equilibrium quantity results from equating marginal revenue to marginal costs of sales volume as to $P_2(\cdot)$, i.e.,

$$\frac{dp(x) \cdot x}{dx} = \frac{d \tau_C \cdot x}{dx} \Rightarrow \frac{a \cdot (1-b)}{x^b} = \tau_C \Leftrightarrow x = \left( \frac{a \cdot (1-b)}{\tau_C} \right)^{1/b} .$$

In contrast, $D^1$’s optimization can be reduced to the question whether the transfer price $\tau_C$ covers the total marginal costs of capacity. These costs do not only consist of the component $k$ for setting up capacity but also of the variable unit costs $v$ resulting from capacity utilization, since $D^1$ optimally does not have idle capacity. In case the transfer price $\tau_C$ does not cover these costs amounting to $v + k$, $D^1$ chooses zero capacity in order to prevent a loss from participating in the transaction. Otherwise, $D^1$ maximizes its divisional profit by setting up the maximal capacity which is subsequently fully utilized by $D^2$.

3.2 Coordination under market-based transfer pricing

Provided that scheme $R$ is applied, the sales price $p(\cdot)$ is allocated between divisions $D^1$ and $D^2$ in the ratio $\tau_R : (1-\tau_R)$. Hence, following (1) the decentral decision on the sales
volume is based on the calculation

\[ P_2(\tau_R \cdot p(x), x) = (1 - \tau_R) \cdot a \cdot x^{1-b} \rightarrow \max_{x \in [0, \min\{x(\tau_R \cdot (\alpha/v)^{1/b})\}]} \]

where the additional restriction on the sales volume guarantees that the transfer price \( \tau_R \cdot p(\cdot) \) does not fall short of the variable unit costs \( v \) such that \( D1 \) has an incentive to deliver. The above profit maximization problem is equivalent to a maximization of sales revenue. By analogy to scheme \( C \), let \( \bar{x}_R^\alpha : [0, 1] \times \mathbb{R}_+ \rightarrow \mathbb{R}_+ \) denote the decentral quantity decision for given sharing parameter \( \tau_R \) and capacity \( \bar{x} \) when scheme \( R \) is applied. Similar to (4), \( D1 \) chooses the capacity that maximizes \( P_1(\tau_R \cdot p(\bar{x}_R^\alpha(\tau_R, \bar{x})), \bar{x}, \bar{x}_R^\alpha(\tau_R, \bar{x})) \) and decides according to \( \bar{x}_R^\alpha : [0, 1] \rightarrow \mathbb{R}_+ \). The equilibrium decisions are captured by the following proposition.

**Proposition 2.** In scenario \( \alpha \), the equilibrium capacity \( \bar{x}_R^\alpha(\tau_R) \) and sales volume \( x_R^\alpha(\tau_R) \) for given scheme \( R \) and sharing parameter \( \tau_R \in [0, 1] \) are

\[ \bar{x}_R^\alpha(\tau_R) = x_R^\alpha(\tau_R) = \left( \frac{\tau_R \cdot a \cdot (1-b)}{(v+k)} \right)^{1/b} . \]

**Proof.** The optimal sales volume is \( \bar{x}_R^\alpha(\tau_R, \bar{x}) = \min \left\{ \bar{x}, (\tau_R \cdot a/v)^{1/b} \right\} \), if we presume that \( D2 \) chooses quantity \( x = (a/v)^{1/b} \) in case of indifference (\( \tau_R = 1 \)). Capacity \( \bar{x}_R^\alpha(\tau_R) \) maximizes

\[ P_1(\tau_R \cdot p(\bar{x}_R^\alpha(\tau_R, \bar{x})), \bar{x}, \bar{x}_R^\alpha(\tau_R, \bar{x})) = \begin{cases} \tau_R \cdot a \cdot \bar{x}^{1-b} - (v+k) \cdot \bar{x} & \text{if } \bar{x} \leq (\tau_R \cdot a/v)^{1/b} \\ -k \cdot \bar{x} & \text{otherwise} \end{cases} \]

and induces the equilibrium quantity \( x_R^\alpha(\tau_R) = \bar{x}_R^\alpha(\tau_R, \bar{x}_R^\alpha(\tau_R)) \). \( \square \)

In contrast to the cost-based scheme, \( D1 \) is able to influence the transfer price under scheme \( R \): \( D1 \) may raise the transfer price by making capacity scarce, i.e., choosing such small a capacity that \( D2 \) is effectively restrained in its decision on the sales volume. Thereby the share \( \tau_R \) of marginal revenue as to capacity accrues to \( D1 \). Since the revenue maximization pursued by \( D2 \) implies vanishing marginal revenue, the optimal capacity –from \( D1 \)’s perspective– is scarce.\(^{33}\) The optimal restriction of the sales volume is reached if partial marginal revenue equals total marginal costs of capacity, \( v+k \). Hence, the equilibrium capacity may be calculated by

\[ \frac{d}{d \bar{x}} \tau_R \cdot a \cdot \bar{x}^{1-b} = \frac{d}{d \bar{x}} (v+k) \cdot \bar{x} \Rightarrow \frac{\tau_R \cdot a \cdot (1-b)}{\bar{x}^b} = v+k \Leftrightarrow \bar{x} = \left( \frac{\tau_R \cdot a \cdot (1-b)}{(v+k)} \right)^{1/b}, \]

\(^{33}\)Note that the fact that \( D1 \)’s optimal capacity constrains \( D2 \)’s revenue maximization is not an artefact of the multiplicative demand function.
which implies an equilibrium capacity (strictly) increasing in the sharing parameter $\tau_R$. Consequently, it is primarily the production division who induces equilibrium decisions. A condition of the above coordinative effect is that capacity is actually fixed at the time of $D2$’s decision on the sales volume. Otherwise, i.e., if $D1$ is able to expand capacity on a short term basis, the upstream division is deprived of its influence on the sales volume and thus on the transfer price.\footnote{Cf. the ‘soft’ capacity restriction of Banker & Hughes (1994).}

### 3.3 Equilibrium divisional profits

The above analysis reveals different coordinative effects associated to cost- and market-based transfer pricing in scenario $\alpha$. The following proposition quantifies their effects on divisional profits. Therefore, let the function $P_{i,j}^\alpha$ map scheme $j$ and parameter $\tau_j$ to $D_i$’s profit in equilibrium. For instance, we have $P_{1,C}^\alpha(\tau_C) := P_1(\tau_C, x_C(\tau_j), x_C(\tau_C))$ or $P_{2,R}^\alpha(\tau_R) := P_2(\tau_R \cdot p(x_R(\tau_R)), x_R(\tau_R)).$

**Proposition 3.** The equilibrium divisional profit functions $P_{i,j}^\alpha(\tau_j), i \in \{1, 2\}, j \in \{C, R\}$, are given by

$$P_{1,C}^\alpha(\tau_C) = \begin{cases} (\tau_C - (v + k)) \cdot \left(\frac{a \cdot (1 - b)}{\tau_C}\right)^{1/b} & \text{if } \tau_C \geq v + k, \\ 0 & \text{otherwise} \end{cases}$$

$$P_{2,C}^\alpha(\tau_C) = \begin{cases} b \cdot \tau_C \cdot \left(\frac{a \cdot (1 - b)}{\tau_C}\right)^{1/b} & \text{if } \tau_C \geq v + k, \\ 0 & \text{otherwise} \end{cases}$$

for scheme $C$, $\tau_C \geq 0$, and by

$$P_{1,R}^\alpha(\tau_R) = \frac{b \cdot (v + k)}{1 - b} \cdot \left(\frac{a \cdot (1 - b) \cdot \tau_R}{v + k}\right)^{1/b} \geq 0,$$

$$P_{2,R}^\alpha(\tau_R) = \frac{(1 - \tau_R) \cdot (v + k)}{(1 - b) \cdot \tau_R} \cdot \left(\frac{a \cdot (1 - b) \cdot \tau_R}{v + k}\right)^{1/b} \geq 0$$

for scheme $R$, $\tau_R \in [0, 1]$.

**Proof.** The functions result from a direct evaluation of $P_1$ and $P_2$. \qed

Figure 3 illustrates typical graphs of divisional profit functions $P_{i,j}^\alpha$. Furthermore, it introduces their (unique global) maximizers $\tau_{i,j}^\alpha, i \in \{1, 2\}, j \in \{C, R\}$, which are defined...
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as

\[ \tau_{i,j}^\alpha := \arg\max_{\tau_j \in D_j^\alpha} P_{i,j}^\alpha(\tau_j), \]

where \( D_j^\alpha \) denotes the domain of the profit functions for scheme \( j \) in scenario \( \alpha \). Thus we have \( D_C^\alpha = [0, \infty) \) and \( D_R^\alpha = [0, 1] \). Lemma 1 states some properties of the profit functions \( P_{i,j}^\alpha \).

![Figure 3: Divisional profit functions for scenario \( \alpha \)](image)

**Lemma 1.** The divisional profit functions \( P_{i,j}^\alpha \), \( i \in \{1, 2\}, j \in \{C, R\} \), have the following properties:

1. \( P_{i,C}^\alpha \) is strictly quasi-concave on the interval \([v+k, \infty)\) and has a unique maximizer \( \tau_{i,C}^\alpha \in [v+k, \infty) \).
2. \( P_{i,R}^\alpha \) is strictly quasi-concave and has a unique maximizer \( \tau_{i,R}^\alpha \in D_R^\alpha \).
3. The maximizers of \( P_{1,j}^\alpha \) and \( P_{2,j}^\alpha \) satisfy the relation \( \tau_{2,j}^\alpha < \tau_{1,j}^\alpha \).
4. We have

\[
P_{1,C}^\alpha(v+k) = P_{1,R}^\alpha(0) = P_{2,R}^\alpha(0) = P_{2,R}^\alpha(1) = \lim_{\tau_C \to \infty} P_{1,C}^\alpha(\tau_C) = \lim_{\tau_C \to \infty} P_{2,C}^\alpha(\tau_C) = 0
\]

and

\[
P_{2,C}^\alpha(v+k) = P_{1,R}^\alpha(1) > 0.
\]

---

\(^{35}\)The parameter setting is \( a = v+k = 1 \) and \( b = 1/2 \).
The unique maximizers are readily identified as \( \tau_{1,1} \) and \( \tau_{2,2} \):

\[
\begin{align*}
\tau_C & \geq v + k : \quad \mathcal{P}^{\alpha}_{1,C}(\tau_C) \leq 0 \iff \tau_C \leq (v + k)/(1 - b), \\
\tau_C & \geq v + k : \quad \mathcal{P}^{\alpha}_{2,C}(\tau_C) < 0 \iff \tau_C \geq v + k, \\
\tau_R \in D^\alpha_R : \quad \mathcal{P}^{\alpha}_{1,R}(\tau_R) \geq 0 \iff \tau_R \geq 0, \\
\tau_R \in D^\alpha_R : \quad \mathcal{P}^{\alpha}_{2,R}(\tau_R) \leq 0 \iff \tau_R \leq 1 - b.
\end{align*}
\]

The unique maximizers are readily identified as \( \tau_{1,1} = (v + k)/(1 - b) \), \( \tau_{2,2} = v + k \), \( \tau^*_{1,R} = 1 \), and \( \tau^*_{2,R} = 1 - b \). Properties 3 and 4 are obtained immediately.

The curvatures of the graphs result from the interplay of a price and a quantity effect. We start the explanation with scheme C. An increase of the transfer price causes an increase of the unit contribution margin for the upstream division, since \( D_1 \) receives an amount of \( \tau_C - (v + k) \) per sales unit. At first glance it is surprising that the same is true for the downstream division. The reason is found in the fact that \( D_2 \) uses such a cost-plus pricing rule, namely \( p(x^C_C(\tau_C)) = (1 + b)/(1 - b) \cdot \tau_C \), that \( D_2 \)'s unit contribution margin reads \( p(x^C_C(\tau_C)) - \tau_C = b/(1 - b) \cdot \tau_C \) and increases in \( \tau_C \). There is a negative quantity effect opposed to this positive price effect because the sales volume always decreases in the transfer price. In terms of divisional profits, the quantity effect is always stronger than the price effect for \( D_2 \), whereas \( D_1 \) only suffers by increases of the transfer price if it exceeds the critical amount of \( \tau^*_{1,C} \).

Focusing on market-based transfer pricing, we first note that \( D_1 \)'s equilibrium capacity choice is such that his revenue per sales unit is independent of the sharing parameter \( \tau_R \): \( \tau_R \cdot p(x^C_C(\tau_R)) = (v + k)/(1 - b) \). Consequently, there is no price effect for \( D_1 \). In contrast, \( D_2 \) pays a constant transfer price but receives a sales price which decreases in \( \tau_R \). The quantity effect works –like for scheme C– in the same direction for both divisions. However, here the sales volume increases in the transfer pricing parameter. Whereas the positive quantity effect is not impaired for \( D_1 \), for \( D_2 \) the negative price effect prevails for sharing parameters exceeding \( \tau^*_{2,R} \).

### 3.4 Negotiated transfer prices

In terms of divisional profits, feasible results of divisional negotiation can be described for scheme \( j \in \{C, R\} \) by the set \( P^\alpha_j \subseteq \mathbb{R}^2_+ \) with

\[
P^\alpha_j := \left\{ (P^\alpha_{1,j}(\tau_j), P^\alpha_{2,j}(\tau_j)) : \tau_j \in D^\alpha_j \right\}.
\]

According to bargaining theory, we would have to allow for free disposal so that the set of feasible negotiation outcomes would be the comprehensive hull of \( P^\alpha_j \) instead of \( P^\alpha_j \) itself. In our context, it
The left diagram of Figure 4 corresponds to Figure 3 and depicts the sets $P_C^\alpha$ and $P_R^\alpha$, the intersection of which is denoted by $P_\times \in \mathbb{R}_2^{++}$ with $P_\times := P_C^\alpha \cap P_R^\alpha \cap \mathbb{R}_2^{++}$. The following lemma confirms that the depicted curvature of the graphs can be transferred to any parameter constellation.

![Figure 4: Divisional profits for scenarios $\alpha$ and $\beta_1$](image)

**Lemma 2.** In addition to Lemma 1, the following properties hold:

1. $P_C^\alpha$ and $P_R^\alpha$ can each be represented as the graph of a continuous and strictly concave function on the interval $[0, P_{2,C}(v+k)] = [0, P_{1,R}(1)]$.

2. $P_\times$ is given by $(P_{1,C}^\alpha(\tau_{1,C}), P_{2,C}^\alpha(\tau_{1,C})) = (P_{1,R}^\alpha(\tau_{2,R}), P_{2,R}^\alpha(\tau_{2,R}))$.

**Proof.** For scheme $R$, the function alluded to in property 1 is $P_{2,R}^\alpha \circ P_{1,R}^{\alpha^{-1}}$, since $P_{1,R}^\alpha$ can be inverted (cf. Lemma 1). Thus we have

$$P_{2,R}^\alpha(\tau_R) = P_{2,R}^\alpha(P_{1,R}^{\alpha^{-1}}(P_{1,R}^\alpha(\tau_R))) = a \cdot \left(\frac{1-b}{b \cdot (v+k)} \cdot P_{1,R}^\alpha(\tau_R)\right)^{(1-b)} - \frac{1}{b} \cdot P_{1,R}^\alpha(\tau_R),$$

is not indicated to account for this difference. See Haake & Martini (2004) for a rigorous transfer pricing approach based on bargaining theory.

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Note that the point $(0, 0)$ is excluded in the definition of $P_\times$.

The parameter constellation is $a = b = v + k = 1$, $\tau_C = 4/5$, $\tau_C = 5/3$, $\tau_R = 1/3$, and $\tau_R = 2/3$. 

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so that \( P^\alpha_{2,R}(\tau_R) \) can be represented as a continuous and strictly concave function in \( P^\alpha_{i,R}(\tau_R) \). Analogously, we compute \( P^\alpha_{1,C} \circ P^{\alpha-1}_{2,C} \) for scheme \( C \),

\[
P^\alpha_{1,C}(\tau_C) = P^\alpha_{1,C}\left(P^{\alpha-1}_{2,C}\left(P^\alpha_{2,C}(\tau_C)\right)\right) = \frac{1-b}{b} \cdot P^\alpha_{2,C}(\tau_C) - (v+k) \cdot \left(\frac{1}{a-b} \cdot P^\alpha_{2,C}(\tau_C)\right)^{1/(1-b)}.
\]

However, here we have to respect that \( P^\alpha_{2,C} \) can only be inverted on the interval \([v+k, \infty)\), so that the above expression is not defined for \( P^\alpha_{2,C}(\tau_C) = 0 \). Nevertheless, a check against Proposition 3 shows that the right hand side of the above expression yields the correct upstream profit for \( P^\alpha_{2,C}(\tau_C) = 0 \) amounting to zero.

From property 1 and Lemma 1 follow \( \{(0,0)\} \in P^\alpha_C \cap P^\alpha_R \) and \( |P^\alpha_C \cap P^\alpha_R| \leq 2 \). It is easy to verify that \( \left(P^\alpha_{1,C}(\tau^\alpha_{1,C}), P^\alpha_{2,C}(\tau^\alpha_{1,C})\right) = \left(P^\alpha_{1,R}(\tau^\alpha_{1,R}), P^\alpha_{2,R}(\tau^\alpha_{1,R})\right) \in P^\alpha_C \cap P^\alpha_R \cap \mathbb{R}^2_{++} \) holds which implies property 2.

Despite the fact that it is hardly possible to forecast the negotiation outcome, it is plausible to assume that the divisions agree on a parameter \( \tau^\alpha_j \) which induces Pareto-efficient divisional profits.\(^{39}\) In Figure 4, such pairs of divisional profits are emphasized by thick lines and are henceforth denoted by \( \partial P^\alpha_j \). Thus \( \tau^\alpha_j = \tau^\alpha_j \) satisfies \( \left(P^\alpha_{i,j}(\tau^\alpha_j), P^\alpha_{2,j}(\tau^\alpha_j)\right) \) \( \in \partial P^\alpha_j \). The sets of Pareto-efficient parameter values can be stated by means of Lemmas 1 and 2: \( \tau^\alpha_j \in [\tau^\alpha_{2,j}, \tau^\alpha_{1,j}] \).

Proposition 4 applies the proposed preference model to scenario \( \alpha \).

**Proposition 4.** In scenario \( \alpha \), there exists for any pair of negotiated transfer pricing parameters \( (\tau^\alpha_C, \tau^\alpha_R) \neq (\tau^\alpha_{1,C}, \tau^\alpha_{2,R}) \) a sufficiently small (resp. large) weight \( w_1 \in [0, 1] \) such that the corresponding stakeholder prefers scheme \( C \) (resp. scheme \( R \)).

**Proof.** The stakeholder’s preference over the schemes can be deduced from the solution to \( \arg\max_{j \in \{C,R\}} \sum_{i=1}^{2} w_i \cdot P^\alpha_{i,j}(\tau^\alpha_j) \). The objective function has a constant, nonpositive slope of \(-w_1/w_2\) in the \( (P_1, P_2)\)-plane, where we define the slope for \( w_2 = 0 \) as \(-\infty\). The slope of the straight line through the points \( \left(P^\alpha_{i,C}(\tau^\alpha_C), P^\alpha_{2,C}(\tau^\alpha_C)\right) \in \partial P^\alpha_C \) and \( \left(P^\alpha_{1,R}(\tau^\alpha_R), P^\alpha_{2,R}(\tau^\alpha_R)\right) \in \partial P^\alpha_R \), is \( \Delta P^\alpha_C/\Delta P^\alpha_R \) where \( \Delta P^\alpha_i := P^\alpha_{i,C}(\tau^\alpha_C) - P^\alpha_{i,R}(\tau^\alpha_R) \) for \( i \in \{1, 2\} \). On the basis of the properties stated in Lemmas 1 and 2, we have \( \Delta P^\alpha_C < 0 \) and \( \Delta P^\alpha_R > 0 \), if we exclude the negotiation result \( (\tau^\alpha_C, \tau^\alpha_R) = (\tau^\alpha_{1,C}, \tau^\alpha_{2,R}) \), for which both negotiated transfer prices induce the same profits of \( P_x \). Hence, we may determine the preference over the scheme by a comparison of slopes:

\[
\sum_{i=1}^{2} w_i \cdot P^\alpha_{i,C}(\tau^\alpha_C) \gg \sum_{i=1}^{2} w_i \cdot P^\alpha_{i,R}(\tau^\alpha_R) \iff -\frac{w_1}{w_2} \gg \frac{\Delta P^\alpha_C}{\Delta P^\alpha_R} \iff w_1 \ll \frac{\Delta P^\alpha_R}{\Delta P^\alpha_C} \in (0, 1).
\]

\(^{39}\)Cf. Haake & Martini (2004) for an analysis of different bargaining solutions in a similar context. In Figure 4 \( P^\alpha_{C,N} \) and \( P^\alpha_{R,N} \) denote the well-known Nash bargaining solution.

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The term on the left hand side represents the preference statement in its original form. The term in the middle gives the comparison of slopes. The right term exploits \( w_1 + w_2 = 1 \) and proves the assertion.

The proposition reflects the particular allocation effect of the transfer pricing schemes: On the one hand, it does not occur that an element from \( \partial P_C^\alpha \) (resp. \( \partial P_R^\alpha \)) is Pareto-dominated by one from \( \partial P_R^\alpha \) (resp. \( \partial P_C^\alpha \)) meaning that generally both schemes \( C \) and \( R \) might be the preferred mode of transfer pricing. On the other hand, it is always scheme \( C \) (resp. scheme \( R \)) inducing a higher profit for \( D2 \) (resp. \( D1 \)) than scheme \( R \) (resp. scheme \( C \)).

4 Transfer prices determined ex post

Ex post, the transfer price is determined by HQ at date 5. At this time, the divisions have already taken their decisions anticipating HQ’s choice of transfer price which merely allocates a given corporate profit. On the basis of the preference model, it is evident that HQ wants to shift this profit to that division showing the largest weight \( w_0^i \). However, HQ’s choice is restricted by the arm’s length principle. We assume that arm’s length prices result from external and indirect comparisons, i.e., they are derived from data on transactions between external, uncontrolled parties and have to be adjusted due to less than perfect comparability.\(^{40}\) In the following we propose and discuss three different ways how such data are used to derive admissible transfer prices. Whereas the preferences as to the ex-post allocation of corporate profit are obvious, we concentrate on ex-ante effects on divisional decisions and profits of ex-post determined transfer prices.

Independent transfer prices (scenario \( \beta_1 \))

In case of independence, arm’s length prices of scheme \( j \in \{C, R\} \) originate in a given and constant interval of parameters \([\bar{\tau}_C, \tilde{\tau}_C] \subset (0, \infty) \) or \([\bar{\tau}_R, \tilde{\tau}_R] \subset (0, 1)\), respectively. The endpoints of these intervals, \( \bar{\tau}_j \) and \( \tilde{\tau}_j \), are interpreted as the minimal and maximal parameter values which can be justified by HQ to the other stakeholders. The width and position of such an interval is mainly determined by the availability, the sampling, the verifiability, and the interpretation of data on comparables. Since it is primarily HQ who prepares and presents such data, she may exert an influence on these intervals. We use the attribute ‘independent’ because admissibility of a transfer price

\(^{40}\)Thus we exclude sources of ex-ante discretion other than the sales price \( p(x) \).
under one scheme neither depends on the other scheme nor on the induced divisional profits.

Given these assumptions, HQ may choose any transfer price $\tau_C \in [\bar{\tau}_C, \bar{\tau}_C]$ for scheme $C$ or $\tau_R \cdot p(x) \in [\bar{\tau}_R \cdot p(x), \bar{\tau}_R \cdot p(x)]$ for scheme $R$. Due to the analysis of scenario $\alpha$, it is straight-forward to state the set of feasible divisional profits in scenario $\beta_1$ which is denoted by $P_{\beta_1}$ and reads

$$P_{\beta_1} := \left\{ (P_{1j}^\alpha(\tau_j), P_{2j}^\alpha(\tau_j)) : \tau_j \in [\bar{\tau}_j, \bar{\tau}_j] \right\}.$$ 

Unlike for negotiated transfer prices, here the choice of transfer price is evident: At date 5, HQ selects the parameter $\tau_j^{\beta_1}$, $j \in \{C, R\}$, according to

$$\tau_j^{\beta_1} \begin{cases} = \tau_j & \text{if } w_1^0 < w_2^0 \\ \in [\bar{\tau}_j, \bar{\tau}_j] & \text{if } w_1^0 = w_2^0 \\ = \bar{\tau}_j & \text{if } w_1^0 > w_2^0 \end{cases}.$$ 

For instance, in the upper case HQ ex post chooses the smallest arm’s length price, because she is more interested in the profit of $D1$ than in that of $D2$ ($w_1^0 < w_2^0$). In the following, we disregard the case of HQ being indifferent, i.e., we assume $w_1^0 \neq w_2^0$.

It is important to note that in general this behavior is only optimal ex post, because we generically have $\tau_j^{\beta_1} \neq \arg\max_{\tau_j \in [\bar{\tau}_j, \bar{\tau}_j]} \sum_{i=1}^2 w_i^0 \cdot P_{ij}^\alpha(\tau_j)$. It is even possible that a profit situation occurs that is –from an ex-ante perspective– Pareto-inefficient. An instructive example is depicted in the right diagram of Figure 4. Suppose that HQ ex post wants to maximize $D2$’s profit ($w_1^0 < w_2^0$) and thereby chooses $\tau_C^{\beta_1} = \bar{\tau}_C$ for which $\tau_C^{\beta_1} < \bar{\tau}_C$ holds. As $\tau_C^{\beta_1} < \bar{\tau}_C$ holds, $D1$ anticipates a loss, does not provide any capacity, and there is no transaction. Ex ante, this result is not optimal from any stakeholder’s perspective as there is at least one transfer price, namely $\tau_C = \bar{\tau}_C$, implying positive profits for both divisions. Lemma 3 states all situations of ex-ante inefficient transfer prices.

**Lemma 3.** In scenario $\beta_1$, divisional profits are Pareto-inefficient from an ex-ante perspective, i.e., $(P_{1j}^\alpha(\tau_j^{\beta_1}), P_{2j}^\alpha(\tau_j^{\beta_1})) \notin \partial P_{\beta_1}$, $j \in \{C, R\}$, if and only if

1. $w_1^0 < w_2^0 \land v + k \in (\bar{\tau}_C, \bar{\tau}_C]$ or $w_1^0 > w_2^0 \land \bar{\tau}_C > \tau_C^{\alpha}$ for scheme $C$, resp.

2. $w_1^0 < w_2^0 \land \bar{\tau}_R < \tau_R^{\alpha}$ for scheme $R$

hold.
Proof. The assertion directly follows from the definitions of \( P_j^{\beta_1} \) and \( \tau_j^{\beta_1} \) as well as from Lemmas 1 and 2.

In order to avoid this dilemma, HQ would have to commit herself or to be bound to a range of transfer prices not identified by Lemma 3. On the grounds of the presented model, this commitment can be given by the transfer-pricing scheme: In the above example, scheme \( R \) coupled with any parameter \( \tau_R \in (0, 1) \) implies positive divisional profits and thus an improvement for all stakeholders as opposed to scheme \( C \) and transfer price \( \bar{\tau}_C \). Anticipating this circumstance, HQ would initially choose scheme \( R \) and thereby commit herself for subsequent periods.\(^{41}\) Transfer-pricing guidelines and advance pricing agreements can be interpreted in the same respect. Corresponding to Proposition 4, we make the following statement concerning the preferences over the schemes in scenario \( \beta_1 \):

**Proposition 5.** In scenario \( \beta_1 \), there are intervals \([\bar{\tau}^j_{C}, \bar{\tau}^j_{C}] \subseteq D^\alpha_{C} \) for parameter \( \tau_C \) and \([\bar{\tau}^j_{R}, \bar{\tau}^j_{R}] \subseteq D^\alpha_{R} \) for parameter \( \tau_R \) such that any stakeholder ex ante prefers scheme \( j \in \{C, R\} \) over scheme \( k \in \{C, R\} \setminus j \). The intervals satisfy \([\bar{\tau}^j_{C}, \bar{\tau}^j_{C}] \not\subseteq [v+k, \tau^{\alpha_1}_{1,C}] \land [\bar{\tau}^j_{R}, \bar{\tau}^j_{R}] \not\subseteq [\tau^{\alpha_2}_{2,R}, 1] \).

**Proof.** We have to prove the existence of intervals \([\bar{\tau}^j_{C}, \bar{\tau}^j_{C}] \) and \([\bar{\tau}^j_{R}, \bar{\tau}^j_{R}] \) such that the relation \( \sum_{i=1}^2 w_i \cdot P^\alpha_{i,j}(\tau_j^{\beta_1}) > \sum_{i=1}^2 w_i \cdot P^\alpha_{i,k}(\tau_k^{\beta_1}) \) holds for \( w_i \geq 0 \) and \( w_1 + w_2 = 1 \). The property \([\bar{\tau}^j_{C}, \bar{\tau}^j_{C}] \subseteq [v+k, \tau^{\alpha_1}_{1,C}] \land [\bar{\tau}^j_{R}, \bar{\tau}^j_{R}] \subseteq [\tau^{\alpha_2}_{2,R}, 1] \) induces Pareto-efficient divisional profits and thus must not be satisfied by these intervals. The unanimous preference of scheme \( R \) over scheme \( C \) for \( w_1^0 < w_2^0 \) is shown by the above example \( \bar{\tau}^R_C < v+k \) and \( \bar{\tau}^R_R > 0 \). It is easy to find appropriate examples for the other cases.

**Mutually consistent transfer prices (scenario \( \beta_2 \))**

In scenario \( \beta_1 \), the intervals of admissible transfer prices are considered as independent. However, bearing in mind that data on comparable transactions may depend on the scheme, independent transfer prices are extreme. Going further, one alternative to cope with the fuzziness of transfer pricing is to include data pertaining to more than one scheme. The idea is to find transfer prices that are mutually consistent, i.e., that can be justified by both schemes. Another alternative dealt with in the following section is to deduce transfer prices from the resulting profit allocation. Note that both approaches—as well as independent transfer prices—do not necessarily call for (legal) codification or

\(^{41}\)Cf. Section 2 for reasons that the transfer-pricing scheme cannot be changed deliberately.
have to be carried out explicitly. They rather constitute different ways of modeling the discretion and complexity which is typically associated with the evaluation of transfer prices and with the procedures of this evaluation. For instance, HQ may want to apply a mutual consistent transfer price under scheme $C$ in order to preempt an objection by tax authorities on the basis of scheme $R$.

Mutual consistency itself is a fuzzy notion which can be operationalized in different ways. One possibility is to accept a transfer price as an arm’s length price if it is admissible under both schemes. Thus the set of consistent transfer prices is given by the intersection of the (independent) intervals $[\bar{\tau}_C, \bar{\tau}_C]$ and $[\bar{\tau}_R \cdot p(x), \bar{\tau}_R \cdot p(x)]$. A drawback of this approach is that it is difficult to interpret an empty intersection. Another, more robust approach to ‘average’ the independent parameter intervals $[\bar{\tau}_C, \bar{\tau}_C]$ and $[\bar{\tau}_R, \bar{\tau}_R]$ of scenario $\beta_2$ is as follows: The endpoints of the aggregate interval $[\bar{t}^{\beta_2}, \bar{t}^{\beta_2}]$ are defined as a convex combination of the left resp. the right endpoints of the isolated intervals. The weights used for this convex combination can be interpreted as a measure of adequacy pertaining to the transfer pricing schemes. We assume schemes with equal weights and therefore set $t^{\beta_2} := (\bar{\tau}_C + \bar{\tau}_R \cdot p(x))/2$ and $\bar{t}^{\beta_2} := (\bar{\tau}_C + \bar{\tau}_R \cdot p(x))/2$.

An important observation is that mutual consistency makes the issue of the employed scheme obsolete since always both schemes are considered due to their aggregation. Hence, assertions in the sense of Propositions 4 or 5 cannot be made in scenario $\beta_2$. Proposition 6 states the equilibrium decisions in scenario $\beta_2$. In order to simplify the presentation, it makes use of the parameter $\gamma \in [0, 1]$ representing a standardized transfer price defined as $\gamma := (t - \bar{t}^{\beta_2}) / (\bar{t}^{\beta_2} - \bar{t}^{\beta_2})$, $t \in [\bar{t}^{\beta_2}, \bar{t}^{\beta_2}]$. For example, $\gamma = 0$ (resp. $\gamma = 1$) corresponds with the transfer price $t^{\beta_2}$ (resp. $\bar{t}^{\beta_2}$).

**Proposition 6.** In scenario $\beta_2$, the equilibrium capacity $\bar{x}^{\beta_2}(\gamma)$ and sales volume $x^{\beta_2}(\gamma)$ for (standardized) transfer price $\gamma \in [0, 1]$ are given by

$$\bar{x}^{\beta_2}(\gamma) = x^{\beta_2}(\gamma) = \begin{cases} x_2(\gamma) & \text{if } m_C(\gamma) \geq v + k, \\ \min\{x_1(\gamma), x_2(\gamma)\} & \text{otherwise} \end{cases},$$

where $x_i(\gamma) > 0$, $i \in \{1, 2\}$, and $m_j(\gamma) > 0$, $i \in \{C, R\}$, are defined as

$$x_1(\gamma) := \left( \frac{a \cdot (1-b) \cdot m_R(\gamma)}{v + k - m_C(\gamma)} \right)^{1/b}, \quad x_2(\gamma) := \left( \frac{a \cdot (1-b) \cdot (1-m_R(\gamma))}{m_C(\gamma)} \right)^{1/b},$$

$$m_C(\gamma) := \gamma \cdot \frac{\bar{\tau}_C - \bar{\tau}_C}{2} + \frac{\bar{\tau}_C}{2}, \quad m_R(\gamma) := \gamma \cdot \frac{\bar{\tau}_R - \bar{\tau}_R}{2} + \frac{\bar{\tau}_R}{2} \in (0, 1/2].$$

**Proof.** We start by assuming $m_C(\gamma) \geq v$. Considering that the transfer price $t$ is equivalently given by $m_C(\gamma) + m_R(\gamma) \cdot p(x)$, $D2$’s profit function reads $P_2((\bar{t}^{\beta_2} - t^{\beta_2}) \cdot \gamma + \bar{t}^{\beta_2}, x) =$
\[a(1-m_R(\gamma)x^{1-b}-m_C(\gamma)x.\] Since \(m_C(\gamma) \geq v\) holds, \(D1\) is motivated to deliver and \(D2\) maximizes \(P_2(\cdot)\) over \(x \in [0, \bar{x}]\). The solution is \(\bar{x}^{b_2}(\gamma, \bar{x}) = \min\{\bar{x}, x_2(\gamma)\}\). Thus \(D1\) chooses the capacity which maximizes \(P_1((\bar{t}^{\beta_2}_2-t^{\beta_2}_3)\cdot \gamma + t^{\beta_2}_3, \bar{x}, x) = \alpha m_R(\gamma)x^{1-b}-(v-m_C(\gamma))x-k\bar{x}\) for \(x = \bar{x}^{b_2}(\gamma, \bar{x})\). As excessive capacity cannot be optimal for \(D1\), in equilibrium we have \(\bar{x} \leq x_2(\gamma)\) and thereby \(\bar{x}^{b_2}(\gamma, \bar{x}) = \bar{x}\). For \(m_C(\gamma) < v+k\) the maximizer of \(P_1((\bar{t}^{\beta_2}_2-t^{\beta_2}_3)\cdot \gamma + t^{\beta_2}_3, \bar{x}, \bar{x})\) is \(\bar{x} = x_1(\gamma) \geq x_2(\gamma)\), otherwise \(D1\) wants to expand capacity beyond any bound. \(\bar{x}^{b_2}(\gamma)\) and \(x^{b_2}(\gamma)\) follow immediately.

In case \(m_C(\gamma) < v\) holds, we additionally have to account for \(D1\)'s motivation to deliver when determining the optimal sales volume. This yields the condition \(x \leq x_3(\gamma)\) where \(x_3(\gamma)\) is defined as \(a \cdot m_R(\gamma)/(v-m_C(\gamma))\) implying \(\bar{x}^{b_2}(\gamma, \bar{x}) = \min\{\bar{x}, x_2(\gamma), x_3(\gamma)\}\). Since \(x_3(\gamma) > x_1(\gamma)\) holds, \(D1\) again installs capacity \(\bar{x}^{b_2}(\gamma) = \min\{x_1(\gamma), x_2(\gamma)\}\).

It is not surprising that the aggregation of the transfer pricing schemes \(C\) and \(R\) is reflected by equilibrium decisions in scenario \(\beta_2\). For sufficiently high arm's length prices according to scheme \(C\) - and thereby a high value of \(m_C(\gamma)\) - an equilibrium occurs which is comparable to that of scheme \(C\) in the scenarios \(\alpha\) and \(\beta_1\), respectively: The sales volume is determined by the optimal sales volume from \(D2\)'s perspective (here \(x_2(\gamma)\)), and \(D1\) installs the corresponding capacity. Otherwise, i.e. for sufficiently small arm's length prices according to scheme \(C\), \(D1\) has an incentive to make capacity scarce (here \(x_1(\gamma)\)), in order to benefit from an increasing transfer price. Here, \(D2\) is passive because he always sells up to capacity. Furthermore, it can be shown that any of the two regimes can be induced by an appropriate choice of transfer price \(\gamma\) if the condition \(\tau_C < 2(v+k)\) holds. Otherwise, only the regime of scheme \(C\) occurs.

The left diagram of Figure 5 depicts the equilibrium divisional profits for scenario \(\beta_2\). The underlying parameter constellation is compatible to those of Figures 3 and 4. The set \(P^{\beta_2}_\cdot := \left\{ (P^{\beta_2}_1(\gamma), P^{\beta_2}_2(\gamma)) : \gamma \in [0, 1] \right\}\) is defined in analogy to scenarios \(\alpha\) and \(\beta_1\), where \(P^{\beta_2}_1(\gamma) := P_1((\bar{t}^{\beta_2}_2-t^{\beta_2}_3)\cdot \gamma + t^{\beta_2}_3, \bar{x}^{b_2}(\gamma), x^{b_2}(\gamma))\) and \(P^{\beta_2}_2(\gamma) := P_2((\bar{t}^{\beta_2}_2-t^{\beta_2}_3)\cdot \gamma + t^{\beta_2}_3, x^{b_2}(\gamma))\) are used for notational convenience.

By Figure 5, it is easy to observe that for scenario \(\beta_2\) the dilemma of ex-ante inefficiency of ex-post efficient transfer prices may occur, too. In contrast to scenario \(\beta_1\), here \(HQ\) cannot evade this dilemma by committing herself to one of the schemes in advance. \(HQ\) would rather have to commit herself to a (standardized) transfer price \(\gamma\) which -by definition- is based on both schemes. Note that \(HQ\) has an incentive to manipulate the endpoints \(\tau_j\) and \(\bar{\tau}_j\), \(j \in \{C, R\}\), ex post in a way which is different to that in scenario \(\beta_1\). In scenario \(\beta_1\), \(HQ\) has an incentive to argue in favor of the highest (resp.
smallest) endpoint $\bar{\tau}_j$ (resp. $\overline{\tau}_j$), if $w_1^0 > w_2^0$ (resp. $w_1^0 < w_2^0$) holds. The other endpoint of the applied scheme $j$ as well as the endpoints of the scheme not applied are irrelevant for all stakeholders. A similar effect can be identified for the following scenario $\beta_3$. In scenario $\beta_2$ and given $\gamma \in (0,1)$, however, $HQ$ is interested in increasing ($w_1^0 > w_2^0$) resp. decreasing ($w_1^0 < w_2^0$) all endpoints. This circumstance does not only have to be considered for a comparison of scenarios $\beta_1$, $\beta_2$, and $\beta_3$, but also for an audit of the transfer prices by external stakeholders. Nevertheless, it is questionable whether advance pricing agreements or transfer pricing guidelines are used in praxis for scenarios $\beta_2$ (and $\beta_3$).

Figure 5: Divisional profits in scenarios $\beta_2$ and $\beta_3$ \textsuperscript{42}

Transfer prices depending on profit allocation (scenario $\beta_3$)

A different kind of dependence occurs if acceptance of a transfer price can be traced to the divisional profits induced by it. This perspective sharply reflects that stakeholders are actually interested in divisional profits and that transfer prices are just an instrument to induce and allocate these profits.

We describe the set of admissible divisional profits by means of the interval $[\delta, \overline{\delta}] \subseteq (0,1)$, $\delta < \overline{\delta}$. Ideally, parameter $\delta \in [\delta, \overline{\delta}]$ denotes the share of corporate profit reported

\textsuperscript{42}The parameters are $a=1$, $b=v=k=1/2$, $\tau_C = 4/5$, $\tau_C = 5/3$, $\tau_R = 1/3$, $\tau_R = 2/3$, $\delta = 1/4$, and $\overline{\delta} = 1/2$.
by $D1$.

However, we have to account for the fact that the values of $x, \bar{x}, p(x), v$, and especially $k$ are needed to compute corporate profit $P_0(\bar{x}, x)$. For reasons of asymmetric information, we disregard capacity cost $k$ when calculating corporate profit. Consequently, the parameter $\delta$ relates to the total contribution margin $(p(x)-v) \cdot x$ instead of corporate profit. The functions of divisional profits are $P_1(t^\delta(x), \bar{x}, x) = \delta \cdot (p(x)-v) \cdot x - k \cdot \bar{x}$ and $P_2(t^\delta(x), x) = (1-\delta) \cdot (p(x)-v) \cdot x$ where $t^\delta(x)$ is the corresponding transfer price for sharing parameter $\delta$. It can be computed by expression (1) as follows:

$$P_2(t^\delta(x), x) = (1-\delta) \cdot (p(x)-v) \cdot x \Rightarrow t^\delta(x) = \delta \cdot (p(x)-v) + v.$$ 

An important property of the above profit functions is that they are independent of the transfer pricing scheme. The transfer price does not depend on any parameter of scheme $C$ or $R$, but solely on the parameter $\delta$. The conversion into a transfer price of a certain scheme as $\tau_C = t^\delta(x)$ (scheme $C$) or $\tau_R = t^\delta(x)/p(x)$ (scheme $R$) has no consequence in terms of divisional incentives and profits. Proposition 7 states this result from the stakeholders’ perspectives.

**Proposition 7.** In scenario $\beta_3$, all stakeholders are indifferent as to the scheme of transfer pricing.

**Proof.** Confer to the definitions of $P_1(t^\delta(x), \bar{x}, x)$ and $P_2(t^\delta(x), x)$.

It can be shown by means of the following proposition that incentives in scenario $\beta_3$ are comparable to those in scenario $\beta_1$ for scheme $R$.

**Proposition 8.** In scenario $\beta_3$, the equilibrium capacity $\bar{x}^{\beta_3}(\delta)$ and sales volume $x^{\beta_3}(\delta)$ depending on $D1$’s share of total contribution margin, $\delta \in [0, 1]$, read

$$\bar{x}^{\beta_3}(\delta) = x^{\beta_3}(\delta) = \left(\frac{a \cdot (1-b) \cdot \delta}{\delta \cdot v + k}\right)^{1/b}.$$ 

The equilibrium divisional profits $P_i^{\beta_3}(\delta), i \in \{1, 2\}$, are

$$P_1^{\beta_3}(\delta) = \frac{b \cdot (\delta \cdot v + k)}{1-b} \cdot \left(\frac{a \cdot (1-b) \cdot \delta}{\delta \cdot v + k}\right)^{1/b} > 0,$$

$$P_2^{\beta_3}(\delta) = \frac{(1-\delta) \cdot (\delta \cdot v + k)}{(1-b) \cdot \delta} \cdot \left(\frac{a \cdot (1-b) \cdot \delta}{\delta \cdot v + k}\right)^{1/b} > 0.$$

\[43\text{Cf. the profit split method in OECD (1995, III-1–9).}\]
Proof. The derivation of equilibrium decisions goes along the lines of the proof of Proposition 2. For divisional profits we have $P_1^{\beta_2}(\delta) := P_1(t^\beta(x^{\beta_2}(\delta)), \bar{x}^{\beta_2}(\delta), x^{\beta_2}(\delta))$ and $P_2^{\beta_3}(\delta) := P_2(t^\beta(x^{\beta_3}(\delta)), x^{\beta_3}(\delta))$. \hfill $\square$

Denoting the combinations of ex-ante feasible divisional profits in scenario $\beta_1$ by $P^{\beta_1} := \left\{\left(P_1^{\beta_1}(\delta), P_2^{\beta_1}(\delta)\right) : \delta \in [\bar{\delta}, \delta]\right\}$, the similarity to scenario $\beta_1$ becomes evident: $P^{\beta_1}$ has similar properties as $P^{\beta_3}$ has. Hence, it is possible to make assertions for scenario $\beta_3$ which are similar to those of Lemmas 1, 2 and 3 as well as Proposition 5. Especially the dilemma of ex-ante inefficiency of transfer prices determined ex post by HQ remains. The right diagram of Figure 5 confirms this result.

5 Inclusion of the decision on the scheme

Now, we additionally consider the decision on the scheme. Note that there is no decision on the scheme in scenarios $\beta_2$ and $\beta_3$. In order to sketch the effects of the extension of scenarios $\alpha$ and $\beta_1$, we abstract from implementation costs and assume that the divisions or HQ base the choice of scheme exclusively on the period under consideration.

It is straight forward to integrate the decision on the transfer pricing scheme in the scenario of negotiated transfer prices.\footnote{Cf. Haake & Martini (2004).} The divisions may agree on any profit constellation in $P^{\alpha}_C \cup P^{\alpha}_R$. Presuming Pareto efficiency of the negotiation result, we see that the divisions agree on a point of the Pareto boundary of the union of $P^{\alpha}_C$ and $P^{\alpha}_R$. We further conclude by Lemmas 1 and 2 that this boundary is given by the union of the Pareto boundaries of $P^{\alpha}_C$ and $P^{\alpha}_R$, i.e., $\partial(P^{\alpha}_C \cup P^{\alpha}_R) = \partial P^{\alpha}_C \cup \partial P^{\alpha}_R$.\footnote{Referring to the left diagram of Figure 4 and applying the Nash bargaining solution, the divisions agree on the point $(P_1, P_2) \in \left\{P^{\alpha}_{C,N}, P^{\alpha}_{R,N}\right\}$ the product of divisional profits of which is maximal.}

In the extension of scenario $\beta_1$, HQ’s choice is given by transfer price $t^{\beta_1}$ which reads

$$
t^{\beta_1}(x) = \begin{cases} 
\min\{\tau_C, \tau_R \cdot p(x)\} & \text{if } w^0_1 < w^0_2 \\
\left[\min\{\tau_C, \tau_R \cdot p(x)\}, \max\{\bar{\tau}_C, \tau_R \cdot p(x)\}\right] & \text{if } w^0_1 = w^0_2, \\
\max\{\bar{\tau}_C, \tau_R \cdot p(x)\} & \text{if } w^0_1 > w^0_2
\end{cases}
$$

(7)

where $\beta^e_1$ denotes the extension of scenario $\beta_1$. In the following, we focus on the case $w^0_1 > w^0_2$ so that ex post HQ maximizes the transfer payment for given capacity and sales volume. We further impose the condition $\bar{\tau}_C \geq v+k$ so that scheme $C$ is HQ’s optimal choice for some (sufficiently large) sales volume. Proposition 9 states the equilibrium
divisional decisions and profits. It is important to realize that the proposition focuses on the choice of scheme while abstracting from alternative pricing for a given scheme. Hence, the proposition is based on HQ’s actual choice of the arm’s length price according to (7) rather than on the entire set of admissible prices.

**Proposition 9.** In scenario $\beta^*_i$ with $w_1^0 > w_2^0$, the equilibrium capacity $x^\beta_i$ and sales volume $x^\beta_i$ depending on pricing parameters $\bar{R}_C \geq v + k$ and $\bar{R}_R \in (0, 1)$ are

$$
x^\beta_i = x^\beta_i = \begin{cases} 
x^\alpha_i(\bar{R}_R) & \text{if } \bar{R}_C < \bar{R}_C^\alpha \wedge \bar{R}_R > \frac{(1-b)^b.(\bar{R}_C-(v+k))}{b\cdot\bar{R}_C.(v+k)^{b-1}} \\
\left(\frac{a \cdot \bar{R}_R}{\bar{R}_C}\right)^{1/b} & \text{if } \bar{R}_C \geq \bar{R}_C^\alpha \wedge \bar{R}_R \geq \bar{R}_2^\alpha \\
x^\alpha_i(\bar{R}_C) & \text{otherwise}
\end{cases}
$$

Equilibrium divisional profits in the top (resp. bottom) case of (8) are $P^\beta_i(\bar{R}_C, \bar{R}_R) = P^\alpha_i(\bar{R}_R)$ (resp. $P^\beta_i(\bar{R}_C, \bar{R}_R) = P^\alpha_i(\bar{R}_C)$), $i \in \{1, 2\}$. In the middle case, we have equilibrium profits

$$
P^\beta_i(\bar{R}_C, \bar{R}_R) = \begin{cases} 
(\bar{R}_C-(v+k)) \cdot \left(\frac{a \cdot \bar{R}_R}{\bar{R}_C}\right)^{1/b} & \text{if } i = 1 \\
\bar{R}_C \cdot (1-\bar{R}_R) \cdot \left(\frac{a \cdot \bar{R}_R}{\bar{R}_C}\right)^{1/b} & \text{if } i = 2
\end{cases}
$$

**Proof.** Given $t^\beta_i(x) = \max\{\bar{R}_C, \bar{R}_R \cdot p(x)\}$, D2 solves the following problem at date 3:

$$
P_2(t^\beta_i(x), x) = \begin{cases} 
(1-\bar{R}_R) \cdot a \cdot x^{1-b} & \text{if } x \leq \left(a \cdot \bar{R}_R / \bar{R}_C\right)^{1/b} \\
\bar{R}_C \cdot (a^{1-b} - \bar{R}_C \cdot x) & \text{otherwise}
\end{cases}
\rightarrow \max_{x \in [0, \bar{x}]}.
$$

In (9) two cases occur because HQ switches from scheme $R$ to scheme $C$ if sales volume $x$ exceeds the value $(a \cdot \bar{R}_R / \bar{R}_C)^{1/b}$. Hence, in contrast to (6), we do not have to impose a further condition on sales volume for scheme $R$ in order to guarantee that $D1$ delivers because $\bar{R}_C \geq v + k$ holds by assumption. The solution to (9) is the function $\hat{x}^\beta_i$ with

$$
\hat{x}^\beta_i(\bar{x}) = \begin{cases} 
\min\{\bar{x}, x^\alpha_i(\bar{R}_C)\} & \text{if } \bar{R}_R < 1-b \\
\min\{\bar{x}, (\bar{R}_R / \bar{R}_C)^{1/b}\} & \text{otherwise}
\end{cases}
$$

Assuming $\bar{R}_R < \bar{R}_2^\alpha$, $D1$ maximizes $P_1(t^\beta_i(\hat{x}^\beta_i(\bar{x})), \bar{x}, \hat{x}^\beta_i(\bar{x}))$ given by

$$
P_1(\cdot) = \begin{cases} 
\bar{R}_R \cdot a \cdot x^{1-b} - (v+k) \cdot \bar{x} & \text{if } \bar{x} \leq \left(a \cdot \bar{R}_R / \bar{R}_C\right)^{1/b} \\
(\bar{R}_C-(v+k)) \cdot \bar{x} & \text{if } \bar{x} \in \left(\left(a \cdot \bar{R}_R / \bar{R}_C\right)^{1/b}, x^\alpha_i(\bar{R}_C)\right] \\
(\bar{R}_C-v) \cdot x^\alpha_i(\bar{R}_C) - k \cdot \bar{x} & \text{otherwise}
\end{cases}
$$
The solution \( \bar{x}^{\beta_1} \) bases on the top and middle case of (10) and reads

\[
\bar{x}^{\beta_1} = \begin{cases} 
  x^\alpha_R(\bar{\tau}_R) & \text{if } \bar{\tau}_C < \tau^\alpha_{1,C} \land \bar{\tau}_R > \frac{(1-b)^b(\bar{\tau}_C-(v+k))^b}{b^b \cdot \bar{\tau}_C \cdot (v+k)^b-1} < \tau^\alpha_{2,R} \\
  x^\alpha_C(\bar{\tau}_C) & \text{otherwise}
\end{cases}
\] (11)

Otherwise, i.e., if \( \bar{\tau}_R \geq \tau^\alpha_{2,R} \) applies, D1 maximizes

\[
P_1(t^{\beta_1}(\bar{x}^{\beta_1}(\bar{x})), \bar{x}, x^{\beta_1}(\bar{x})) = \begin{cases} 
  \bar{\tau}_R \cdot a \cdot \bar{x}^{1-b} - (v+k) \cdot \bar{x} & \text{if } \bar{x} \leq \left(a \cdot \bar{\tau}_R / \bar{\tau}_C \right)^{1/b} \\
  (\bar{\tau}_C - v) \cdot (a \cdot \bar{\tau}_R / \bar{\tau}_C)^{1/b} - k \cdot \bar{x} & \text{otherwise}
\end{cases}
\]

by installing capacity

\[
\bar{x}^{\beta_1} = \begin{cases} 
  x^\alpha_R(\bar{\tau}_R) & \text{if } \bar{\tau}_C < \tau^\alpha_{1,C} \\
  (a \cdot \bar{\tau}_R / \bar{\tau}_C)^{1/b} & \text{otherwise}
\end{cases}
\] (12)

Combining (11) and (12) yields the equilibrium in (8).

Referring to Propositions 1–3, equilibrium profit functions are easily verified.

The equilibrium in Proposition 9 results from an involved strategic situation between the divisions and is sensitive to the parameter constellation. However, it can readily be observed that the top (resp. bottom) case in (8) implies a large (resp. small) parameter \( \bar{\tau}_R \) in relation to \( \bar{\tau}_C \) and thus scheme \( R \) (resp. scheme \( C \)) is applied. In these cases, HQ ex post selects that scheme which yields the highest transfer payment and thus the highest profit for D1. In the middle case, the equilibrium divisional decisions are given by the critical sales volume for which HQ switches from scheme \( R \) to scheme \( C \). This can be verified by checking that the resulting transfer prices are equal across the schemes, i.e., \( \bar{\tau}_R \cdot p(x^{\beta_1}) = \bar{\tau}_C \) holds.

The numerical example in Table 1 demonstrates that the possibility of inefficiency carries over to scenario \( \beta_1^e \). We start explanations by the top case in (8) which corresponds to the first two parameter settings in the table. In parameter setting 1, HQ chooses scheme \( R \) at date 5 and earns a higher weighted profit than she would earn under scheme \( C \) if she had been able to commit to this scheme before date 2. In setting 2, however, choosing scheme \( R \) is inefficient because a commitment to scheme \( C \) would have induced an increase of weighted corporate profit. The reason for this effect is that HQ takes the decision on the scheme solely on the basis of maximal transfer payment and thus on maximal upstream profit while neglecting the other division’s profit since \( w^1_1 > w^1_2 \) holds. However, by Lemmas 1 and 2 we know that in the top case of (8)
scheme $R$ cannot yield higher profits for the downstream division than scheme $C$. Hence, given a parameter setting satisfying the top case in (8), the inefficiency effect described above for $HQ$ occurs for any stakeholder characterized by a sufficiently small weight $w_i$. Parameter settings 4 and 5 illustrate that equivalent effects may be observed in the opposite direction (bottom case in (8)).

<table>
<thead>
<tr>
<th>parameter setting</th>
<th>$\beta_1$ (scheme $C$)</th>
<th>$\beta_1$ (scheme $R$)</th>
<th>$\beta_1^c$</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 $\tau_C = 1.5$</td>
<td>$P_{1,C}^\alpha(\tau_C) = 5.56$</td>
<td>$P_{1,R}^\alpha(\tau_R) = 9$</td>
<td>$P_{1}^{\beta_1}(\tau_C, \tau_R) = 9$</td>
</tr>
<tr>
<td>$\tau_R = 0.6$</td>
<td>$P_{2,C}^\alpha(\tau_C) = 16.67$</td>
<td>$P_{2,R}^\alpha(\tau_R) = 12$</td>
<td>$P_{2}^{\beta_1}(\tau_C, \tau_R) = 12$</td>
</tr>
<tr>
<td>$\sum_{i=1}^2 w_i^0 \cdot P_{i,C}^\alpha(\tau_C) = 10$</td>
<td>$\sum_{i=1}^2 w_i^0 \cdot P_{i,R}^\alpha(\tau_R) = 10.2$</td>
<td>$\sum_{i=1}^2 w_i^0 \cdot P_{i}^{\beta_1}(\tau_C, \tau_R) = 10.2$</td>
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</tr>
<tr>
<td>2 $\tau_C = 1.5$</td>
<td>$P_{1,C}^\alpha(\tau_C) = 5.56$</td>
<td>$P_{1,R}^\alpha(\tau_R) = 6.25$</td>
<td>$P_{1}^{\beta_1}(\tau_C, \tau_R) = 6.25$</td>
</tr>
<tr>
<td>$\tau_R = 0.5$</td>
<td>$P_{2,C}^\alpha(\tau_C) = 16.67$</td>
<td>$P_{2,R}^\alpha(\tau_R) = 12.5$</td>
<td>$P_{2}^{\beta_1}(\tau_C, \tau_R) = 12.5$</td>
</tr>
<tr>
<td>$\sum_{i=1}^2 w_i^0 \cdot P_{i,C}^\alpha(\tau_C) = 10$</td>
<td>$\sum_{i=1}^2 w_i^0 \cdot P_{i,R}^\alpha(\tau_R) = 8.75$</td>
<td>$\sum_{i=1}^2 w_i^0 \cdot P_{i}^{\beta_1}(\tau_C, \tau_R) = 8.75$</td>
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<tr>
<td>3 $\tau_C = 2.1$</td>
<td>$P_{1,C}^\alpha(\tau_C) = 6.24$</td>
<td>$P_{1,R}^\alpha(\tau_R) = 9$</td>
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<tr>
<td>$\tau_R = 0.6$</td>
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<td>$P_{2,R}^\alpha(\tau_R) = 12$</td>
<td>$P_{2}^{\beta_1}(\tau_C, \tau_R) = 11.43$</td>
</tr>
<tr>
<td>$\sum_{i=1}^2 w_i^0 \cdot P_{i,C}^\alpha(\tau_C) = 8.5$</td>
<td>$\sum_{i=1}^2 w_i^0 \cdot P_{i,R}^\alpha(\tau_R) = 10.2$</td>
<td>$\sum_{i=1}^2 w_i^0 \cdot P_{i}^{\beta_1}(\tau_C, \tau_R) = 9.96$</td>
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<td>4 $\tau_C = 2$</td>
<td>$P_{1,C}^\alpha(\tau_C) = 6.25$</td>
<td>$P_{1,R}^\alpha(\tau_R) = 4$</td>
<td>$P_{1}^{\beta_1}(\tau_C, \tau_R) = 6.25$</td>
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<td>$\tau_R = 0.4$</td>
<td>$P_{2,C}^\alpha(\tau_C) = 12.5$</td>
<td>$P_{2,R}^\alpha(\tau_R) = 12$</td>
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<tr>
<td>$\sum_{i=1}^2 w_i^0 \cdot P_{i,C}^\alpha(\tau_C) = 8.75$</td>
<td>$\sum_{i=1}^2 w_i^0 \cdot P_{i,R}^\alpha(\tau_R) = 7.2$</td>
<td>$\sum_{i=1}^2 w_i^0 \cdot P_{i}^{\beta_1}(\tau_C, \tau_R) = 8.75$</td>
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<tr>
<td>5 $\tau_C = 3$</td>
<td>$P_{1,C}^\alpha(\tau_C) = 5.56$</td>
<td>$P_{1,R}^\alpha(\tau_R) = 4$</td>
<td>$P_{1}^{\beta_1}(\tau_C, \tau_R) = 5.56$</td>
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<tr>
<td>$\tau_R = 0.4$</td>
<td>$P_{2,C}^\alpha(\tau_C) = 8.33$</td>
<td>$P_{2,R}^\alpha(\tau_R) = 12$</td>
<td>$P_{2}^{\beta_1}(\tau_C, \tau_R) = 8.33$</td>
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<tr>
<td>$\sum_{i=1}^2 w_i^0 \cdot P_{i,C}^\alpha(\tau_C) = 6.67$</td>
<td>$\sum_{i=1}^2 w_i^0 \cdot P_{i,R}^\alpha(\tau_R) = 7.2$</td>
<td>$\sum_{i=1}^2 w_i^0 \cdot P_{i}^{\beta_1}(\tau_C, \tau_R) = 6.67$</td>
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Table 1: Numerical example for scenarios $\beta_1$ and $\beta_1^c$ \[46\]

Setting 3 corresponds to the middle case in (8). The circumstance that scheme $R$ in scenario $\beta_1$ yields higher profits for both divisions than scenario $\beta_1^c$ is systematic because

\[46\] The other parameters are $a = v + k = 1$, $b = 1/2$, $w_i^0 = 3/5$, and $w_i^2 = 2/5$. All profits are multiplied by 100 and rounded to two digits after the decimal point.
it can be shown that the following profit relations hold:

\[ P_{1,C}^{\alpha} (\bar{\tau}_C) \leq P_{1}^{\beta^e_1} (\bar{\tau}_C, \bar{\tau}_R) \leq P_{2}^{\beta^e_1} (\bar{\tau}_C, \bar{\tau}_R) \leq P_{2,C}^{\alpha} (\bar{\tau}_C), \]

Consequently, any stakeholder prefers confinement to scheme R to scenario \( \beta^e_1 \) if maximal admissible transfer pricing parameters satisfy \( \bar{\tau}_C \geq \tau_{1,C}^{\alpha} \) and \( \bar{\tau}_R \geq \tau_{2,R}^{\alpha} \).

Finally, putting the three cases together we learn that there is no stakeholder who strictly prefers scenario \( \beta^e_1 \) to scenario \( \beta_1 \) if in the latter scenario that scheme is applied which is best from his perspective. This underpins the fact that a high degree of discretion as to arm’s length prices may be harmful to efficiency and that an ex-ante commitment may prevent such situations of inefficiency.

### 6 Conclusion

This paper examines the conflict between coordination and profit determination in a decentralized firm. This conflict is most pronounced for firms using the same transfer price for both functions. On the basis of the arm’s length principle, we first argue that admissible transfer prices are either negotiated between the divisions before or administered by headquarters after the divisions have taken the decisions delegated to them.

We find that negotiations protect all stakeholders from Pareto-inefficient divisional profits regardless of the parameter setting and the transfer-pricing scheme. Furthermore, we observe that the preference over the schemes always depends on the stakeholder’s type. Thus headquarters has a strong incentive to select (at least) the scheme, whereas the actual transfer price remains negotiable. It is important to realize that this preference result cannot be generalized. For instance, in the investment setting introduced by Haake & Martini (2004), it can be shown that there are parameter settings for which all stakeholders prefer the same scheme.

For administered transfer prices, we propose three ways how (relevant) stakeholders deal with the fuzziness of the arm’s length principle. Whereas the approach of ‘independent’ transfer prices preserves a strong dependence of stakeholders’ preferences on the scheme, ‘mutually consistent’ and ‘profit-based’ transfer prices dissolve it. All three approaches, however, ex ante may lead to Pareto-inefficient divisional profits. Note that this result contrasts with the idea proposed by other authors that headquarters ex ante may choose a transfer price in anticipation of its effect on both coordination and profit.
determination.\footnote{Cf. Schjelderup & Sorgard (1997), Narayanan & Smith (2000), or Baldenius et al. (2004).} We posit that headquarters cannot easily commit herself not to select the ex-post optimal transfer price so that coordination is actually dominated by profit determination. One instrument to avoid this dilemma are advance pricing agreements or transfer pricing guidelines. In this context, it can also be inferred from our analysis that ex-post discretion over transfer prices may mitigate negative effects on coordination. Hence, with regard to Smith (2002a), we show that a positive effect of ex-post discretion does not necessitate ex-ante discretion. We further show that an endogenous choice of the transfer-pricing scheme also has an effect on divisional decisions but does not improve divisional profits.

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