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Vertical Financial Interest and Corporate Influence

Matthias Hunold[*] and Frank Schlütter[†]

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Abstract

The established literature on partial vertical ownership has derived distinct pro- and anti-competitive effects, depending on whether the upstream or the downstream firm holds the shares (forward or backward). We show that forward ownership can have the same effects as backward ownership (and vice versa) when it entails both profit and control rights. Moreover, we demonstrate novel anti-competitive effects of partial ownership that arise when the upstream tariffs are non-linear. This contrasts well-established findings that are based on linear tariffs and adds to the current debate on how to treat partial shareholdings in merger control.

JEL classification: L22, L40, L8

Keywords: corporate influence, financial interest, minority shareholding, partial ownership

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1 Introduction

Recent econometric and survey-based studies provide evidence that minority shareholders influence the target firms' strategies in an anti-competitive way. Azar et al. (2016) show that common ownership of large institutional investors and cross-ownership between competing US banks are positively associated with higher prices in this industry. Similarly, Nain and Wang (2018) report for a cross-section of US manufacturing industries that partial ownership between competitors is associated with higher prices and profits. Whereas the main effects of ownership links between competitors (horizontal ownership) appear to be well understood, the effects of ownership between firms in a supply relationship (vertical ownership) are arguably less clear. Vertical ownership is, however, prevalent in various industries. Examples include cable operators and broadcasters, banks and payment providers, financial exchanges and clearing houses, as well as automobile producers and their suppliers.[1]

A developing theoretical literature indeed studies the competitive effects of partial vertical ownership. This literature distinguishes between forward ownership, where an upstream firm partially owns a downstream firm, and the reverse case of backward ownership. One strand of this literature points out that foreclosure may arise if a partial owner has full control and only limited profit rights of a vertically related firm (Baumol and Ordover, 1994; Spiegel, 2013; Levy et al., 2018). We mainly build on a second strand which focuses on the polar case of non-controlling ownership and shows that partial vertical ownership can affect prices in different directions. A central insight of the literature is that the direction of ownership matters for the competitive effects. Forward ownership is shown to be rather pro-competitive by reducing downstream prices compared to vertical separation (Flath, 1989; Fiocco, 2016), whereas backward ownership does not have this feature (Greenlee and Raskovich, 2006), but can instead increase prices (Hunold and Stahl, 2016).

The analyses of the polar cases of non- controlling and fully-controlling partial ownership provide clean theoretical benchmarks. Yet, the implications for the arguably highly – if not most – relevant case that ownership includes both partial profit and partial control

[1] See Brito et al. (2016), Greenlee and Raskovich (2006), Hunold (2017), and Hunold and Shekhar (2018) for the different cases.

rights (or less formal means of influence) are not fully developed.[2] We contribute by showing that a distinct treatment of forward and backward ownership can be misleading if the corporate shareholders can (partially) influence the target's strategy, for instance, by means of control rights. We model corporate influence as a channel that induces the target firm to internalize the objectives of the acquiring firm. This has conceptually the same effect *as if* the target firm had a financial interest in the acquiring firm (O'Brien and Salop, 2000). By applying this logic to vertical relations, we demonstrate that, if corporate influence is involved, partial forward and backward ownership can have a similar or even equivalent impact on the objectives and strategies of firms (Section 2). This implies that competitive effects, which have so far been attributed to forward ownership, can also materialize in the case of backward ownership (and vice versa). Consequently, much of the existing economic literature on – particularly non-controlling – partial ownership should be read and interpreted with this insight in mind. In general, the analysis of partial vertical ownership should focus on forward and backward profit internalization, and not merely on the direction of ownership as such.

Partial vertical ownership (either forward or backward), which endows the vertically related owner with both influence over the target and part of its profit, generally leads to forward and backward internalization at the same time (bi-directional internalization). It is therefore *a priori* not clear how the separate effects of pure forward and backward internalization, which have been studied in previous articles, interact with each other. We study this question in detail in Section 5.

One important finding is that the competitive effects depend on whether there is upstream competition and not primarily on the direction of ownership. With linear tariffs and upstream competition, for instance, bi-directional internalization either has no effect on consumer prices or increases them, in line with the results of Greenlee and Raskovich (2006) and Hunold and Stahl (2016) for non-controlling backward ownership. With upstream monopoly and linear tariffs, instead, partial vertical ownership with bi-directional internalization tends to reduce the consumer prices, as has also been shown by Flath (1989) (for non-controlling forward ownership) and Brito et al. (2016) (for influential backward ownership).

[2]For instance, McCahery et al. (2016) document that institutional investors use behind-the-scenes interventions in order to influence a target firm's corporate governance. See Section 2.1 for details.

Another important finding is that the competitive effects of partial vertical ownership arrangements pivotally depend on the supply contracts. In particular, we identify anti-competitive effects of partial vertical ownership when firms use either observable or unobservable two-part tariffs. This occurs in cases where the assumptions of linear tariffs and upstream monopoly suggest pro-competitive (Flath, 1989; Brito et al., 2016) or no effects (Greenlee and Raskovich, 2006). This shows that changing either the assumption of upstream monopoly or the assumption of linear supply contracts can instead yield strong anti-competitive results of partial vertical ownership. In particular, we demonstrate that, if competing downstream firms have a relevant supply alternative and tariffs are observable, the supplier can extract more profits from them by selling at marginal prices below the level that maximizes industry profits (Caprice, 2006). We show in Section 4 that forward internalization reduces the supplier's incentive to charge low marginal prices and high fixed fees, which in turn leads to higher marginal input costs and output prices downstream. The incentive to decrease the downstream firms' outside option and its interaction with partial vertical ownership drives the results with observable tariffs. This strategic channel is not present if a supplier's contract offers are unobservable.[3] We show that partial vertical ownership with elements of forward internalization is nevertheless anti-competitive in this case (Section 6.1). The partial internalization of downstream profits helps the supplier to overcome the well-known *commitment problem* (Hart et al., 1990), which can lead to cost-based marginal input prices and low profits under vertical separation.

Whereas we use symmetric vertical ownership as a tractable framework for our main analyses, we extend our analysis in Section 6.2 to asymmetric shareholdings. This analysis confirms that the overall effect of asymmetric ownership on the price level and consumer surplus tends to go in the same direction as that of symmetric ownership. The section also relates to the literature on foreclosure and shows that, with asymmetric ownership, one downstream firm can obtain more favorable contract terms than its downstream competitor. Moreover, in Section 6.3, we argue that partial vertical ownership can be profitable for the industry as a whole and for the firms involved in a partial ownership acquisition, especially with two-part tariffs.

[3]With unobservable contracts, a downstream firm does not observe the offers that the supplier has made to competing downstream firms when it has to accept its own offer.

Our results are of relevance for the current competition policy debate on minority shareholdings. Competition authorities are increasingly wondering how to deal with partial ownership. For instance, the European Commission considers in a recent public consultation whether and, if yes, how to extend its merger control to the acquisition of minority shareholdings, which is so far not the case.[4] As of today, the European Commission has jurisdiction to review the acquisition of shares only if the acquiring firm obtains *decisive influence* over the target firm. It does acknowledge, however, that less influential shareholdings may also restrict competition. This is consistent with the economic theory that competition is dampened when a firm can influence the strategic decisions of a competitor or when it (partially) internalizes the competitor's profit (Reynolds and Snapp, 1986; Brito et al., 2018).

The present article contributes to this debate in two regards. First, we emphasize that the distinction of profit claims and (potentially less than decisive) influence is particularly important in the domain of partial vertical ownership as profit claims and influence can lead to opposite effects. Second, an important question in the debate is which criteria – such as thresholds for profit shares and control rights – an acquisition should reach to be subject to a review. Our analysis suggests that a differential treatment of profit and control rights may not be optimal because control rights in one direction (forward or backward) can have the same effect as profit rights in the other direction. What matters for the potential competitive effects is the strength and direction of profit internalization that arises from profit claims and control rights associated with an ownership stake. Moreover, it is crucial to take into account the pricing schemes of the vertically related firms to correctly assess the price effects. We conclude in Section 7 with a more detailed discussion of how our results can improve the economic analyses of partial vertical ownership and how that could find consideration in competition policy.

2 Objective functions under partial ownership

In this section, we develop the objective functions of the upstream and the downstream firms when there is a partial ownership link between two or several of them. We distinguish

[4]See the 2014 European Commission's White Paper "Towards more effective EU merger control" and its Annex II for a comprehensive overview.

between the effect of a profit participation and the effect of influence.

2.1 Profit participation and influence

An equity stake of a firm generally entitles the shareholder to a share of the target's profits and the right to participate in its decision-making process (we refer to the latter as *corporate influence*).[5] We take the differences between profit shares and influence into account by distinguishing between the profit share α and the degree of influence β for a particular ownership stake. If there are two or more types of influential shareholders, it is necessary to define how the target's strategy balances the shareholder's objectives. We follow O'Brien and Salop (2000) and formalize this translation by assuming that the target firm's objective function consists of a weighted sum of its shareholders' objective functions, with the weights being the respective degrees of influence.[6]

We allow for a general relationship between profit participation and corporate influence as a shareholder's effective degree of influence may differ from the profit share in various ways. For instance, multi-class share structures generally do not fulfill proportionality in the sense of *one share, one vote* (see Bebchuk et al., 2000). For example, *Google LLC* and – since 2016 – also *Facebook Inc.* have issued three different share classes.[7] The first class has one vote per share whereas the second class has no voting rights. Both classes trade publicly. The third class has ten votes per share and is generally held by company insiders and not traded publicly. With these different share classes, voting rights are not proportional to the profit rights.

Other mechanisms that aim at enhancing corporate influence for one group of shareholders include *stock pyramids* and *golden shares* that confer only corporate influence but no profit claims.[8] Moreover, the degree of a shareholder's actual influence not only depends

[5]Partial ownership may include rights to information, which we do not model separately, but assume to be part of the ability to influence the target firm. For example, the European Directive on the Exercise of Shareholder Rights (2007/36/CE) and its amendment (2017/828) seek to ensure that shareholders obtain all relevant information for voting in general annual meetings.

[6]For instance, Antón et al. (2018), Brito et al. (2016), Levy et al. (2018), and López and Vives (forthcoming) also make this assumption. Azar (2017) and Brito et al. (2018) provide micro-foundations for this approach.

[7]See the following article on www.cnbc.com on the prevalence of multi-class share structures in the Russel 3000 (last accessed February 2019).

[8]See the Report on the Proportionality Principle in the EU of 2007, undertaken by Institutional Shareholder Services in collaboration with Sherman & Sterling LLP and the European Corporate Governance Institute on behalf of the European Commission.

on the number of votes, but also on whether these votes are pivotal for a voting outcome. This depends – among other things – on the exact governance provisions of the target firm (majority vote, etc.), the distribution of the remaining shares, and the particular legal rules. In order to protect their financial interests, minority shareholders might also have certain veto rights that allow them to veto on matters such as changes in the statutes, capital increases or liquidation. As already argued in the introduction, besides these formal mechanisms, there is evidence that institutional investors also use behind-the-scenes interventions, such as private discussions with the top management or with members of the company board, to exert influence (McCahery et al., 2016). The approach therefore nests any combination of profit participation and partial corporate influence, including proportional influence ($\alpha = \beta$) and non-controlling ownership ($\beta = 0$).

We apply this approach to a vertically related industry. In particular, we study the case in which an upstream firm has partial ownership of one or more downstream firms, as well as the reverse case of backward ownership.[9] Upstream firm U produces inputs, which the two downstream firms A and B transform into final products. The reference case of *vertical separation* is that each firm is owned by a different outside investor with no other interest in the industry. In this case, each downstream firm $i \in \{A, B\}$ maximizes shareholder value by maximizing its operational profits, denoted by π_i and π^U. We denote with Ω_i and Ω^U the objective functions, which may include (fractions of) the other firms' profits (partial profit internalization).

Alternative interpretations of partial internalization. Our analyses also apply to other mechanisms that induce an equivalent form of partial profit internalization. For instance, a divisionalization strategy can prompt different units of an integrated firm to not (fully) internalize each other's profits (Baye et al., 1996). Crawford et al. (2018) empirically investigate the effects of vertical integration in the US television market and estimate that a downstream unit of an integrated firm only internalizes 79% of its fully integrated upstream unit's profits. They argue that this imperfect internalization can be due to intra-firm frictions, such as poor management or conflicts between the managers of different divisions. Managers' compensation schemes can also induce partial profit

[9] We focus on market structures with one strategic upstream firm. The insights also apply to cases with more than one strategic upstream firm.

internalization. For industries with common ownership, Antón et al. (2018) find that compensation schemes depend more on industry performance and less on the firm's own performance. This induces managers to internalize the profits of other firms even absent (direct) ownership links between them.

2.2 Single vertical ownership relation

Here, we study the case that supplier U has partial ownership of downstream firm i (forward ownership), and that this is the only ownership link between firms in the industry. The same analysis applies to the analogous case of backward ownership. We generalize the analysis of a single ownership relation to multiple ownership links in Section 2.3.

Target firm i has two shareholders with different objectives. The initial shareholder only holds shares of firm i and has no other interests in this industry. Therefore, this shareholder's objective is to maximize i's operational profit π_i. The total profit of the second shareholder, upstream firm U, is

$$\Omega^U = \pi^U + \alpha_{Ui}\pi_i, \tag{1}$$

where α_{Ui} denotes the profit participation. Both operational profits generally depend on the strategic decisions of downstream firm i, for instance, its supplier choice and pricing. Unsurprisingly, there can be a conflict of interest with respect to the profit of firm i and supplier U, for instance, when bargaining over input prices. Upstream firm U can therefore have an incentive to influence the strategy of downstream firm i in order to increase π^U. We allow that the ownership stake confers influence over the target firm i to U. The management of target firm i balances the interests of the shareholders by maximizing a weighted average of the shareholders' objective functions according to their degree of influence. Parameter $\beta_{Ui} \in [0, 1]$ denotes the influence of firm U, and $1 - \beta_{Ui}$ correspondingly the influence of the initial shareholder. Formally, the objective function of downstream firm i is

$$\begin{aligned} \tilde{\Omega}_i &= \beta_{Ui}\,\Omega^U + (1 - \beta_{Ui})\pi_i \qquad (2) \\ &= \beta_{Ui}\,\pi^U + (1 - \beta_{Ui}\,(1 - \alpha_{Ui}))\,\pi_i. \end{aligned}$$

We can further simplify the objective function by defining the *coefficient of U's corporate influence* over firm i:

$$\sigma_{Ui}\left(\alpha_{Ui},\beta_{Ui}\right)\equiv\frac{\beta_{Ui}}{1-\beta_{Ui}\left(1-\alpha_{Ui}\right)}. \tag{3}$$

For a given corporate influence $\beta_{Ui}>0$, the influence coefficient σ_{Ui} decreases in the profit participation α_{Ui}, whereas it increases in the degree of influence β_{Ui}. We can rewrite the objective function as

$$\tilde{\Omega}_i \;=\; \left(1-\beta_{Ui}\left(1-\alpha_{Ui}\right)\right)\left[\pi_i+\sigma_{Ui}\pi^U\right]. \tag{4}$$

The pre-multiplied factor $(1-\beta_{Ui}\left(1-\alpha_{Ui}\right))$ does not affect the firm's optimal strategy. To simplify, we therefore redefine the objective function as

$$\Omega_i=\pi_i+\sigma_{Ui}\,\pi^U. \tag{5}$$

We use this function to analyze the optimal sourcing and pricing strategies for a given ownership structure. The corporate influence coefficient σ_{Ui} measures the weight of U's operational profit π^U in i's objective function relative to target i's operational profit. For $\sigma_{Ui}>0$, the target firm i partially internalizes the upstream firm's profit, even though it does not hold any shares of U in this example. It turns out that the same profit internalization emerges if the target firm i obtains an equal-sized share of the upstream firm's profit. In order to account for the fact that different ownership structures can lead to equivalent degrees of profit internalization, we introduce

Definition 1. If a downstream firm internalizes (a share of) the upstream profit, we refer to this as (partial) *backward internalization.* Analogously, we refer to (partial) *forward internalization* if the upstream firm internalizes (a share of) a downstream firm's profit.

Comparison of backward and forward ownership. Table 1 summarizes the objective functions of both the acquiring and the target firm under forward and backward ownership. In each case, the objective function is a weighted sum of the firm's own operational profit and the profit of the vertically related firm. Consequently, influential forward ownership induces an equivalent objective function for downstream firm i as backward ownership when the coefficient of U's corporate influence, σ_{Ui}, equals the backward ownership stake α_{iU}, that is $\alpha_{Ui} = \sigma_{iU}$. The same holds for the effect of influential backward ownership on the objective function of upstream firm U. We conclude that both forward and backward ownership can lead to either forward internalization, backward internalization, or internalization in both directions (bi-directional internalization).

For example, consider that upstream firm U has forward ownership with a 20% profit share of firm i and proportional influence ($\alpha_{Ui} = \beta_{Ui}$). This yields a corporate influence coefficient of $\sigma_{Ui} = 24\%$. The resulting objective function of downstream firm i is equivalent to the case that downstream firm i obtains a $\alpha_{iU} = 24\%$ share of firm $U's$ profit because of non-controlling partial backward ownership.[10]

		Partial ownership forward	Partial ownership backward
Partial internalization	forward	$\Omega^U = \pi^U + \alpha_{Ui}\pi_i$	$\Omega^U = \pi^U + \sigma_{iU}\pi_i$
	backward	$\Omega_i = \pi_i + \sigma_{Ui}\pi^U$	$\Omega_i = \pi_i + \alpha_{iU}\pi^U$

Table 1: Objective functions with one ownership link

The table shows the objective functions of supplier U and downstream firm i with a single ownernship link that confers partial influence over the target firm's strategy.

The following proposition summarizes the result that corporate influence can induce equivalent objective functions compared to financial profit participation.

Proposition 1. *Let a firm hold an ownership share α with associated influence β of a target firm, whereas there are not any other ownership links within the industry. The resulting objective function of the target firm is the same as when the target instead holds partial ownership of the acquiring firm with a profit share equal to $\sigma = \beta / (1 - \beta(1 - \alpha))$.*

The result is an application of O'Brien and Salop (2000) and holds independent of whether the firms are vertically related. Applying this insight to vertically related firms, we obtain

Corollary 1. *A single forward ownership relation with profit rights α_{Ui} and corporate*

[10] Assuming proportional influence ($\alpha_{Ui} = \beta_{Ui}$) implies $\sigma_{Ui} = \alpha_{Ui} / (1 - \alpha_{Ui}(1 - \alpha_{Ui}))$ (using Equation (3)). A profit share of $\alpha_{Ui} = 20\%$ implies $\sigma_{Ui} = 24\%$, which means that the equivalent backward profit share amounts to $\alpha_{iU} = 24\%$.

influence σ_{Ui} yields the same objective functions as a single backward ownership relation with profit rights $\alpha_{iU} = \sigma_{Ui}$ and corporate influence $\sigma_{iU} = \alpha_{Ui}$, and vice versa.

For the literature on partial vertical ownership, it is arguably an important new insight that both directions of partial ownership (forward and backward) can induce equivalent objective functions for up- and downstream firms if partial ownership entails corporate influence. This equivalence implies that the competitive effects of partial ownership, which the literature has identified for one direction of ownership, can also materialize in the other direction.

2.3 Several vertical ownership relations

Forward ownership. We now allow upstream firm U to hold partial ownership of both downstream firms (common ownership). In this case U's objective function becomes

$$\Omega^U = \pi^U + \alpha_{UA}\pi_A + \alpha_{UB}\pi_B, \tag{6}$$

and the objective function of a downstream firm, say A, becomes

$$\begin{aligned} \tilde{\Omega}_A &= \beta_{UA}\Omega^U + (1-\beta_{UA})\pi_A \\ &= \beta_{UA}\pi^U + (1-\beta_{UA}(1-\alpha_{UA}))\,\pi_A + \alpha_{UB}\beta_{UA}\pi_B. \end{aligned} \tag{7}$$

Downstream firm A now internalizes the operational profit π_B of its downstream competitor. By the same logic as above, it is equivalent to consider the simplified objective function

$$\Omega_A = \pi_A + \sigma_{UA}\left(\pi^U + \alpha_{UB}\pi_B\right), \tag{8}$$

with $\sigma_{UA} = \beta_{UA}/\left(\beta_{UA}(1-\alpha_{UA})\right)$. The partially owned firm A (partially) internalizes the operational profit of the acquiring firm, plus U's profit participation of the other downstream firm B. The latter implies that the downstream firm A directly internalizes the profits of its competitor B. This horizontal profit internalization does not arise when the supplier has forward ownership of only one downstream firm. We summarize in

Lemma 1. *Consider that supplier U holds influential ownership stakes in both down-*

stream firms. The resulting objective function of downstream firm i contains a share of the rival downstream firm's profit π_{-i} (horizontal profit internalization).

As a common owner induces the downstream firms to internalize each other's profit, this ownership arrangement can reduce competition in the downstream market (Schmalz, 2018). The effect of horizontal internalization under common ownership already emerges if upstream firm U participates only in the profit of one downstream firm (say B) and exercises corporate influence over the other downstream firm (say A). This implies that downstream firm A partially internalizes the profit of downstream firm B.

Backward ownership. This form of direct horizontal profit internalization does not emerge under backward ownership with several ownership links. Too see this, suppose that each downstream firm partially owns supplier U. The objective function of a downstream firm is

$$\Omega_i \quad = \quad \pi_i + \alpha_{iU}\pi^U, \tag{9}$$

as in the case of a single backward ownership relation. Backward ownership endows each downstream firm $i \in \{A, B\}$ with degrees of influence β_{AU} and β_{BU} over U, such that the initial owner is left with influence of $1 - \beta_{AU} - \beta_{BU}$. The resulting objective function of supplier U is

$$\tilde{\Omega}^U \quad = \quad \beta_{AU}\Omega_A + \beta_{BU}\Omega_B + (1 - \beta_{AU} - \beta_{BU})\pi^U. \tag{10}$$

Defining the *coefficient of corporate influence* over U as

$$\sigma_{iU}\left(\alpha_{AU}, \alpha_{BU}, \beta_{AU}, \beta_{BU}\right) \equiv \frac{\beta_{iU}}{1 - \beta_{AU}\left(1 - \alpha_{AU}\right) - \beta_{BU}\left(1 - \alpha_{BU}\right)} \tag{11}$$

allows us to write firm U's (simplified) objective function as

$$\Omega^U \quad = \quad \pi^U + \sigma_{AU}\pi_A + \sigma_{BU}\pi_B. \tag{12}$$

An inspection of the objective functions (9) and (12) leads to

Lemma 2. *Direct horizontal internalization does not emerge under backward ownership by several competing downstream firms.*

Comparing Lemmas 1 and 2 suggests that influential forward ownership of competing downstream firms is anti-competitive in itself as it induces a direct horizontal profit internalization in the downstream market. As we will show, even vertical internalization (forward or backward) alone can have anti-competitive effects that should find consideration in the assessment of partial ownership among vertically related firms. In order to focus on these effects, we mainly consider ownership structures that do not induce a horizontal profit internalization between competing downstream firms.

3 Competitive framework

To study the competitive effects of partial vertical ownership, we set up a model that allows for both upstream and downstream competition. The production of one unit of downstream output requires one unit of a homogeneous input. There are two upstream firms producing the input goods. The efficient upstream firm U produces the input at marginal costs normalized to zero. In addition, there is a less efficient competitive fringe, denoted by V, which can also produce the input, but at higher marginal costs of $c > 0$. The cost difference between the efficient supplier and the fringe, c, is a measure for the intensity of upstream competition. If c is large, the competitive fringe is not a relevant competitor and the efficient supplier can set wholesale contracts effectively as upstream monopolist. For sufficiently small cost differences, the fringe is a relevant supply alternative and its presence constrains the price setting of the efficient supplier. This improves the downstream firms' position *vis-à-vis* the efficient supplier U. In either case, the efficient upstream firm (weakly) prefers to serve each downstream firm instead of letting it source from the fringe or instead of foreclosing it from the market.

The efficient upstream firm offers two symmetric downstream firms indexed with $i \in \{A, B\}$ an observable contract that has a linear (marginal) price w_i and a non-linear upfront fee f_i that the downstream firm pays upon contract acceptance. For $f_i = 0$, the tariff is linear. The two downstream firms purchase the input in order to produce substitutable products on a one-to-one basis. Denote the reduced form downstream profits before fixed fees, which depend on the firms' input prices, with $\pi_i(w_i, w_{-i}) = (p_i - w_i) q_i$. The reduced profits are consistent with both quantity and imperfect price competition in the downstream market. Assume that the operational profits are symmetric and have the following standard properties.[11]

Assumption 1. *The operational downstream profit $\pi_i(w_i, w_{-i})$ decreases in the own input costs: $\partial\pi_i/\partial w_i < 0$, and increases in the competitor's input costs: $\partial\pi_i/\partial w_{-i} > 0$ (in the range where both firms make positive sales). A simultaneous increase in all input costs decreases downstream profits: $\partial\pi_i/\partial w_i + \partial\pi_i/\partial w_{-i} < 0$.*

For a given ownership structure, we analyze the following non-cooperative game where each firm maximizes its objective function that takes the resulting internalization of other firms' profits into account.

1. Supplier U offers each downstream firm an input contract with tariff $t_i = (w_i, f_i)$, $i \in \{A, B\}$. The fringe V offers the input at its unit cost of c.
2. Downstream firms A and B observe the contract offers by U and simultaneously accept or reject the offer.
3. If active, each downstream firm sources inputs (from U if it accepted its contract, otherwise from the fringe V), produces, and sells its products.

We solve the game by backward induction. As outlined in Table 1, each ownership form can lead to profit internalization in both directions of the vertical chain. We denote with σ_{iU} the final degree with which supplier U internalizes a share of downstream firm i's profit and with α_{iU} the final degree with which downstream firm i internalizes a share of the supplier's profit.[12] If downstream firm i internalizes a share of the supplier's profit, its objective function is

$$\Omega_i(w_A, w_B, f_A, f_B) = \underbrace{\pi_i(w_i, w_{-i}) - f_i}_{\text{downstream profit } i} + \underbrace{\alpha_{iU}\left(\pi^U(w_i, w_{-i}) + f_A + f_B\right)}_{\text{internalized upstream profit}}, \tag{13}$$

[11]See, for instance, Farrell and Shapiro (2008) and Levy et al. (2018) for similar assumptions on reduced form profits.

[12]This notation corresponds to the case of influential backward ownership of Section 2, which rules out direct horizontal internalization between the downstream firms (Lemma 1) and allows to focus on the competitive effects of vertical internalization.

with the upstream operational profit $\pi^U = \sum_{i\in\{A,B\}} w_i q_i$.

Assumption 2. *The downstream firms' objective functions are strictly concave in their choice variables (either quantity or price) and a unique, stable interior equilibrium exists in the downstream market.*

The assumption implies that an increase of the input costs of both firms leads to a lower total output and higher downstream prices (both with downstream price and quantity competition).

Similarly, the objective function of upstream firm U consists of its own operational profit and potentially the downstream firms' profits, weighted by the internalization shares σ_{iU}:

$$\Omega^U(w_A, w_B, f_A, f_B) = \underbrace{\pi^U(w_A, w_B) + f_A + f_B}_{\text{upstream profit } U} + \underbrace{\sum_{i\in\{A,B\}} \sigma_{iU}\left(\pi_i(w_i, w_{-i}) - f_i\right)}_{\text{internalized downstream profits}}. \tag{14}$$

Assumption 3. *With observable contracts, supplier U's objective function is strictly concave in w_A and w_B.*

This assumption implies that there exists a unique interior solution to the supplier's unconstrained maximization problem.[13] In the analyses, we compare the equilibrium input prices with the input prices that emerge under vertical separation and with the input prices that a monopolist supplier would set in order to maximize the industry profit.

Assumption 4. *The industry profit is a strictly concave function in the downstream firms' strategic variables (prices or quantities).*

Denote the unique pair of input prices that induces the downstream firms to set their strategic variables such that the industry profit is maximized as $\left(w_A^I, w_B^I\right) = \arg\max_{w_i} \sum_{i\in\{A,B\}} p_i q_i$. These input prices do not depend on the degree of vertical profit internalization. The sum of all firms' profits (industry profit) increases if the input price approaches w_i^I (either from above or below).

We illustrate some of our results with closed-form solutions based on the quadratic utility

[13] We revisit this assumption in Section 6.1 for secret contracting.

of a representative consumer (Singh and Vives, 1984; Häckner, 2000)

$$CS\left(q_A, q_B, I\right) = q_A + q_B - \frac{1}{2}\left(q_A^2 + q_B^2 + 2\gamma q_A q_B\right) + I. \tag{15}$$

The consumer obtains utility from consuming the products from downstream firms A and B and a numeraire good I. The parameter $\gamma \in [0,1]$ captures the degree product substitutability. The budget-constrained consumer's maximization problem yields the inverse linear demand function

$$p_i\left(q_i, q_{-i}\right) = 1 - q_i - \gamma q_{-i}, \tag{16}$$

and the demand function

$$q_i\left(p_i, p_{-i}\right) = \frac{1}{1+\gamma}\left(1 - \frac{1}{1-\gamma}p_i + \frac{\gamma}{1-\gamma}p_{-i}\right). \tag{17}$$

For $\gamma \to 0$, the product markets are completely separated and as $\gamma \to 1$, the products become close substitutes.[14]

Discussion on contract observability. The assumption of contract observability implies that the supplier can commit to its customers not to make aggressive price offers to competing customers. This may be plausible with repeated interactions when the supplier cares about its reputation and therefore abstains from opportunistic behavior. Legal non-discrimination and information disclosure obligations can also imply that downstream firms know or can infer the contracts offered to their competitors. In the absence of credible commitment, however, contract observability may not be an appropriate information structure. In order to allow for a lack of commitment, we follow the established literature on secret contracting (for instance, Hart et al. 1990; O'Brien and Shaffer 1992; McAfee and Schwartz 1994; Rey and Vergé 2004) and allow that a downstream firm may not be able to observe the contract offer that the supplier made to the downstream rival. This is, for instance, plausible if the supplier can secretly renegotiate with one of the downstream

[14] We verified that these demand functions fulfill the common Assumptions 1 - 4 on the reduced form objective functions and the industry profit made above. See also, for example, Caprice (2006) and Bourreau et al. (2011).

firms. We analyze unobservable contract offers in Section 6.1.

4 Forward internalization

As a building block for more general ownership structures, we first analyze the competitive effects of an upstream firm internalizing part of the downstream profits (pure forward internalization), whereas each downstream firm simply maximizes its own operational profit. This is the case when the upstream firm owns rights to a share of the downstream profit (non-controlling forward ownership). As demonstrated in Section 2, forward internalization can also result from partial backward ownership if this allows the downstream firm to influence the upstream strategy.

We first show that symmetric forward internalization can lead to *lower* upstream and downstream prices when upstream tariffs are linear ($f_i = 0$) and upstream competition is weak (c is sufficiently large), in line with the insights of Flath (1989) for non-controlling forward ownership.[15] Crawford et al. (2018) provide empirical support of the theory by showing that partial profit internalization indeed reduces double marginalization in the US television market where input prices are predominantly linear – as they argue.

We then show that forward internalization can instead lead to *higher* marginal input prices when the supplier uses two-part tariffs (that is, when allowing for $f_i \neq 0$). This means that vertical partial ownership can be anti-competitive under non-linear tariffs, although it might be pro-competitive under linear tariffs. This is arguably an important insight that should find consideration in the assessment of partial shareholdings. It complements the existing literature, which argues that non-controlling forward ownership is pro-competitive (Flath, 1989; Fiocco, 2016). As we show, the restriction on linear tariffs is not innocuous here. In Section 5 we extend the analysis to more general ownership structures with bi-directional internalization.

4.1 Linear tariffs

We now fix $f_i = 0$, which implies that supply contracts are linear. Under vertical separation, linear tariffs result in double marginalization (Cournot, 1838). This means that

[15] We study asymmetric ownership structures in Section 6.2.

the linear input prices (and the resulting downstream prices) are above the level that maximizes industry profit. Partial forward internalization can alleviate this problem by reducing the upstream prices. For symmetric forward internalization, $\sigma_{AU} = \sigma_{BU} = \sigma$ the problem of supplier U is to

$$\max_{w_A, w_B} \Omega^U (w_A, w_B) = \pi^U (w_A, w_B) + \sigma (\pi_A (w_A, w_B) + \pi_B (w_B, w_A)), \quad (18)$$

subject to the constraint $w_i \leq c$, which ensures that both downstream firms source from U. This implies the first-order conditions

$$\frac{\partial \Omega^U}{\partial w_i} = \frac{\partial \pi^U (w_i, w_{-i})}{\partial w_i} + \sigma \left(\frac{\partial \pi_i (w_i, w_{-i})}{\partial w_i} + \frac{\partial \pi_{-i} (w_{-i}, w_i)}{\partial w_i} \right) = 0, \; i \in \{A, B\}. \quad (19)$$

Denote with $w_A^l(\sigma) = w_B^l(\sigma) = w^l(\sigma)$ the symmetric linear input price that solves the above conditions. As the supplier internalizes the same share of each downstream profit, there is an incentive to decrease the symmetric linear input price: $\partial w^l(\sigma)/\partial\sigma < 0$. This internalization effect yields input and downstream prices below the level of vertical separation and is therefore pro-competitive.

If upstream competition is fierce, the optimal input price w^l may be above the marginal cost of the competitive fringe. In this case, the internalization effect derived above does not materialize and upstream firm U sets the input price to the highest possible level of c. Hence, the equilibrium input price is $w = \min\left\{w^l(\sigma), c\right\}$. We summarize in

Proposition 2. *Let the efficient supplier U charge observable linear input prices ($f_i = 0$) and internalize a share $\sigma > 0$ of each downstream firm's profit. This symmetric forward internalization leads to lower input prices and downstream prices than full separation if upstream competition is weak or non-existent (c sufficiently large). Otherwise, forward internalization does not affect prices.*

Proof. See Appendix A1. □

With homogeneous quantity competition and linear demand as defined in Equation (16), the optimal unconstrained input price is $w^l(\sigma) = (3 - 2\sigma)/(6 - 2\sigma)$, which equals 1/2 for $\sigma = 0$ and decreases in σ. This implies that any marginal increase in σ reduces prices if $c > 1/2$. For $c < 1/2$, forward internalization is competitively neutral in an interval of σ

starting at $\sigma = 0$ but it can affect prices once σ is large enough (such that $w^l(\sigma) < c$). For instance, at a share $\sigma = 0.25$, we obtain $w^l(0.25) = 0.45$, which implies that forward internalization above 25% only decreases prices if $c > 0.45$. Double marginalization also arises with unobservable linear tariffs (Gaudin, forthcoming). We show in Appendix B2 that forward internalization can reduce double marginalization in this case as well.

4.2 Two-part tariffs

With observable two-part tariffs, the resulting prices do not maximize the industry profit if there is competition both upstream and downstream. In this case, the efficient supplier optimally sets the marginal input prices below the level that would result in the industry profit-maximizing downstream prices in order to improve its bargaining position toward the downstream firms. This bargaining effect also finds consideration in, for instance, Marx and Shaffer (1999) and Caprice (2006).

We now show that forward internalization leads to higher marginal input prices and thus industry profits, compared to the case of vertical separation. Again, let supplier U internalize a share $\sigma_{UA} = \sigma_{UB} = \sigma$ of each downstream firm's profit. The maximization problem of supplier U is

$$\begin{aligned}\max_{w_i, f_i,\ i\in\{A,B\}} \Omega^U &= \pi^U(w_A, w_B) + f_A + f_B + \sigma \sum_{i\in\{A,B\}} (\pi_i(w_i, w_{-i}) - f_i) \\ s.t.\ & \pi_i(w_i, w_{-i}) - f_i \geq \pi_i(c, w_{-i}),\ i \in \{A, B\}.\end{aligned} \tag{20}$$

The participation constraints mean that each downstream firm i must weakly prefer sourcing from U to sourcing from the competitive fringe at linear costs of c, which yields the outside option of $\pi_i(c, w_{-i})$. The competitive fringe is a *relevant supply alternative* if a downstream firm can obtain positive profits when sourcing from the competitive fringe. Otherwise, for a sufficiently large c, a downstream firm's outside option has a value of zero. In equilibrium, supplier U sets the fixed fees such that each downstream firm is just indifferent between the contract offer and its outside option such that each firm sources from U. Hence, the reduced maximization problem is

$$\max_{w_A, w_B} \Omega^U = \pi^I(w_A, w_B) - (1-\sigma)(\pi_A(c, w_B) + \pi_B(c, w_A)), \tag{21}$$

where $\pi^I = \pi^U + \sum_{i \in \{A,B\}} \pi_i$ denotes the industry profit. The implied system of first-order conditions is

$$\frac{\partial \Omega^U}{\partial w_i} = \frac{\partial \pi^I (w_i, w_{-i})}{\partial w_i} - (1-\sigma) \frac{\partial \pi_{-i} (c, w_i)}{\partial w_i} = 0, \ i \in \{A, B\}. \tag{22}$$

Denote the symmetric optimal marginal input price $w_A^{tp}(\sigma) = w_B^{tp}(\sigma) = w^{tp}(\sigma)$. For $\sigma = 1$, Equation (22) is the optimality condition as in the case of vertical integration and the optimal marginal prices maximize the industry profit. The same holds true if $\partial \pi_{-i}(c, w_i) / \partial w_i = 0$, as in the case if supplier U is a monopolist (no supply alternative: c sufficiently large). In these cases, the upstream firm can extract all downstream profits through the fixed fees and simply maximize the industry profit by setting the marginal input price equal to w^I.

The situation is different if $\sigma < 1$ and if the downstream firms obtain positive profits in case they source from the competitive fringe. With such a relevant supply alternative, the outside option profit of a downstream firm decreases if its competitor faces lower marginal input costs: $\partial \pi_{-i}(c, w_i) / \partial w_i > 0$. The supplier thus faces a trade-off between a high industry profit π^I and less valuable outside options $\pi_i(c, w_{-i})$ for the downstream firms. As a result, the supplier charges input prices below the industry profit-maximizing level.

The supplier's marginal profit from lowering a downstream firm's outside option shrinks in the internalization share σ (Equation (22)). Intuitively, partial internalization of the downstream profits makes decreasing these outside option profits less attractive and the supplier puts more emphasis on maximizing the industry profit.

Proposition 3. *Let supplier U charge observable two-part tariffs. With upstream competition (c sufficiently small), forward internalization $\sigma > 0$ leads to higher marginal input prices and downstream prices, compared to full separation. Without upstream competition, supplier U sets the input price w^I such that downstream prices maximize the industry profit for all $\sigma \in [0, 1]$.*

Proof. See Appendix A1. □

The result that with two-part tariffs forward internalization leads to higher marginal input prices is in stark contrast to the result of price reductions with linear tariffs (Proposition 2). With linear tariffs, the equilibrium yields excessive double marginalization, which dampens industry profits and makes it profitable to *decrease* the input prices. If the supplier can charge two-part tariffs instead, double marginalization is not a concern anymore. With up- and downstream competition, input prices and profits are too low from an industry perspective in the case of separation. This makes an *increase* of the input prices profitable.

Under homogeneous quantity competition with linear demand as defined in Equation (16), the optimal input price is $w^{tp}(\sigma) = (4c(1-\sigma) + 2\sigma - 1)/2(3-\sigma)$, which increases in $\sigma \in [0,1]$ if $c < 0.625$. Note that the competitive fringe is a relevant supply alternative in this range of c. If the competitive fringe has larger marginal costs in this example, the downstream firms prefer to stay inactive instead of sourcing from the fringe if they refuse U's offer. For $c < 0.625$, forward internalization thus increases prices.

Difference to supply contracts with revenue sharing. One might wonder whether the results obtained for ownership arrangements with forward internalization (Proposition 3) can also be obtained without an ownership arrangement, but with a supply contract which entitles the supplier to a share of the downstream profits (similar to "revenue sharing"). This is not the case. The difference is that partial ownership entitles the upstream firm to a share of the downstream profit even when the firms do not conclude a supply contract. As the contract does not influence a downstream firm's outside option of sourcing alternatively, such a contract does not change the pricing incentives of the supplier.

Proposition 4. *The competitive results derived for forward internalization do not emerge under vertical separation if firms sign a supply contract with a profit-sharing clause.*

Proof. See Appendix A1. □

5 Bi-directional internalization

The preceding section established that the competitive effects of forward internalization pivotally depend on whether the supply contracts contain linear or two-part tariffs. However, partial vertical ownership with both profit rights and means of influence tends to induce forward and backward internalization at the same time (Section 2). That is, upstream firm U internalizes a share of the downstream profits and the downstream firms internalize a share of the U's profit as well.

We show in this section how the competitive effects confer to this case of bi-directional internalization. We first present the results for linear tariffs, which build on the literature that studies the competitive effects of partial ownership for the polar case of non-controlling ownership (Flath, 1989; Greenlee and Raskovich, 2006; Hunold and Stahl, 2016). The analysis reveals that the competitive effects depend on whether there is upstream competition and not primarily on the direction of ownership. With upstream monopoly, partial vertical ownership decreases prices whereas it is competitively neutral or increases prices if upstream competition is effective.

Secondly, we turn to the analysis of two-part tariffs. Importantly, the anti-competitive effect of two-part tariffs with pure forward internalization derived in Section 4 largely extends to more general ownership structures. We focus on observable tariffs in this section and study secret contracting in Section 6.1.

5.1 Linear tariffs

In order to study backward internalization in addition to forward internalization, recall from Equation (13) that the objective function of a downstream firm essentially looks as follows:

$$\underbrace{(p_i - w_i)\, q_i}_{\text{downstream profit } i} \;+\; \underbrace{\alpha\,(w_i q_i + w_{-i} q_{-i})\,.}_{\text{internalized upstream profit}} \qquad (23)$$

Due to the backward profit internalization, a downstream firm perceives a rebate on its input costs through the internalized upstream profit. For future reference, denote a downstream firm's *effective input price* that takes these rebates on the nominal input price into account as w_i^{ef}.[16] Importantly, the downstream firms' effective input costs determine the optimal strategic behavior and equilibrium in the downstream market. An increase in effective input costs is therefore a sufficient statistic for the price effects in the downstream

[16]This is $w_i^{ef} = (1-\alpha)\cdot w_i$ for Cournot competition. See Greenlee and Raskovich (2006) and Lemma 4 in Appendix A2 for details.

market.

Upstream monopoly. Greenlee and Raskovich (2006) show that symmetric passive backward ownership of an upstream monopoly does not affect downstream prices, neither with quantity nor with price competition and linear demand. The reason is that the upstream firm anticipates this rebate and sets a higher nominal input price, such that the effective input price remains as in the reference case of vertical separation. We find that backward ownership is no longer neutral when there is also forward internalization ($\sigma > 0$).

Proposition 5. *Let supplier U charge linear input prices ($f_i = 0$) and be a monopolist (c sufficiently large). Let the downstream firms compete in price (with linear demand) or quantity.*[17] *If U internalizes a share $\sigma > 0$ of each downstream firm, the effective input prices and downstream prices increase in the degree of backward internalization α. Without forward internalization ($\sigma = 0$), a change in α does not change the effective prices.*

Proof. See Appendix A2. □

To understand why an increase in backward internalization increases prices when there is also forward internalization, note that it changes the relative weight of a downstream firm's operational profit in the maximization problem of the supplier. In particular, backward internalization induces the downstream firms to internalize a larger share of U's operational profit. Hence, U's operational profit receives a larger weight in U's maximization problem (which is a weighted average of A's and U's objective function) and this leads to an increase in input prices and double marginalization.

As derived in Section 4, an increase in forward internalization instead reduces double marginalization in this case (Proposition 2). We therefore assess the price effect of a simultaneous increase of both forward and backward internalization. As a clean theoretical benchmark, we focus on the example of influential backward ownership. This ownership structure induces bi-directional profit internalization, but – different from symmetric

[17] With price competition, the derivation is more involved and we follow Greenlee and Raskovich (2006) in focusing on linear demand for this case. The result for quantity competition relies only on the reduced form Assumptions 1 – 4.

influential forward ownership – does not induce direct horizontal profit internalization downstream (see Section 2.3 for details). Afterwards, we show that the results also hold for other ownership structures. We present certain results for the case of a proportional relationship between the backward profit share and the corporate influence over the target firm (proportional influence: $\alpha = \beta$). This implies a coefficient of corporate influence over the supplier of $\sigma = \alpha / (1 - 2\alpha(1 - \alpha))$ (see Section 2).

Corollary 2. *Maintain the assumptions of Proposition 5 and let each downstream firm hold a backward profit share* α *with proportional influence:* $\sigma = \alpha / (1 - 2\alpha(1 - \alpha))$. *An increase in the ownership share* α *leads to lower effective input prices and downstream prices.*

Proof. See Appendix A2. □

The corollary shows that the pro-competitive effect of forward internalization dominates the anti-competitive effect of backward internalization if corporate influence is proportional to the ownership share and upstream competition is sufficiently weak. This finding is in line with Brito et al. (2016). Below, we further investigate that this result pivotally depends on the assumptions of upstream monopoly and linear tariffs. Changing either of these assumptions can lead to opposite results.

Upstream competition. Hunold and Stahl (2016) demonstrate that non-controlling backward ownership can raise consumer prices in the case of upstream and downstream price competition. Upstream competition fixes the input costs at an effective level (the marginal costs of the fringe in the present model), such that the net effect of backward internalization is that of an indirect horizontal internalization of the downstream rival's sales through the input margin. We find that this anti-competitive result generalizes to the case of bi-directional internalization, as with influential backward ownership.

Proposition 6. *Let supplier* U *internalize a share* $\sigma \geq 0$ *of the downstream firms' profits and charge linear input prices* ($f_i = 0$). *Let upstream competition be sufficiently intense (c small enough). If downstream firms compete in prices, an increase in the degree of backward internalization* α *leads to higher downstream prices. If they compete in quantities, downstream prices are independent of* α.

Proof. See Appendix A2. □

Intuitively, the fact that there is effective upstream competition neutralizes the pro-competitive effect of forward internalization. Hence, the anti-competitive effect of backward internalization prevails with bi-directional ownership structures.

Illustration and summary of price effects (linear tariffs). Table 2 illustrates the price effects of partial vertical ownership for linear tariffs, downstream price competition, and an ownership share of 15%.[18] It compares ownership structures that induce pure backward and forward internalization (first and second column) with two ownership structures that induce bi-directional internalization (third and fourth column). For an upstream monopoly (first row), it confirms the result of Greenlee and Raskovich (2006) that pure backward internalization is competitively neutral as downstream prices do not change compared to the reference case of vertical separation (Column 1). In contrast, the (pure) forward internalization (Column 2) reduces prices by 2.2% (Proposition 2).

Consistent with Corollary 2, the price-decreasing effect of forward internalization prevails with bi-directional internalization (Columns 3 and 4). The price decrease is smaller for influential forward than backward ownership (−2.1% versus −2.9%) as influential forward ownership additionally yields direct horizontal downstream internalization, which increases prices.[19]

[18]We chose 15% as it is a considerable stake, but is well below the thresholds of 20% and 25% that trigger, or are proposed to trigger, more scrutiny in certain competition policy regimes. See Section 7 for details.

[19]A downstream firm partially internalizes the objective function of the upstream firm, which in turn obtains part of the profit of the rival downstream firm. See Section 2.3 for details.

	Passive backward ownership (15%)	Passive forward ownership (15%)	Infl. backward ownership (15%, prop. influence)	Infl. forward ownership (15%, prop. influence)
Upstream monopoly ($c \to \infty$)	0.0%	−2.2%	−2.9%	−2.1%
Eff. upstream comp. ($c = 0.3$)	6.2%*	0%	6.2%*	7.7%

Table 2: Downstream price effects of partial vertical ownership under linear tariffs

The table shows changes in downstream prices relative to vertical separation under linear tariffs. Assumptions: Downstream price competition; linear demand as in Eq. (17) with $\gamma = 7/10$. Column 1: Each downstream firm internalizes 15% of supplier U's profit. Column 2: Supplier U internalizes 15% of each downstream firm's profit. Column 3: Symmetric backward ownership with 15% profit participation and proportional influence. Column 4: Symmetric forward ownership with 15% profit participation and proportional influence. *Note that these effects are zero with downstream quantity competition.

With effective upstream competition (second row), the fringe costs determine the efficient supplier's pricing, so that pure forward internalization has no pro-competitive effect (Column 2). Instead, pure backward internalization of 15% leads to a 6.2% increase of the downstream prices. Note that backward internalization leads to an indirect horizontal internalization in the downstream market only in the case of price competition (Proposition 6). Instead, this price effect does not arise with quantity competition, whereas the other results are qualitatively similar for quantity competition. Columns 3 and 4 indicate that the anti-competitive result obtained with pure backward internalization persists under bi-directional internalization. With influential forward ownership, there is again direct horizontal internalization between the downstream firms, which leads to a total price increase of 7.7%.

5.2 Two-part tariffs

The analysis of partial bi-directional vertical ownership is more challenging with two-part tariffs than with linear tariffs. Unsurprisingly, most of the established literature has only studied the case of linear tariffs.[20] In our general model, evaluating the various price effects of partial ownership with bi-directional internalization analytically is not tractable with observable two-part tariffs. Using the assumption of linear demand (as defined in

[20]Exceptions are Hunold and Stahl (2016) who show anti-competitive effects of backward internalization also for observable two-part tariffs and Fiocco (2016) who studies competing manufacturer-retailer pairs. Levy et al. (2018) abstract from this issue by assuming unit demand for the input.

Equations (16) and (17)), we find that the anti-competitive result derived in Section 4 for pure forward internalization with upstream competition extends largely to bi-directional internalization.

When supplier U is a monopolist and charges observable two-part tariffs, it sets the industry-maximizing marginal input prices under vertical separation. Perhaps surprisingly, prices can decrease slightly below the monopoly level when the ownership structure also involves backward internalization.[21] For the case of unobservable contracts, we show in Section 6.1 that partial vertical ownership leads to higher prices if it induces forward internalization.

With two-part tariffs, the objective function of downstream firm i, which internalizes a share α of the supplier's profits, is

$$\begin{aligned} \Omega_i &= (p_i - w_i)\, q_i - f_i \\ &+ \alpha \left(w_i q_i + f_i + w_{-i} q_{-i} + f_{-i} \right). \end{aligned} \tag{24}$$

With backward internalization, a downstream firm partially internalizes the supplier's profit, which includes profit from selling the input good to the downstream rival. This ensures the downstream firms a positive profit when rejecting U's supply contract, even when U is a monopolist. As in Section 4, the supplier can affect this rejection profit by distorting marginal input prices in order to strike a balance between high industry profits and low rejection profits (and thus outside options) for the downstream firms. When there is a relevant supply alternative for the downstream firms, it is generally not clear how the outside option, which consists of the own profit when sourcing alternatively and the partially internalized profit from the supplier serving the downstream rival, shapes the equilibrium input prices. Using the assumption of linear demand, we show that the overall effect of bi-directional internalization is nevertheless anti-competitive if the supply alternative is efficient enough. Again, we first focus on the benchmark case of influential backward ownership and show below that the result extends to other ownership structures.

Proposition 7. *Let supplier U charge observable two-part tariffs and let c be sufficiently*

[21] We consider this result of lower importance as the industry profit (which U internalizes) is maximal absent partial ownership, such that the involved firms cannot increase their joint profits by means of partial vertical ownership.

small. With linear demand as defined in Equations (16) *and* (17)*, symmetric backward ownership with profit share* α *and proportional influence* ($\sigma = \alpha / (1 - 2\alpha(1 - \alpha))$) *leads to higher effective input prices and downstream prices.*

Proof. See Appendix A2. □

The proposition shows that the anti-competitive effect derived for pure forward internalization also extends to bi-directional ownership structures. As we will see below, with upstream competition, the effect of pure backward internalization also leads to higher prices and, hence, the combination of forward and backward internalization increases prices as well. The proposition holds for any degree of downstream product differentiation (γ) as well as for both price and quantity competition, but requires c to be sufficiently small. Although this requirement may be stricter than merely the fringe being a relevant supply alternative, we show in Appendix A3 that this range is indeed large. For instance, for quantity competition, the effective input prices increase at $\alpha = 20\%$ if $c < 0.52$, where 0.5 is the downstream monopoly price level. This restriction also illustrates why the effect of partial ownership in the general model framework is difficult to identify for observable two-part tariffs.

Illustration and summary of price effects (observable two-part tariffs). The anti-competitive effect derived in Proposition 7 is not specific to influential backward ownership, but also arises with other ownership arrangements. Table 3 shows how downstream prices change with different partial ownership structures relative to separation.

Let us start with the results when supplier U is a monopolist (Row 1). Notably, the supplier obtains the maximal industry profit already with vertical separation and hence the supplier (as well as the industry as a whole) cannot increase profits by means of ownership links. In line with Proposition 3, there is no price effect with pure forward internalization (Column 2). The downstream firm's outside option is zero and the supplier is therefore able to extract the maximal industry profit, as under vertical separation. In contrast, prices are slightly lower compared to vertical separation if the ownership structure involves backward internalization (Columns 1, 3, and 4). Even though there is no relevant supply alternative, a downstream firm makes positive profits when rejecting

$U's$ offer as it internalizes part of $U's$ profit. Hence, the supplier strategically decreases the effective marginal input prices below the level of vertical separation to reduce the rejection profit as this allows to extract more profits through the fixed fees.

	Passive backward ownership (15%)	Passive forward ownership (15%)	Infl. backward ownership (15%, prop. influence)	Infl. forward ownership (15%, prop. influence)
Upstream monopoly ($c \to \infty$)	−1.8%	0%	−1.5%	−1.1%
Eff. upstream comp. ($c = 0.3$)	2.5%	4.0%	7.5%	7.1%

Table 3: Downstream price effects of partial vertical ownership under two-part tariffs

The table shows changes in downstream prices relative to vertical separation under two-part tariffs. Assumptions: Downstream price competition with linear demand as defined in Eq. (17), with $\gamma = 7/10$. Column 1: Each downstream firm internalizes 15% of supplier U's profit. Column 2: Supplier U internalizes 15% of each downstream firm's profit. Column 3: Symmetric backward ownership with 15% profit participation and proportional influence. Column 4: Symmetric forward ownership with 15% profit participation and proportional influence.

The second row contains the results for the case of effective upstream competition. In line with Proposition 3, the price level is 4% higher with non-controlling forward ownership where the supplier obtains 15% of each downstream firm's profit if there is upstream competition (second row, Column 2). Pure backward internalization increases prices as well, by 2.5% with profit shares of 15% (Column 1). In contrast to the monopoly case, the supplier increases the effective input prices above the level of vertical separation to decrease the downstream firms' outside options.

Given the price increases with pure forward and backward internalization, the ownership structures with bi-directional internalization consequently increase prices even more (7.1% and 7.5% in Columns 3 and 4). The price effect under influential forward ownership (Column 4) is slightly lower than under influential backward ownership (Column 3) even though the former induces a direct horizontal internalization of 2.6% between the downstream firms. The reason is that backward ownership induces a higher degree of vertical profit internalization than forward ownership ($\sigma = 15\%$ and $\alpha = 17.2\%$ under forward ownership and $\sigma = 20.1\%$ and $\alpha = 15\%$ under backward ownership).

In summary, we find that bi-directional ownership tends to increase prices in various cases. With linear tariffs, this is the case with backward internalization when there is effective upstream competition and downstream price competition. Forward internalization can reduce the double-marginalization problem in the case of an upstream monopoly. With observable two-part tariffs, both back- and forward internalization (in isolation and together) tend to increase prices when there is upstream competition. An upstream monopoly already charges the prices that maximize the industry profit in case of vertical separation, such that there is no scope for vertical ownership within the model framework.

6 Extensions

6.1 Secret contracting

We now study the case in which a downstream firm cannot observe the contract terms and acceptance decision of the rival downstream firm before making its own sourcing and sales decisions. We find that the main competitive effects derived for observable contracts prevail.

With secret contracting, the supplier has the incentive to secretly offer each downstream firm a contract with a low linear price as this maximizes the bilateral profit, which the supplier internalizes through the fixed fee. Under vertical separation, this can lead to marginal prices equal to the supplier's marginal costs, and in turn low downstream prices and industry profits (Hart et al., 1990; O'Brien and Shaffer, 1992; McAfee and Schwartz, 1994).[22] With vertical ownership links, firms may be able to exchange information in a credible way and build trust, such that the opportunism problem of the supplier charging lower input prices to the downstream firm's competitors ceases to exist. We do not model these potential cooperative effects of vertical ownership, but show that even if the firms stick to the non-cooperative, short-term optimal behavior, the scope for opportunism is nevertheless lower with partial vertical ownership if it involves forward internalization. As the commitment problem exists even with an upstream monopoly, we simplify by assuming that supplier U does not face any competition ($c = \infty$).[23]

[22] Fiocco (2016) studies secret contracting and partial backward ownership, but excludes that an upstream firm supplies two competing downstream firms. Hence, there is no commitment problem à la Hart et al. (1990).

[23] This is without loss of generality as with unobservable contracts a competitive fringe does not affect the marginal prices of the efficient supplier, but only affects how firms split the joint surplus from trade through the fixed fee (Hart et al., 1990).

We solve for symmetric perfect Bayesian-Nash equilibria as contract unobservability leads to an incomplete information game. Each downstream firm therefore has to form beliefs about the contract offered to its competitor. In this section, we assume that the downstream firms have passive beliefs: they do not update their beliefs when receiving out-of-equilibrium offers.[24] Appendix A4 contains the formal analysis, including the (standard) regularity assumptions on demand and profits, as well as the proofs. Our starting point is the established result that under vertical separation the marginal input prices equal the supplier's marginal costs in equilibrium. The situation is different with partial vertical ownership.

Lemma 3. *Let supplier U charge unobservable two-part tariffs and let the downstream firms hold passive beliefs. With forward internalization, there exists **no** perfect Bayesian-Nash equilibrium with marginal input prices equal to the supplier's marginal costs. Pure backward internalization does not affect the supplier's optimality condition compared to vertical separation.*

Proof. See the Lemmas 5 and 6 and their proofs in Appendix A4. □

Forward internalization changes the result as the supplier now (partly) internalizes the effect of its opportunistic behavior on the actual downstream profits. In contrast, pure backward internalization does not confer additional commitment power to the supplier and the equilibrium input costs remain at the same level as under vertical separation.

In order to establish a perfect Bayesian-Nash equilibrium under partial vertical ownership structures, it is generally not sufficient that the first-order conditions hold. It is also necessary to verify that the supplier has no incentive to change both contracts simultaneously (a multilateral deviation). For vertical separation, Rey and Vergé (2004) show that an equilibrium exists if there is downstream quantity competition or price competition that is not too intense. We extend their results to the case of partial vertical ownership in the following propositions for quantity and price competition.

Proposition 8. *Suppose the downstream firms compete in quantities, supplier U charges unobservable two-part tariffs, and there is symmetric forward internalization σ and backward internalization α. There always exists a unique symmetric perfect Bayesian-Nash*

[24] In Appendix B1, we analyze the case of *wary beliefs* and obtain similar results.

equilibrium with passive beliefs. Symmetric marginal input prices (and thus downstream prices) increase in the degree of forward internalization σ and reach the industry-maximizing level at $\sigma = 1$ for all $\alpha \in [0, 1/2]$.

Proof. See Appendix A4. □

An equilibrium in passive beliefs exists if downstream firms compete in quantities although the contracts do not affect the supplier's maximization problem in a separable way, as under vertical separation. For price competition, we obtain

Proposition 9. *Suppose the downstream firms compete in prices and supplier U charges unobservable two-part tariffs, and there is symmetric forward internalization σ and backward internalization α. There exists a unique symmetric perfect Bayesian-Nash equilibrium if and only if the cross elasticity of substitution is sufficiently small. For linear demand, the condition is*

$$\epsilon_S \;\leq\; \epsilon\,(1-\alpha\sigma)\,/\,\Big(2\,(1-\sigma)+\sigma\,(1-\alpha)\,\partial p_A/\partial w_A^{ef}\Big)\,, \tag{25}$$

with ϵ and ϵ_S defined in Equation (73). *Equation* (77) *contains the condition for non-linear demand.*

In equilibrium, starting from $\sigma = 0$, the symmetric marginal input prices and downstream prices increase for a marginal increase in σ and reach the industry-maximizing level at $\sigma = 1$ for all $\alpha \in [0, 1/2]$.

Proof. See Appendix A4. □

Propositions 8 and 9 show that partial vertical ownership with forward internalization reduces the supplier's commitment problem that secret contracting causes. The reason is that the supplier internalizes a share of the loss of one downstream firm if it secretly offers a lower input price to the downstream rival. Hence, partial vertical ownership is an effective commitment to higher input (and thus downstream) prices.

Again, we analyze the effect of a simultaneous change of both forward and backward internalization. We focus on the ownership structure of influential backward ownership as it offers a clean theoretical benchmark and allows to abstract from direct horizontal internalization between the downstream firms.[25]

Corollary 3. *Let the supplier charge unobservable two-part tariffs and let the downstream firms hold partial backward ownership with profit share* $\alpha \in [0, 1/2]$ *and proportional influence:* $\sigma = \alpha / (1 - 2\alpha(1-\alpha))$. *With Cournot competition, effective input prices and downstream prices increase in* $\alpha \in [0, 1/2]$. *With Bertrand competition, starting from* $\alpha = 0$, *the symmetric input prices and downstream prices increase for a marginal increase in* α *and reach the industry-maximizing level for* $\alpha = 50\%$.

Proof. See proofs of Corollaries 4 and 5 in Appendix A4. □

In Appendix B1, we additionally analyze the belief refinement of *wary beliefs* whereby – in case of an out-of-equilibrium offer – a downstream firm anticipates that the supplier might also have an incentive to change the contract offer to the downstream rival. As with passive beliefs, we find that forward internalization yields higher input prices than vertical separation and therefore reduces the commitment problem.

Discussion of competitive effects with observable and secret two-part tariffs. Our analysis shows that partial vertical ownership increases the supplier's input prices with both observable and unobservable two-part tariffs (Sections 4.2, 5, and 6.1). The economic reason differs, however. Under observable two-part tariffs, the supplier strategically depreciates the outside option profit of the downstream firms. With partial vertical ownership, the supplier allows the downstream firms to obtain a larger profit as it internalizes a share of this profit. This strategic channel is not present with unobservable two-part tariffs. In fact, both downstream firms make the same (zero) profit in equilibrium irrespective of whether the supplier internalizes a share of these profits or not.[26] It may therefore seem odd at first glance that vertical ownership actually affects the equilibrium input prices. Nevertheless, partial vertical ownership allows the supplier to commit to higher input prices as it now internalizes a part of the losses that its opportunism (a

[25] See Section 2.3 for details.

[26] Even with a relevant supply alternative, a downstream firm's anticipated outside option remains constant if the supplier offers the downstream rival lower marginal input prices, as the contract offers are secret.

lower marginal input price for the competitor) would cause. This leads to higher downstream prices and lower consumer surplus.

6.2 Asymmetric ownership

Symmetry is a useful benchmark and helps to keep the model tractable. The results that we present for asymmetric ownership structures are twofold. First, for a given market structure, asymmetric ownership tends to affect the price level (and thus consumer surplus) in the same direction as symmetric ownership. Second, and consistent with the existing literature, our analysis confirms that asymmetric partial ownership may have foreclosure effects. A downstream firm may pay a higher input price than its competitor when a supplier (partially) internalizes the competitor's profit. Instead, a supplier may increase the price that it charges a downstream firm if it partly internalizes the supplier's profit, so that the downstream firm may not benefit from backward profit internalization as with symmetric ownership.

We start by discussing the case of linear tariffs and turn to two-part tariffs afterwards. As in the analysis of symmetric ownership structures it is necessary to distinguish between the cases of upstream competition and upstream monopoly. For upstream competition, we know from Proposition 6 that the pro-competitive effect of forward internalization does not materialize as the downstream firms' effective input costs remain at the same level as under vertical separation. Asymmetric bi-directional profit internalization thus leads to higher downstream prices if downstream firm compete in à la Bertrand. This insight builds on Hunold and Stahl (2016) who study non-controlling asymmetric ownership structures.

For the case of upstream monopoly and linear tariffs, symmetric forward internalization (as derived in Proposition 2 and Corollary 2) induces U to charge the downstream firms lower input prices than under vertical separation. For the sake of tractability, we analyze the case of asymmetric ownership on the downstream firms' effective input prices with Bertrand competition and linear demand (Eq. (16), with $\gamma = 7/10$). The results are robust for large parameter ranges of γ and are qualitatively similar for Cournot competition.[27]

In particular, we assume that there is partial vertical ownership $\alpha_{AU} \in [0, 1]$ between

[27]We use the same linear demand as in Section 5.

supplier U and downstream firm A, whereas B has no ownership link. This implies that supplier U internalizes a share $\sigma_{AU} = \alpha_{AU} / (1 - \alpha_{AU}(1 - \alpha_{AU}))$ of firm A's profit, which is consistent with backward ownership that confers proportional influence as well as with any other ownership link that yields these degrees of internalization.[28] Panel (a) of Figure 1 illustrates that asymmetric ownership induces U to set lower input prices to downstream firm A compared to vertical separation. Additionally, U has an incentive to divert profits from firm B to firm A by setting A's input costs below those of B. Asymmetric vertical ownership, therefore, induces the supplier to offer less favorable supply terms to the independent downstream firm. If there is no forward internalization (as is the case with pure backward internalization), this incentive is not present and the invariance result of Greenlee and Raskovich (2006) prevails in that the downstream firms' input costs remain at the same level as under vertical separation and asymmetric partial vertical ownership is competitively neutral.

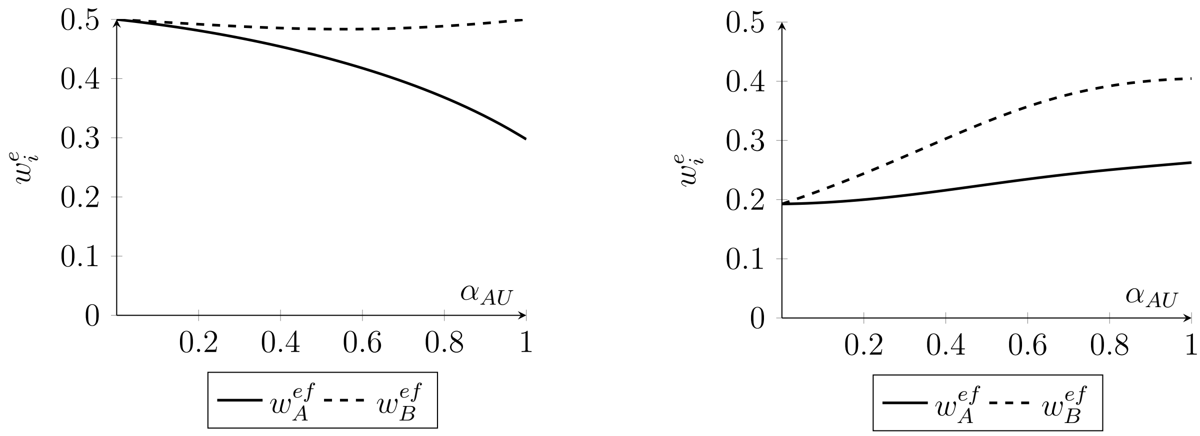
With observable two-part tariffs, an unconstrained upstream monopolist obtains the maximal industry profit already under vertical separation. Partial ownership thus appears to be less relevant in this case.[29] With upstream competition and observable two-part tariffs, our main result is that partial vertical ownership interacts with the rent-shifting mechanism that induces the supplier to set input prices below the industry-maximizing level (Proposition 3). In particular, forward internalization induces the supplier to increase the input prices towards the level that maximizes the industry profit. Using again the linear demand framework introduced above, we find that with asymmetric ownership ($\alpha_{AU} \in [0, 1]$ and $\alpha_{BU} = 0$) the supplier only wants to increase the channel profit with downstream firm A whereas it still wants to keep B's outside option profit low as in the case of vertical separation. Panel (b) of Figure 1 shows that this is possible by increasing the input costs of downstream firm B as this allows A to achieve a higher profit. As B's outside option profit needs to stay small, there is only a minor increase of A's input costs. Summarizing the results in Figure 1, we conclude that, besides the result of an *unequal treatment*, asymmetric partial ownership tends to affect the effective input prices

[28] Note that a single vertical ownership link does not induce direct horizontal internalization between the downstream firms. See Section 2.3.

[29] With bi-directional internalization, there is only a minor effect on prices due to the fact that backward internalization gives the downstream firms an outside option even if there is no relevant supply alternative (see Section 5.2).

on average in the same direction as symmetric partial ownership. In the next section, we discuss how this affects the consumer surplus and the profitability of partial ownership arrangements for the firms.

Figure 1: Effective marginal input prices with backward ownership of firm A



(a) Linear tariffs (b) Two-part tariffs

The left panel shows the optimal effective linear input prices for upstream monopoly (i.e., sufficiently large c). The right panel shows the optimal effective marginal input prices under two-part tariffs when the competitive fringe is a relevant supply alternative (with $c = 0.3$). Both panels show the input prices for $\alpha_{AU} \in [0, 1]$ and $\alpha_{BU} = 0$. Competition is in prices with demand defined in Eq.(17) and $\gamma = 7/10$.

Literature on asymmetric integration and foreclosure. The analysis of asymmetric ownership relates to the literature on vertical integration and foreclosure of competitors. In this regard, our model is closest related to Spiegel (2013) who also considers that the supplier may offer better contract terms to a partially integrated downstream firm. Spiegel analyzes the effects of these discriminatory input prices on the downstream firms' investment incentives and, in turn, the propensity to be vertically foreclosed. Vertical foreclosure occurs if one downstream firm successfully improves the product whereas the other fails to do so. In contrast to Spiegel (2013), who fixes the input price for the integrated downstream firm at the level under vertical separation, we allow the upstream firm to adjust the contract that it offers to the partially integrated downstream firm and compare the effects under linear and two-part tariffs. Moreover, our focus is not on investment incentives in the downstream market.

Other articles study whether a firm refuses to participate in the market for the intermediate good as supplier or customer. With full vertical integration, Salinger (1988) and Ordover et al. (1990) show that this form of foreclosure can be profitable as it can raise the rivals' costs.[30] As regards partial vertical ownership, Baumol and Ordover (1994) establish that a downstream firm that fully controls a bottleneck supplier, but gets only part of its profit, can have higher incentives to foreclose a downstream rival than under full vertical integration. The partial owner has to bear only a fraction of the upstream costs of foreclosure (foregone input sales), but internalizes the full benefit of relaxed downstream competition. Levy et al. (2018) show that the profitability of such a foreclosure strategy depends on the initial ownership structure. Related to the present article, Spiegel (2013) and Levy et al. (2018) also treat the case of intermediate control in an extension and show that the incentive to foreclose vertically related firms prevails to this case.

6.3 Profitability of partial ownership and consumer surplus

We have studied how partial vertical ownership with different directions of internalization (forward, backward) affects the market prices. A related question is how this affects the firms' profits, consumer surplus and, ultimately, what ownership structure is likely to arise.

If the firms can arrive at efficient agreements with each other ("Coasian bargaining"), they should implement an ownership arrangement that maximizes their joint (industry) profits. In our setting, symmetric partial vertical ownership increases industry profits if it moves the downstream price towards the monopoly level. With an upstream monopoly and observable two-part tariffs, the equilibrium prices are already at the monopoly level with vertical separation, such that vertical ownership yields no improvement. With an upstream monopoly (or insufficient upstream competition) and linear tariffs, the price level with vertical separation are above the monopoly level, such that decreasing the downstream prices increases the joint profit. The industry can implement such a decrease of double marginalization with partial vertical ownership that involves forward internalization (Corollary 2).

In all other cases, the price level in the case of vertical separation is below the monopoly level. Partial vertical ownership arrangements which increase the downstream prices thus

[30] The analysis of Ordover et al. 1990 has been criticized on the grounds that the integrated supplier needs to commit itself to refusing to supply of the non-integrated downstream firm (Hart et al., 1990; Reiffen, 1992). Among others, Allain et al. (2016) propose a model that does not rely on this form of commitment. They also study the case of partial ownership in an extension and find that forward integration increases the incentive to degrade the conditions offered to the downstream rival.

increase the industry profits. With linear tariffs, we confirm the result of Hunold and Stahl (2016) in this case and show that downstream prices increase if the downstream firms compete in prices. Moreover, the results of Sections 5 and 6.1 on symmetric degrees of internalization show that, both with observable and unobservable two-part tariffs, the input prices approach the level that yields the maximal industry profit as the ownership shares increase. The industry should thus have an incentive in these cases to choose an ownership structure that yields monopoly prices, or if this is not attainable, it should choose the highest possible internalization.

Even if the firms in the industry cannot implement ownership structures that maximize the industry profit (the joint profit of U, A, and B in the model), it might still be feasible and profitable for pairs of firms to bilaterally establish an ownership link. With upstream monopoly and linear tariffs, as well as with upstream competition and two-part tariffs, the supplier tends to offer more favorable contract terms to a partially integrated downstream firm compared to the independent downstream firm (Section 6.2). This favorable treatment to the detriment of an outsider can increase the joint profit between the supplier and a partially integrated downstream firm, both with linear and two-part tariffs.[31] Moreover, Hunold and Stahl (2016) show that non-controlling backward ownership of a supplier that faces fringe competition can be bilaterally profitable as this induces the independent competitor to set higher prices. Hence, even bilaterally, there can be strict incentives to acquire a partial vertical ownership stake.

The effect of partial vertical ownership on the consumer surplus depends on whether the overall downstream price level increases or decreases with partial vertical ownership. In case of linear tariffs and upstream monopoly, we find that the preferences of the firms and the consumers are aligned in that partial vertical ownership reduces double marginalization and therefore increases profits and consumer surplus. In stark contrast, the price level remains constant or even increases when changing either of these assumptions. This implies that partial vertical ownership can decrease the consumer surplus significantly in these cases, especially with two-part tariffs. Again, this confirms that the competitive assessment of partial vertical ownership needs to carefully analyze the degree of upstream competition and the contract terms between up- and downstream firms.

[31] In Appendix A5, we provide a numerical example that shows how asymmetric partial vertical ownership affects the firms' profits and the consumer surplus.

7 Conclusion

We offer novel insights for the competitive assessment of partial ownership in vertically related industries. One important insight is that forward and backward ownership can have the same effects when they entail both profit and control rights. For instance, a typical forward shareholding of an upstream in a downstream firm entitles the upstream firm to part of the downstream firm's profit, which it therefore internalizes in its objective function. Moreover, the upstream firm can exercise its influence as an owner to induce the downstream firm to (partially) internalize its own interests, which is primarily the upstream profit. The analogous argument applies to backward ownership. An ownership share that confers profit claims and corporate influence therefore inherently induces bi-directional profit internalization. Consequently, the economic analysis of partial vertical ownership should first identify the strength of forward and backward internalization and then derive their competitive effects. This is arguably in contrast to various articles on vertical partial ownership that focus on non-controlling ownership and derive distinct competitive effects, depending on the direction of ownership. We show that important results from this literature can indeed emerge with either direction of partial vertical ownership.

The second contribution of the present article is to demonstrate that the effects of partial vertical ownership crucially depend on the degree and type of competition as well as on the pricing arrangement between upstream and downstream firms. Various articles of the established literature only analyze an upstream monopoly charging linear tariffs and typically find pro-competitive or no effects of partial vertical ownership (Flath, 1989; Greenlee and Raskovich, 2006; Brito et al., 2016). In stark contrast, our analysis reveals that partial vertical ownership instead tends to have anti-competitive price effects when changing either of these assumptions. With linear tariffs and upstream competition, consumer prices remain constant or increase with partial vertical ownership. With observable two-part tariffs, a supplier strategically sets marginal prices below the level that maximize industry profits if downstream firms have a relevant supply alternative. This allows the upstream firm to obtain a larger share of the industry profit, though at the same time reducing the total industry profit. This extraction incentive is lower if the supplier internalizes a share of the downstream profits, which implies higher marginal input prices and thus downstream prices as well as industry profits than with vertical separation. When an upstream monopolist charges observable two-part tariffs, there is limited scope for partial vertical ownership to increase profits as prices already maximize industry profits without it. Instead, with secret contracting, even an upstream monopolist cannot commit to charging downstream competitors high input prices (Hart et al., 1990). This opens the door for profit-increasing structural arrangements even in case of an upstream monopoly. Our analysis reveals that partial vertical ownership with elements of forward internalization effectively enables the upstream firm to commit to higher input prices, which in turn leads to higher consumer prices.

These insights should be taken into account when reading and interpreting results of the existing economic literature on partial ownership as well as for future research in this field. It is crucial to verify the assumptions on contracting and competition in order to derive robust conclusions as various effects of partial vertical ownership vanish or are even opposite when changing one of these assumptions.

The results are of relevance for the current competition policy debate on how to treat non-controlling and influential partial ownership acquisitions in merger control. According to a recent proposal for a renewed European merger regulation, the European Commission should be able to review acquisitions of minority stakes that establish a significant competitive link between competing or vertically related firms.[32] The proposal suggests that

> *"the competitive link would be considered significant if the acquired shareholding is (1) around 20% or (2) between 5% and around 20%, but accompanied by additional factors such as rights which give the acquirer a 'de-facto' blocking minority, a seat on the board of directors, or access to commercially sensitive information of the target."*

Similarly, German competition law requires that acquisitions of shareholdings of less than 25% have to be notified if they establish *material competitive influence*, whereas influence is not necessary for shareholdings above 25%.[33] The competition laws of Austria, Brazil,

[32] Cf. the reference in fn. 4.

[33] The German Act against Restraints of Competition (GWB) prohibits anti-competitive concentrations, where concentrations include "any other combination of undertakings enabling one or several

Germany, Japan, the UK, and the United States also provide the possibility to review the acquisitions of non-controlling minority shareholdings.[34]

These examples reflect the policy view that influential ownership is more harmful than non-controlling ownership. Our theoretical analysis suggests that such a clear distinction may not be optimal. What matters is the implied degree of profit internalization and not whether this stems from influence or from a profit participation. Non-controlling ownership in one direction can be as harmful as influential ownership in the other direction because both ownership arrangements can induce the same degree of profit internalization. Consequently, firms can, in principle, achieve the same market outcome with either arrangement. If merger control is stricter with respect to large ownership shares or elements of influence, firms may be able to find other arrangements with the same effects that are not subject to a competition review. An avenue for future research is therefore to study whether review policies for partial ownership acquisitions can be improved to better balance the effects of profit claims and influence and to reduce possible loopholes for firms.

undertakings to exercise directly or indirectly a material competitive influence on another undertaking" (see § 37(1) No. 4).

[34]See the "EC's support study for impact assessment of minority shareholdings" of 2016.

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Appendix A

A1: Proofs of Section 4

Proof of Proposition 2. If c is sufficiently large $\left(w^l(\sigma) < c\right)$, the symmetric equilibrium input price $w^l(\sigma)$ solves the system of first-order conditions defined in Equation (19). Implicit differentiation of the equilibrium input price with respect to the degree of forward internalization σ yields

$$\frac{\partial w^l(\sigma)}{\partial \sigma} = -\frac{\partial \pi_i(w_i, w_{-i})/\partial w_i + \partial \pi_{-i}(w_{-i}, w_i)/\partial w_i}{\partial^2 \Omega^U/\partial^2 w_i + \partial^2 \Omega^U/\partial w_i \partial w_{-i}} < 0. \tag{26}$$

By Assumption 1, the nominator is negative; the denominator is negative due to concavity of the supplier's objective function. In a symmetric interior equilibrium, the equilibrium input price $w^l(\sigma)$ thus decreases in the degree of forward internalization σ. This implies $w^l(0) > w^l(\sigma)$. By Assumption 2, downstream prices decrease for a uniform increase in the marginal input prices.

A downstream firm's participation constraint binds if $w^l(\sigma) \geq c$. Given the concave optimization problem, the supplier sets the input price as high as possible; that means $w = c$. This is the same input price as under vertical separation as $w^l(0) > w^l(\sigma) \geq 0$: if the participation constraint is binding at σ, it is also binding at any $\sigma' \in [0, \sigma]$ and the equilibrium input price is $w = c$. Thus, downstream prices are at the same level as under vertical separation.This establishes the result. □

Proof of Proposition 3. Recall that we denote by $w^{tp}(\sigma)$ the symmetric per-unit input price with observable two-part tariffs that solves the system of first-order conditions from Equation (22). Implicit differentiation of $w^{tp}(\sigma)$ with respect to σ yields

$$\frac{\partial w^{tp}(\sigma)}{\partial \sigma} = -\frac{\partial \pi_{-i}(c, w_i)/\partial w_i}{\partial^2 \Omega^U/\partial^2 w_i + \partial^2 \Omega^U/\partial w_i \partial w_{-i}} \geq 0. \tag{27}$$

The denominator is negative due to concavity of the supplier's objective function. The nominator is strictly positive if the competitive fringe is a relevant supply alternative (Assumption 1). This implies that the inequality in Equation (27) is strict. In this case input prices (and thus downstream prices) increase in the degree of forward internalization σ.

If the competitive fringe is not a relevant supply alternative, we have $\partial\pi_{-i}(c, w_i)/\partial w_i = 0$ which implies $\partial w^{tp}(\sigma)/\sigma = 0$ and that downstream prices are the same for all $\sigma \in [0, 1]$. □

Proof of Proposition 4. Suppose supplier U offers each downstream firm a supply contract that specifies a linear input price w_i and entitles the supplier to a share σ_{iU} of the downstream firm's profit. The supplier's maximization problem is

$$\begin{aligned} \max_{w_A, w_B, \delta_{UA}, \delta_{UB}} \Omega^U &= \pi^U(w_A, w_B) + \sigma_{AU}\pi_A(w_A, w_B) + \sigma_{BU}\pi_B(w_B, w_A) \\ s.t. &\quad (1 - \sigma_{AU})\pi_A(w_A, w_B) \geq \pi_A(c, w_B), \\ &\quad (1 - \sigma_{BU})\pi_B(w_B, w_A) \geq \pi_B(c, w_A). \end{aligned} \tag{28}$$

Solving the participation constraints for σ_{AU} and σ_{BU} such that they hold with equality and substituting in the objective function yields

$$\max_{w_A, w_B} \Omega^U = \pi^I(w_A, w_B) - \pi_A(c, w_B) - \pi_B(c, w_A), \tag{29}$$

which is the same problem as for the case of vertical separation and observable two-part tariffs (the problem in Equation (21) for $\sigma = 0$). Therefore, the firms do not obtain a higher joint profit (through higher input prices w_i, $i \in \{A, B\}$) with profit sharing on the basis of a supply contract. □

A2: Proofs of Section 5

Preliminaries

This appendix contains the results and proofs of Section 5. We focus on an ownership structure in which the downstream firms hold an influential and symmetric share $\alpha \in [0, 1/2]$ of the efficient supplier U.[35] The ownership confers influence over the supplier's strategic decisions and induces the management of U to internalize a share of σ of

[35] The analysis here is presented for the case of backward ownership in order to focus on the competitive effects of vertical profit internalization only. Recall that there is direct horizontal internalization between

the downstream firms' profits. The analysis also confers to any other ownership structure that induces the same degrees of forward and backward profit internalization. In order to analyze the joint effect of bi-directional internalization, we assume a proportional relationship between the profit share and corporate influence (proportional influence), which yields $\sigma = \alpha / \left(1 - 2\alpha \left(1 - \alpha\right)\right)$.

Proofs

The following lemma introduces the downstream firms' effective input costs if there is backward internalization α.

Lemma 4. *With symmetric backward internalization α, the downstream firm i's effective input costs under Cournot competition are*

$$w_i^{ef} \equiv \left(1 - \alpha\right) w_i. \tag{30}$$

Under Bertrand competition, the effective input costs are

$$w_A^{ef} \equiv \left(1 - \alpha\right) w_A - \alpha w_B \Gamma, \tag{31}$$

with $\Gamma = \frac{\partial q_B(p_B,p_A)/\partial p_A}{\partial q_A(p_A,p_B)/\partial p_A}$. *The downstream prices increase if the effective input costs of both downstream firms increase.*

Proof of Lemma 4. Under Cournot competition with demand $p_i\left(q_i, q_{-i}\right)$, the objective function for (say) downstream firm A is

$$\Omega_A \quad = \quad \left(p_A\left(q_A, q_B\right) - \left(1 - \alpha\right) w_A\right) q_A + \alpha w_B q_B. \tag{32}$$

As the downstream firm internalizes a share of the supplier's profit, it effectively receives a rebate of αw_A on all input purchases from this supplier. Hence, denote the downstream firm's effective input price with $w_i^{ef} \equiv \left(1 - \alpha\right) w_i$ in this case.

Under imperfect Bertrand competition with inverse demand $q_i\left(p_i, p_{-i}\right)$, A's objective func-

the downstream competitors with influential forward ownership (Lemma 1), which is anti-competitive in itself.

tion is

$$\Omega_A = (p_A - (1-\alpha) w_A) q_A (p_A, p_B) + \alpha w_B q_B (p_B, p_A). \tag{33}$$

Denote with p_i^*, $\in \{A, B\}$ the equilibrium downstream price that solves the system of first-order conditions. The first-order condition with respect to $p_A$is

$$\underbrace{p_A^* \frac{\partial q_A (p_A^*, p_B^*)}{p_A}}_{\text{marginal benefit of increasing } p_A} = \underbrace{((1-\alpha) w_A - \alpha w_B \Gamma) \frac{\partial q_A (p_A^*, p_B^*)}{p_A}}_{\text{marginal cost of increasing } p_A}, \tag{34}$$

with $\Gamma = \frac{\partial q_B (p_B^*, p_A^*)/\partial p_A}{\partial q_A (p_A^*, p_B^*)/\partial p_A}$, which captures the decline in B's sales (and therefore input demand) if A increases p_A. With linear demand defined in Equation (17), we have $\Gamma = -\gamma$. Note that this effect is not present under Cournot competition as $\partial (\alpha w_B q_B)/\partial q_A = 0$. We therefore define the effective input costs under Bertrand competition as

$$w_A^{ef} \equiv (1-\alpha) w_A - \alpha w_B \Gamma. \tag{35}$$

Given a stable, interior equilibrium in the downstream market (Assumption 2), an increase in the effective input costs implies that downstream prices increase. □

Proof of Proposition 5. We first present the case of Cournot competition and analyze the case of Bertrand competition afterwards. Let upstream firm U charge linear tariffs. Denote with $q_i^* = q_A (w_A^e, w_B^e)$ downstream firm i's equilibrium quantity choice, which depends on the effective input costs w_i^e. With inverse demand $p_i (q_i, q_{-i})$, the supplier's objective function under linear tariffs is

$$\begin{aligned} \Omega^U (w_A, w_B) &= \sum_{i \in \{A,B\}} w_i q_i^* + \sigma \sum_{i \in \{A,B\}} \left(p_i \left(q_i^*, q_{-i}^* \right) - w_i \right) q_i^* \\ &= (1-\sigma)(w_A q_A^* + w_B q_B^*) + \sigma (p_A (q_A^*, q_B^*) q_A^* + p_B (q_B^*, q_A^*) q_B^*). \end{aligned} \tag{36}$$

The supplier's objective function (36) can also be expressed in terms of effective input prices:

$$\Omega^U \left(w_A^{ef}, w_B^{ef} \right) = \frac{1-\sigma}{1-\alpha} \underbrace{\sum_{i \in \{A,B\}} w_i^e q_i^*}_{\pi^U \left(w_A^e, w_B^e \right)} + \sigma \underbrace{\sum_{i \in \{A,B\}} p_i \left(q_i^*, q_{-i}^* \right) q_i^*}_{\pi^I \left(w_A^e, w_B^e \right)}, \tag{37}$$

such that the supplier's maximization problem can be interpreted as choosing effective input prices directly. The first-order condition for the maximization problem in Equation (37) with respect to (say) w_A^{ef} is

$$\frac{\partial\Omega^U\left(w_A^{ef},w_B^{ef}\right)}{\partial w_A^{ef}} = \frac{1-\sigma}{1-\alpha}\frac{\partial\pi^U\left(w_A^{ef},w_B^{ef}\right)}{\partial w_A^{ef}} + \sigma\frac{\partial\pi^I\left(w_A^{ef},w_B^{ef}\right)}{\partial w_A^{ef}} = 0. \tag{38}$$

Denote the symmetric equilibrium effective input price as $w^{ef}(\alpha,\sigma) = w_A^{ef}(\alpha,\sigma) = w_B^{ef}(\alpha,\sigma)$.[36] If $\sigma = 0$, the first-order condition simplifies to $\partial\pi^U/\partial w_A^{ef} = 0$ as in case of vertical separation. Hence, the effective input price $w^{ef}(\alpha,\sigma)$ is the same under pure backward internalization.

For $\sigma \in (0,1)$, note that the effective input price $w^{ef}(\alpha,\sigma)$ is below the level that maximizes π^U and above the level that maximizes π^I (due to double marginalization). This implies $\partial\pi^I\left(w_A^{ef},w_B^{ef}\right)/\partial w_A^{ef} < 0$. Implicit differentiation of $w^{ef}(\alpha,\sigma)$ with respect to α yields

$$\frac{\partial w^{ef}(\alpha,\sigma)}{\partial\alpha} = -\frac{-\sigma\left(\partial\pi^I\left(w_A^{ef},w_B^{ef}\right)/\partial w_A^{ef}\right)}{\partial^2\Omega^U/\partial^2 w_A^{ef} + \partial^2\Omega^U/\partial w_A^{ef}\partial w_B^{ef}} > 0. \tag{39}$$

The inequality follows from the denominator being negative. Hence, we conclude that the degree of backward internalization α increases effective input prices for the downstream firms if $\sigma > 0$.

For the case of Bertrand competition, we consider the linear demand function defined in Eq. (17). The effective input price $w^{ef}= (1-\alpha(1-\gamma))\,w$ becomes

$$w^{ef}(\alpha,\sigma) = \frac{2-2\sigma+\alpha\gamma^2\sigma-\gamma(1+(-2+\alpha)\,\sigma}{4-2(1+\alpha)\,\sigma+2\gamma(-1+\sigma+\alpha\sigma)}. \tag{40}$$

For $\sigma = 0$, the effective input prices reduces to $w^{ef}(\alpha,0) = 2/(4-2\gamma)$ and is thus independent of the degree of backward internalization α, as are the downstream prices. For $\sigma > 0$, the effective input price increases in the degree of backward internalization α. By Lemma 4, an increase of the effective input prices implies that both downstream prices increase. This establishes the result. □

[36] From now on we will suppress the index for linear or two-part tariffs when there is little chance for confusion.

Proof of Corollary 2. In the case of proportional influence $\sigma = \alpha/1 - 2\alpha(1-\alpha)$, the first-order condition in Equation (38) for quantity competition becomes

$$\underbrace{\frac{1}{1-\alpha} \cdot \frac{1-3\alpha+2\alpha^2}{1-2\alpha(1-\alpha)}}_{\text{neg. derivative in } \alpha} \frac{\partial \pi^U \left(w_A^{ef}, w_B^{ef}\right)}{\partial w_A^{ef}} + \underbrace{\frac{\alpha}{1-2\alpha(1-\alpha)}}_{\text{pos. derivative in } \alpha} \frac{\partial \pi^I \left(w_A^{ef}, w_B^{ef}\right)}{\partial w_A^{ef}} = 0. \quad (41)$$

The comparative static with respect to the symmetric ownership share $\alpha \in (0, 1/2)$, $\partial w^{ef}(\alpha)/\partial\alpha$ is

$$-\frac{1}{1-2\alpha(1-\alpha)} \frac{-4\alpha(1-\alpha)\,\partial\pi^U\left(w_A^{ef}, w_B^{ef}\right)/\partial w_A^{ef} + (1-2\alpha^2)\,\partial\pi^I\left(w_A^{ef}, w_B^{ef}\right)/\partial w_A^{ef}}{\partial^2\Omega^U/\partial^2 w_A^{ef} + \partial^2\Omega^U/\partial w_A^{ef}\partial w_B^{ef}} < 0. \quad (42)$$

The denominator is negative by concavity of the supplier's maximization problem. Recall that $w^e(\alpha, \sigma)$ is below the level that maximizes π^U and above the level that maximizes π^I. This implies $\partial\pi^I\left(w_A^{ef}, w_B^{ef}\right)/\partial w_A^{ef} < 0$ and $\partial\pi^U\left(w_A^{ef}, w_B^{ef}\right)/\partial w_A^{ef} > 0$. Together with the fact that $-4\alpha(1-\alpha) < 0$ and that $1-2\alpha^2 > 0$, we conclude that the nominator is negative and therefore $\partial w_A^{ef}(\alpha)/\partial\alpha < 0$. Hence, a higher degree of backward ownership with proportional influence decreases effective input prices and hence decreases the equilibrium downstream prices.

For price competition and linear demand, the symmetric effective input price $w^{ef} = (1-\alpha(1-\gamma))\,w$ becomes

$$w^{ef}(\alpha, \sigma) = \frac{-2+\alpha(6-4\gamma)+\gamma-\alpha^2(4-3\gamma+\gamma^2)}{2(-2+\alpha(5-3\gamma)\alpha^2(-3+\gamma)+\gamma)}, \quad (43)$$

which decreases if the downstream firms hold a larger symmetric share $\alpha \in (0, 1/2)$ of the upstream firm (still assuming proportional influence). This implies that downstream prices decrease and establishes the result. □

Proof of Proposition 6. Let upstream firm U charge linear tariffs. Denote with $p_i^* = p_i\left(w_i^{ef}, w_{-i}^{ef}\right)$ the downstream firm i's equilibrium price, which depends on the effective input prices. Assume that the competitive fringe is sufficiently efficient (c low enough), such that the the downstream firms' participation constraints define the efficient supplier's optimal input prices. This condition holds if the symmetric linear input price, which solves the supplier's unconstrained maximization problem, is larger than the competitive fringe's marginal costs: $w^{ef}(\alpha,\sigma) > c$. In this case the supplier sets the highest feasible nominal input price $w = c/(1-\alpha)$ because for higher nominal input prices the downstream firms would switch to the competitive fringe. The first-order condition of (say) downstream firm A is therefore

$$\frac{\partial \Omega_A(p_A^*, p_B^*)}{p_A} = \frac{\partial q_A(p_A^*, p_B^*)}{\partial p_A}(p_A^* - c) + q_A(p_A^*, p_B^*) + \alpha \frac{c}{1-\alpha} \frac{\partial q_B(p_B^*, p_A^*)}{\partial p_A} = 0. \quad (44)$$

For a positive degree of backward internalization ($\alpha > 0$), Equation (44) shows that the downstream firms partially internalize the profit of U from supplying the downstream competitor. With downstream substitutes ($\partial q_i / \partial p_{-i} > 0$), the quantity q_i increases if the competitor $-i$ charges a higher price. Therefore, the downstream firms' marginal profits increases in α and both firms have an incentive to increase the price p_i (see proof Proposition 1 in Hunold and Stahl 2016). Diverting sales to the competitor yields additional upstream profit. The effect increases in α as well as in the degree of substitutability between the downstream products. Recall that this effect is not present under Cournot competition, which means that bi-directional internalization is competitively neutral (see proof of Lemma 4). This establishes the result. □

Proof of Proposition 7. Suppose that supplier U charges observable two-part tariffs. With backward internalization, the downstream equilibrium depends on the effective input costs of both downstream firms that account for all potential rebates on the nominal input prices $w_i,\ i \in \{A, B\}$. The objective function of (say) downstream firm A is

$$\Omega_A(w_A, w_B) = \pi_A(w_A, w_B) - (1-\alpha) f_A + \alpha \left(\pi^U(w_A, w_B) + f_B\right). \quad (45)$$

A's outside option from purchasing the input from the competitive fringe at input costs of c is

$$\Omega_A(c, w_B) = \pi_A(c, w_B) + \alpha \left(\pi^U(c, w_B) + f_B\right), \quad (46)$$

where $\pi^U(c, w_B)$ denotes the supplier's profit (with B) if A sources from the fringe and has input costs of c. The supplier sets f_A such that $\Omega_A(w_A, w_B) = \Omega_A(c, w_B)$, which yields

$$(1-\alpha) f_A = \pi_A(w_A, w_B) - \pi_A(c, w_B) + \alpha\left(\pi^U(w_A, w_B) - \pi^U(c, w_B)\right). \quad (47)$$

The last bracket in Equation (47), shows that the fixed fee depends on the profit difference that the supplier obtains from selling the input good to A's downstream rival depending on A's supplier choice.

As ownership is influential, the supplier internalizes a share σ of the downstream profits (bi-directional internalization). The supplier maximizes

$$\begin{aligned} \Omega^U(w_A, w_B, f_A, f_B) &= \pi^U(w_A, w_B) + f_A + f_B \\ &+ \sigma\left(\pi_A(w_A, w_B) - f_A + \pi_B(w_B, w_A) - f_B\right). \end{aligned} \quad (48)$$

Plugging in the fixed fees (f_i) from Equation (47) leads to U's reduced objective function

$$\begin{aligned} \Omega^U &= \frac{1-\alpha\sigma}{1-\alpha}\pi^I(w_A, w_B) - \frac{1-\sigma}{1-\alpha}\left(\pi_A(c, w_B) + \pi_B(c, w_A)\right) \\ &- \frac{(1-\sigma)\alpha}{1-\alpha}\left(\pi^U(c, w_B) + \pi^U(w_A, c) - \pi^U(w_A, w_B)\right). \end{aligned} \quad (49)$$

For $\alpha = 0$, we obtain the same objective function as under pure forward internalization (see Eq. (21)). For bi-directional internalization, the supplier's first-order condition with respect to (say) w_A, $\partial\Omega^U/\partial w_A = 0$, becomes

$$\begin{aligned} &\frac{1-\alpha\sigma}{1-\alpha} \cdot \frac{\partial \pi^I(w_A, w_B)}{\partial w_A} \\ -\ &\frac{1-\sigma}{1-\alpha}\left(\frac{\partial \pi_B(c, w_A)}{\partial w_A} + \alpha\left(\frac{\partial \pi^U(w_A, c)}{\partial w_A} - \frac{\partial \pi^U(w_A, w_B)}{\partial w_A}\right)\right) = 0. \end{aligned} \quad (50)$$

We can interpret the second line of Equation (49) as the supplier's incentive to reduce the downstream firms' outside option. As in Section 4, a downstream firm obtains an outside option due to the fact that it can source alternatively ($\pi_i(c, w_{-i})$). With bi-directional internalization, a downstream firm additionally internalizes with share α that the supplier may achieve a different profit with the downstream rival if it rejects U's offer. The supplier can influence both terms with the input prices that it charges and therefore finds it optimal to distort prices away from the level that maximizes the industry profit

π^I.

We analyze the supplier's maximization problem with linear demand defined in Equations (16) and (17). The effective input price $w_i^{ef} = (1-\alpha)\, w_i$ under Cournot competition and influential backward ownership (profit share α and influence $\sigma = \alpha / (1 - 2\alpha(1-\alpha))$) is

$$\frac{\gamma\left((1-\alpha)(\gamma-2)(\alpha(\gamma+2)-\gamma)+c\left(2\alpha^2\left(\gamma^2-8\right)-\alpha\left(\gamma^2-16\right)-4\right)\right)}{2\left(\alpha^2\left(\gamma^3+\gamma^2-8\gamma-4\right)+\alpha\left(\gamma^3-3\gamma^2+4\gamma+8\right)-\gamma^3+2\gamma^2-4\right)}. \tag{51}$$

Under Bertrand competition, we obtain for the symmetric effective input price $w_i^{ef} = (1-\alpha(1-\gamma))\, w_i$ the following expression

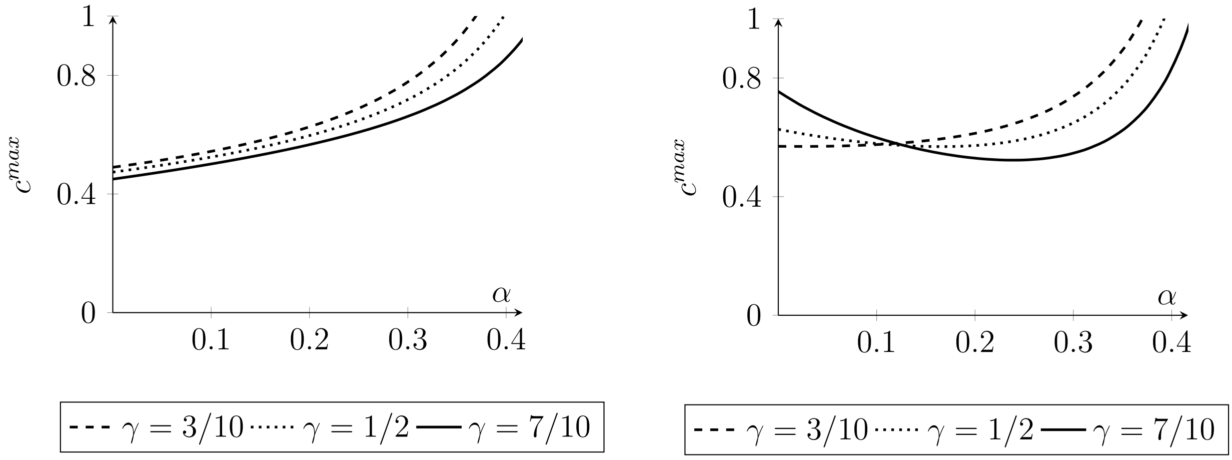
$$\frac{(1+\alpha(-1+\gamma))\gamma\left(\left(2-\gamma-\gamma^2\right)\left(2\alpha+\gamma+\alpha^2\left(-2-\gamma+\gamma^2\right)\right)+c\left(4-2\gamma^2-\alpha\left(16-9\gamma^2+\gamma^4\right)+2\alpha^2\left(8-5\gamma^2+\gamma^4\right)\right)\right)}{-2\left(-4+2\gamma^2+\gamma^3-4\alpha^2\left(3+\gamma-\gamma^2\right)+\alpha\left(12-4\gamma-5\gamma^2+2\gamma^3+\gamma^4\right)+\alpha^3\left(4+16\gamma-5\gamma^2-9\gamma^3+\gamma^4+\gamma^5\right)\right)}. \tag{52}$$

For $c = 0$, one can show that the effective input prices under Cournot (Eq. (51)) and Bertrand (Eq. (52)) competition increase in α: $\partial w_i^{ef} / \partial \alpha > 0$. Due to continuity, this also holds for sufficiently small, but positive values of c. In Appendix A3, we verify that influential backward ownership leads to higher effective input prices for a wide range of parameter values. Given a stable downstream equilibrium (Assumption 2), higher input costs imply higher downstream prices. □

A3: Observable two-part tariffs and bi-directional internalization

With observable two-part tariffs, effective input prices w_i^{ef} increase with bi-directional internalization for large parameter ranges. Let c^{max} denote the highest value of the competitive fringe's marginal costs such that the effective input prices increase in the ownership share α, that is $\partial w_i^{ef} / \partial \alpha > 0$, for all $c < c^{max}$. Figure 2 displays c^{max} for for three different parameter values of γ, both for price and quantity competition.

Figure 2: Maximal efficiency c^{max} of competitive fringe such that $\partial w_i^{ef}/\partial\alpha > 0$



(a) Cournot competition

(b) Bertrand competition

The lines show the maximal values of the marginal costs of the competitive fringe c^{max} for different values of the product differentiation parameter $\gamma = (3/10, 1/2, 7/10)$ such that $\partial w_i^{ef}/\partial\alpha > 0$. Competition is in quantities in the panel (a) and in prices in panel (b). Demand functions are defined in Eq. (16) and (17). Corporate influence is proportional to the share of backward ownership α and the competitive fringe.

A4: Proofs of Section 6.1

Preliminaries

In order to analyze the cases of Cournot and Bertrand competition separately, we first introduce additional notation. Building on Rey and Vergé (2004), we assume that the demand for each downstream firm, $q_i(p_i, p_{-i})$ is symmetric with $\frac{\partial q_i}{\partial p_i} + \frac{\partial q_i}{\partial p_{-i}} < 0 < \frac{\partial q_i}{\partial p_{-i}}$. For the case of Cournot competition, we assume that the resulting inverse demand system $p_i(q_i, q_{-i})$, $i \in \{A, B\}$, with $\frac{\partial p_i}{\partial q_i} < \frac{\partial p_i}{\partial q_{-i}} < 0$, is also symmetric.

We further maintain the assumption that downstream firms' objective functions are strictly concave (Assumption 2). In contrast, we cannot simply assume that the supplier's maximization problem is concave (Assumption 3) in this section. As emphasized by Rey and Vergé (2004) for the case of vertical separation, the supplier's objective function is not necessarily concave with unobservable contracts and thus a perfect Bayesian-Nash equilibrium may fail to exist. Instead we impose

Assumption 5. *There exists a unique symmetric solution to the first-order conditions of the supplier's maximization problem and the objective function $\Omega^U(w_A, w_B)$ has negative second-order derivatives: $\partial^2\Omega^U/\partial^2 w_i$.*

Below, we show that this assumption is always fulfilled for the case of Cournot competition. With Bertrand competition, this assumption is also fulfilled under vertical separation(Rey and Vergé, 2004). Assumption 5 ensures that the same applies for the case of partial vertical ownership and Bertrand competition. It is satisfied if demand is not too convex; for instance, if demand is linear.[37] For equilibrium existence, we still need to check that the sufficient conditions are also fulfilled (additionally a negative definite Hessian).

Recall that we denote a downstream firm's contract offer as $t_i = (w_i, f_i)$. With unobservable contracts, a downstream firm needs to form a belief about the rival's contract offer. We denote beliefs with capital letters. In general, the beliefs depend on t_i, that is, $T_{-i}(t_i) = (W_i(t_i), F_i(t_i))$. In this appendix we analyze that each downstream firm holds passive beliefs about the rival's contract offer. This implies that a downstream firm's belief about the rival's contract does not change if it receives an out-of-equilibrium offer and thus drop the argument t_i in case of passive beliefs: $T_{-i} = (W_{-i}, F_{-i})$. In equilibrium, beliefs are correct.

Let the downstream firms hold a symmetric share of the supplier's shares ($\alpha_{AU} = \alpha_{BU} = \alpha$). With corporate influence, the supplier internalizes a share σ of the downstream firms' profits. As in Section 5, we account for the fact that, with backward internalization, the nominal and effective input prices (w_i and w_i^{ef}) differ for the downstream firms (Lemma 4). We therefore denote the optimal strategic decision of a downstream firm as a function of the effective input prices:$q_i\left(w_i^{ef}\right)$ for Cournot and $p_i\left(w_i^{ef}\right)$ and Bertrand competition. Similarly, downstream firm i expects that the rival $-i$ sets the quantity $Q_{-i} = q_{-i}\left(W_{-i}^{ef}\right)$ or the price $P_{-i} = p_{-i}\left(W_{-i}^{ef}\right)$ (depending on the mode of competition). Given the belief about the rival's contract offer and the rival's strategic decision (price or quantity), each downstream firm also forms belief about the upstream firm's profit from supplying the downstream rival, which it internalizes with a share of α. For Cournot competition this share is $W_{-i}Q_{-i} + F_{-i}$ and for Bertrand competition this share is $W_{-i}Q_{-i}(P_{-i}, p_i) + F_{-i}$.

[37] See, for instance, Pagnozzi and Piccolo (2012) for a related assumption on the supplier's objective function.

Proofs

In order to derive the result of Lemma 3, we prove the following two lemmas for Cournot and Bertrand competition, respectively.

Lemma 5. *Suppose there is Cournot competition downstream. With partial vertical ownership, there always exists a unique equilibrium. In any equilibrium with pure backward internalization (with share $\alpha \geq 0$ and $\sigma = 0$), the (effective) input prices are equal to the supplier's marginal costs. With forward internalization, input prices equal to the supplier's marginal costs are not an equilibrium.*

Proof. First, we derive the supplier's maximization problem and establish equilibrium existence and uniqueness.

With backward internalization, each downstream firm optimally sets the quantity for a given level of effective input prices $w_i^{ef} = (1-\alpha)\, w_i$

$$q_i\left(w_i^{ef}\right) = \arg\max_{q_i} \left(p_i\left(q_i, Q_{-i}\right) - (1-\alpha)\, w_i\right) q_i - (1-\alpha)\, f_i + \alpha\left(W_{-i}Q_{-i} + F_{-i}\right), \quad (53)$$

which is implicitly defined by the downstream firm i's first-order condition

$$\frac{\partial \Omega_i}{\partial q_i} = \left(p_i\left(q_i\left(w_i^{ef}\right), Q_{-i}\right) - (1-\alpha)\, w_i\right) + \frac{\partial p_i\left(q_i\left(w_i^{ef}\right), Q_{-i}\right)}{\partial q_i} q_i\left(w_i^{ef}\right) = 0. \quad (54)$$

The equilibrium quantity decreases monotonically in w_i^{ef}. That is,

$$\frac{\partial q_i\left(w_i^{ef}\right)}{\partial w_i^{ef}} = -\frac{-1}{\partial^2 \Omega_i / \partial^2 q_i} < 0, \quad (55)$$

due to the concavity of i's objective function. Hence, there is one-to-one mapping between the w_i^{ef} and $q_i\left(w_i^{ef}\right)$. Below, we can therefore characterize the supplier's problem as effectively selecting quantities in the downstream market.

Downstream firm i's objective function is

$$\Omega_i = \left(p_i\left(q_i\left(w_i^{ef}\right), Q_{-i}\right) - (1-\alpha)\, w_i\right) q_i\left(w_i^{ef}\right) - (1-\alpha)\, f_i + \alpha\left(W_{-i}Q_{-i} + F_{-i}\right). \quad (56)$$

With passive beliefs, the last term in i's objective function does not depend on i's contract offer. If the downstream firm does not accept the supplier's contract offer, it is inactive in the downstream market and it only expects to obtain the upstream profit share $\alpha\left(W_{-i}Q_{-i}+F_{-i}\right)$. This expected profit does not depend on the acceptance decision of downstream firm i. The supplier cannot adjust its contract offer to the downstream rival and the rival does not adjust Q_{-i} as it cannot observe the deviation. The supplier therefore sets the downstream firms indifferent to their outside option by setting

$$(1-\alpha)\,f_i \;=\; \left(p_i\left(q_i\left(w_i^{ef}\right),Q_{-i}\right)-(1-\alpha)\,w_i\right)q_i\left(w_i^{ef}\right). \tag{57}$$

The supplier internalizes a share σ of each downstream firm's profit (which equals the operational profit $\left(p_i\left(q_i\left(w_i^{ef}\right),q_{-i}\left(w_{-i}^{ef}\right)\right)-w_i\right)q_i\left(w_i^{ef}\right)$ minus the fixed fee f_i). Whereas f_i depends only on the contract offered to i, the operational profit that realizes in the last stage of the game clearly also depends on the rival's contract offer and thus the output choice q_{-i}. As the supplier knows both contract offers, it can correctly infer the actual strategic choices and operational profits of both downstream firms. Hence, for out-of-equilibrium offers, the operational profit in general differs from the fixed fee. The supplier's resulting objective function is

$$\begin{aligned}\Omega^U\left(w_A^{ef},w_B^{ef}\right)= \;\; & \textstyle\sum_{i\in\{A,B\}}\;\;\left(w_iq_i\left(w_i^{ef}\right)+f_i\right. \\ & \left.+\,\sigma\left(\left(p_i\left(q_i\left(w_i^{ef}\right),q_{-i}\left(w_{-i}^{ef}\right)\right)-w_i\right)q_i\left(w_i^{ef}\right)-f_i\right)\right).\end{aligned} \tag{58}$$

As already mentioned above, there is a one-to-one mapping between the effective input prices and equilibrium quantities and, hence, it is convenient to characterize the supplier's maximization problem as selecting the downstream quantities directly. By substituting the fixed fees from (57), we can therefore write the objective function depending on the downstream quantities as follows

$$\Omega^U\left(q_A,q_B\right)=\;\textstyle\sum_{i\in\{A,B\}}\;\left(\sigma p_i\left(q_i,q_{-i}\right)q_i+\dfrac{1-\sigma}{1-\alpha}p_i\left(q_i,Q_{-i}\right)q_i\right). \tag{59}$$

The first term in Equation (59) is proportional to the industry profit $\pi^I=\sum_{i\in\{A,B\}}p_i\left(q_i,q_{-i}\right)q_i$, which is a strictly concave function in q_A and q_B by Assumption 4. The second term contains the supplier's objective function under vertical separation (as in Rey and Vergé

(2004), see Proposition 1 therein). As each contract enters this term in a separable way, it is straightforward to show that this term is also strictly concave. Hence, the objective function in Equation (59) is strictly concave, ensuring that sufficient conditions for equilibrium existence and uniqueness are fulfilled. This also implies that Assumption 5 is fulfilled.

Next, we show that the equilibrium does not involve marginal input prices equal to the supplier's marginal costs if the supplier internalizes a share $\sigma > 0$ of the downstream firms' profits. The first-order condition with respect to (say) q_A is

$$\begin{aligned} \frac{\partial \Omega^U}{\partial q_A} &= \sigma \left(\underbrace{\frac{\partial p_A(q_A, q_B)}{\partial q_A} q_A + p_A(q_A, q_B)}_{=(1-\alpha)w_A = w_A^{ef}} + \frac{\partial p_B(q_B, q_A)}{\partial q_B} q_B \right) \\ &+ \frac{1-\sigma}{1-\alpha} \underbrace{\left(\frac{\partial p_A(q_A, Q_B)}{\partial q_A} q_A + p_A(q_A, Q_B) \right)}_{=(1-\alpha)w_A = w_A^{ef}} = 0. \end{aligned} \tag{60}$$

From the downstream firm's first-order condition (Equation (54)), we can infer that first two terms in the bracket in the first line and the term in the brackets in the second line equals the effective input cost $w_A^{ef} = (1-\alpha) w_A$. The former holds as beliefs are correct in equilibrium.

Note additionally that this first-order condition is a convex combination between the first derivative of the industry profit in the first line $\left(\partial \pi^I / \partial q_A\right)$ and the first derivative of the joint profit of U and A in the second line $\left(\partial \pi_A^U / \partial q_A\right)$. The second line only depends on q_A and not q_B. We can therefore re-write the supplier's first-order condition as

$$\frac{\partial \Omega^U}{\partial q_A} = \sigma \frac{\partial \pi^I(q_A, q_B)}{\partial q_A} + \frac{1-\sigma}{1-\alpha} \frac{\partial \pi_A^U(q_A)}{\partial q_A} = 0 \tag{61}$$

Denote the symmetric equilibrium quantity that solves the supplier's system of first-order conditions as $q_A(\alpha, \sigma) = q_B(\alpha, \sigma) = q(\alpha, \sigma)$ and the symmetric effective input price, which induces this quantity in the downstream market, with $w_A^{ef}(\alpha, \sigma) = w_B^{ef}(\alpha, \sigma) = w^{ef}(\alpha, \sigma)$.

If there is only backward internalization ($\sigma = 0$), the supplier's maximization problem only consists of maximizing the joint profit of U and A and the supplier therefore sets the effective input price $w^{ef} = w = 0$. This input prices maximize the bilateral profit with downstream i firm, as in the case of vertical separation.

The comparative static results change if the ownership structure also involves forward internalization ($\sigma > 0$). In particular, we observe that at $w^{ef} = 0$ the term in the first line of Equation (60) is positive: $\left(\partial p_B \left(q_B, q_A\right)/\partial q_A\right) \cdot q_B > 0$. This implies that input prices equal to the supplier's marginal costs do not maximize the industry profit and, hence, the supplier's objective function, which assigns positive weight on the industry profit. We conclude that input prices equal to the supplier's marginal costs do not fulfill the necessary condition for an equilibrium in this case. This establishes the result. □

Lemma 6. *Suppose there is Bertrand competition downstream. If an equilibrium exists, with pure backward internalization (with share $\alpha > 0$ and $\sigma = 0$), the (effective) input prices are equal to the supplier's marginal costs. With forward internalization, input prices equal to the supplier's marginal costs are not an equilibrium.*

Proof. In the case of Bertrand competition, downstream firm i, which internalizes a share α of the supplier's profit, sets the optimal price given passive beliefs about W_{-i} and the resulting P_{-i} as follows:

$$p_i\left(w_i^{ef}\right) = \arg\max_{p_i} \left(p_i - (1-\alpha)\, w_i\right) q_i\left(p_i, P_{-i}\right) + \alpha\left(W_{-i} Q_{-i}\left(P_{-i}, p_i\right) + F_{-i}\right). \qquad (62)$$

As for the Cournot case, the equilibrium price is monotonic in w_i^e. In particular, $p_i\left(w_i^e\right)$ increases in w_i^e, that is,

$$\frac{\partial p_i\left(w_i^{ef}\right)}{\partial w_i^{ef}} = -\frac{-\partial q_i/\partial p_i}{\partial^2 \Omega_i/\partial^2 p_i} > 0. \qquad (63)$$

Denote with $q_i\left(p_i\left(w_i^{ef}\right), P_i\right)$ the quantity that downstream firm i expects to sell given its own price p_i and the expected competitor's price P_{-i}. Similarly, downstream firm i expects that the supplier sells $Q_{-i}\left(P_{-i}, p_i\left(w_i^{ef}\right)\right)$ to the downstream rival. Instead, if a downstream firm does not accept the supplier's contract offer, it expects that the rival sells $Q_{-i}^D\left(P_{-i}\right)$, where D indicates that the downstream firm does not participate in the downstream market. The supplier sets the effective fixed fee such that the downstream firms are indifferent between the contract offer and being inactive. For downstream firm

A this means

$$(1-\alpha) f_A = \left(p_A\left(w_A^{ef}\right)-(1-\alpha) w_A\right) q_A\left(p_A\left(w_A^{ef}\right), P_B\right) + \alpha W_B\left(Q_B\left(P_B, p_A\left(w_A^{ef}\right)\right)-Q_B^D\left(P_B\right)\right). \tag{64}$$

The supplier can always correctly infer the downstream prices and quantities, as it knows the input prices that it offers to both downstream firms. Hence, denote with $q_i\left(p_i\left(w_i^{ef}\right), p_{-i}\left(w_{-i}^{ef}\right)\right)$ the quantity that downstream firm i ends up selling when the supplier offers effective input prices of w_i^{ef} and w_{-i}^{ef}. Note that the effective input costs are a monotone function of the nominal input costs. The supplier's objective function in w_A and w_B is

$$\Omega^U\left(w_A, w_B\right) = \sum_{i \in\{A, B\}} w_i q_i\left(p_i\left(w_i^{ef}\right), p_{-i}\left(w_{-i}^{ef}\right)\right)+f_i + \sigma\left(\left(p_i\left(w_i^{ef}\right)-w_i\right) q_i\left(p_i\left(w_i^{ef}\right), p_{-i}\left(w_{-i}^{ef}\right)\right)-f_i\right). \tag{65}$$

Substituting for the fixed fees (Equation 64), we can rewrite U's objective function as

$$\Omega^U\left(w_A, w_B\right)= \textstyle\sum_{i \in\{A, B\}} \sigma\left(p_i q_i\left(p_i, p_{-i}\right)\right) + (1-\sigma)\left(w_i\left(q_i\left(p_i, p_{-i}\right)-q_i\left(p_i, P_{-i}\right)\right)\right) + \frac{1}{1-\alpha}\left(p_i q_i\left(p_i, P_{-i}\right)+\alpha W_{-i}\left(Q_{-i}\left(P_{-i}, p_i\right)-Q_{-i}^D\left(P_{-i}\right)\right)\right). \tag{66}$$

The unique candidate equilibrium prices solve the system of the supplier's first-order conditions. The (simplified) first-order condition to the supplier's objective function in Equation (66) with respect to (say) w_A is

$$\frac{\partial \Omega^U}{\partial w_A} = \left(\sigma p_B+\frac{1-\sigma}{1-\alpha} w_B\right) \frac{\partial q_B\left(p_B, p_A\right)}{\partial p_A} + \frac{1-\alpha \sigma}{1-\alpha}\left(q_A\left(p_A, p_B\right)+p_A \frac{\partial q_A\left(p_A, p_B\right)}{\partial p_A}\right)=0, \tag{67}$$

where we use that beliefs are correct in equilibrium ($p_i\left(w_i^{ef}\right)=P_i \equiv p_i$, $w_i=W_i$) and divide the first-order condition by $\frac{\partial p_A\left(w_A^e\right)}{\partial w_A^e} \frac{\partial w_A^e}{\partial w_A}$. Note that for pure backward internalization ($\sigma=0$) the degree of backward internalization only pre-multiplies the first-order condition. Hence, pure backward internalization does not affect the supplier's optimality condition and it chooses the same effective input prices as under vertical separation.

From the downstream firm's first-order condition $\partial\Omega_A/\partial p_A = 0$ we obtain

$$q_A + p_A \frac{\partial q_A}{\partial p_A} = \left(\underbrace{(1-\alpha)\, w_A - \alpha w_B \Gamma}_{w_A^{ef}} \right) \frac{\partial q_A}{\partial p_A}, \tag{68}$$

with $\Gamma = \frac{\partial q_B/\partial p_A}{\partial q_A/\partial p_A}$ (see Proof of Lemma 4). Substituting from Equation (68) in the brackets in the second line of Equation (67) yields

$$\begin{aligned} &\left(\sigma p_B + \frac{(1-\sigma)\, w_B}{1-\alpha} \right) \frac{\partial q_B\,(p_B, p_A)}{\partial p_A} \\ + \quad &\frac{(1-\alpha\sigma)\, w_A^{ef}}{1-\alpha} \frac{\partial q_A\,(p_A, p_B)}{\partial p_A} = 0. \end{aligned} \tag{69}$$

For $\sigma > 0$ and $w_A^{ef} = w_B^{ef} = 0$, the lhs of Equations (69) becomes $\sigma p_B \cdot \partial q_B\,(p_B, p_A)\,/\partial p_A$, which is positive. Input prices equal to the supplier's marginal costs thus do not solve the first-order condition. This establishes the result. □

Proof of Proposition 8. Lemma 5 establishes existence and uniqueness of the equilibrium. Moreover, it shows that input costs equal to the supplier's marginal costs are not an equilibrium for $\sigma > 0$. Here, we characterize the equilibrium for $\sigma > 0$, while keeping α constant. Recall that the supplier's first-order condition with respect to (say) q_A (Eq. (61)) is

$$\frac{\partial\Omega^U\,(q_A, q_B)}{\partial q_A} \;=\; \sigma \frac{\partial\pi^I\,(q_A, q_B)}{\partial q_A} + \frac{1-\sigma}{1-\alpha} \frac{\partial\pi_A^U\,(q_A)}{\partial q_A} = 0. \tag{70}$$

Implicit differentiation of the symmetric downstream quantity $q\,(\alpha, \sigma)$ with respect to σ yields

$$\frac{\partial q\,(\alpha, \sigma)}{\partial \sigma} = - \frac{\partial\pi^I\,(q_A, q_B)\,/\partial q_A - \frac{1}{1-\alpha}\left(\partial\pi_A^U\,(q_A)\,/\partial q_A\right)}{\partial^2\Omega^U\,(q_A, q_B)\,/\partial^2 q_A^e + \partial^2\Omega^U\,(q_A, q_B)\,/\partial q_A^e \partial q_B^e} < 0. \tag{71}$$

By Lemma 5, the denominator is negative. For quantities in the range between the level that maximizes the industry profit and the level that maximizes the bilateral profit of the supplier with one downstream firm, we have that $\partial\pi^I\,(q_A, q_B)\,/\partial q_A < 0$ and

$\partial \pi_A^U(q_A, q_B)/\partial q_A > 0$. Hence, the nominator is negative and the quantity $q(\alpha, \sigma)$ thus decreases (and downstream prices increase) in σ. By the one-to-one mapping between effective input prices and quantities, this implies that effective input prices increase in σ for all $\alpha \in [0, 1/2]$. This establishes the result of Proposition 8 for the case of Cournot competition. □

Proof of Proposition 9. We first establish equilibrium existence and then derive the comparative static results for partial vertical ownership.

As analyzed in Rey and Vergé (2004) for vertical separation (see Proposition 2 therein), an equilibrium exists only if the cross elasticity of demand is small enough in relation to the own price elasticity:

$$\epsilon_s \leq \frac{\epsilon}{2}, \tag{72}$$

where

$$\epsilon \equiv -\frac{\partial q_i(p_i, p_{-i})}{\partial p_i} \frac{p_i}{q_i(p_i, p_{-i})}, \quad \epsilon_s \equiv \frac{\partial q_i(p_i, p_{-i})}{\partial p_{-i}} \frac{p_{-i}}{q_i(p_i, p_{-i})}. \tag{73}$$

If the cross elasticity ϵ_s is larger, Rey and Vergé (2004) demonstrate a profitable multilateral deviation from the candidate equilibrium for the supplier, which implies that a perfect Bayesian-Nash equilibrium in passive beliefs does not exist.

We now derive the condition that there is no profitable multilateral deviation from the candidate equilibrium under partial vertical ownership. A sufficient condition that the candidate equilibrium establishes a perfect Bayesian equilibrium is to verify that the Hesse matrix of second-order derivatives $M = \begin{bmatrix} a & b \\ c & d \end{bmatrix}$ is negative definite at the candidate equilibrium input prices. In a symmetric equilibrium, it holds $a = d = \partial^2 \Omega^U / \partial^2 w_A$ and $b = c = \partial^2 \Omega^U / \partial w_A \partial w_B$ for the elements of the Hesse matrix. The second-order condition of U's maximization problem with respect to w_A, evaluated at the symmetric candidate equilibrium (at which $w_A = w_B$ and $p_A = p_B$ such that the downstream firms' first-order conditions hold), is

$$\begin{aligned} \frac{\partial^2 \Omega^U}{\partial^2 w_A} &= \frac{1-\alpha\sigma}{1-\alpha} \left(\frac{\partial w_A^{ef}}{\partial w_A} \frac{\partial q_A(p_A, p_B)}{\partial p_A} + w_A^{ef} \frac{\partial^2 q_A(p_A, p_B)}{\partial^2 p_A} \frac{\partial p_A}{\partial w_A^{e}} \frac{\partial w_A^{ef}}{\partial w_A} \right) \frac{\partial p_A}{\partial w_A^{ef}} \frac{\partial w_A^{ef}}{\partial w_A} \\ &+ \left(\sigma p_B + \frac{1-\sigma}{1-\alpha} w_B \right) \frac{\partial^2 q_B(p_B, p_A)}{\partial^2 p_A} \left(\frac{\partial p_A}{\partial w_A^{ef}} \frac{\partial w_A^{ef}}{\partial w_A} \right)^2 . \end{aligned} \tag{74}$$

This second-order derivative is negative by Assumption 5. This assumption is fulfilled if demand is not too convex and in particular when demand is linear (as $\partial^2 q_i/\partial p_A = 0,\ i \in \{A, B\}$). The second element of the Hesse matrix evaluated at the symmetric candidate equilibrium is

$$\begin{aligned} \frac{\partial^2 \Omega^U}{\partial w_A \partial w_B} &= \left(2(1-\sigma) + \sigma \frac{\partial p_B}{\partial w_B^{ef}} \frac{\partial w_B^{ef}}{\partial w_B}\right) \frac{\partial q_A(p_A, p_B)}{\partial p_B} \frac{\partial p_A}{\partial w_A^{ef}} \frac{\partial w_A^{ef}}{\partial w_A} \\ &+ \left(\sigma p_B\left(w_B^{ef}\right) + (1-\sigma) w_B\right) \frac{\partial^2 q_B(p_B, p_A)}{\partial p_A \partial p_B} \frac{\partial p_A}{\partial w_A^{ef}} \frac{\partial w_A^{ef}}{\partial w_A} \frac{\partial p_B}{\partial w_B^{ef}} \frac{\partial w_B^{ef}}{\partial w_B} \\ &\left((1-\sigma) w_A + \sigma w_A^{ef} \frac{\partial p_A}{\partial w_A^{ef}} \frac{\partial w_A^{ef}}{\partial w_A}\right) \frac{\partial^2 q_A(p_A, p_B)}{\partial p_A \partial p_B} \frac{\partial p_B}{\partial w_B^{ef}} \frac{\partial w_B^{ef}}{\partial w_B}, \end{aligned} \tag{75}$$

where we use that the equilibrium is symmetric ($\partial q_A(p_A, p_B)/\partial p_B = \partial q_B(p_B, p_A)/\partial p_A$, $\partial p_A/\partial w_A^{ef} = \partial p_B/\partial w_B^{ef}$) and that $w_A^{ef} = (1 - \alpha(1+\Gamma)) w_A$. The Hessian is negative definite if $-\partial^2 \Omega^U/\partial^2 w_A > \left|\partial^2 \Omega^U/\partial w_A \partial w_B\right|$. The second-order derivative $\partial^2 \Omega^U/\partial^2 w_A$ is negative by assumption and the sign of $\partial^2 \Omega^U/\partial w_A \partial w_B$ can be either positive or negative. By inserting Equations (74) and (75) in the inequality above, we obtain

$$\begin{aligned} &- ((1-\alpha)\sigma p_B + (1-\sigma) w_B) \frac{\partial^2 q_B(p_B, p_A)}{\partial^2 p_A} \frac{\partial p_A}{\partial w_A^{ef}} \\ &- (1 - \alpha\sigma)\left(\frac{\partial q_A(p_A, p_B)}{\partial p_A} + w_A^{ef} \frac{\partial^2 q_A(p_A, p_B)}{\partial^2 p_A} \frac{\partial p_A}{\partial w_A^{ef}}\right) \\ > &\left|\left(2(1-\sigma) + \sigma(1-\alpha) \frac{\partial p_A}{\partial w_A^{ef}}\right) \frac{\partial q_A(p_A, p_B)}{\partial p_B}\right| \\ &+ \left|\left((1-\sigma) w_A + \sigma(1-\alpha) w_A^{ef} \frac{\partial p_A}{\partial w_A^{ef}}\right) \frac{\partial^2 q_A(p_A, p_B)}{\partial p_A \partial p_B}\right| \\ &+ \left|((1-\alpha)\sigma p_B + (1-\sigma)(1-\alpha) w_B) \frac{\partial^2 q_B(p_B, p_A)}{\partial p_A \partial p_B} \frac{\partial p_A}{\partial w_A^{ef}}\right|, \end{aligned} \tag{76}$$

where we use that $\frac{\partial p_A}{\partial w_A^{ef}} \frac{\partial w_A^{ef}}{\partial w_A} = \frac{\partial p_B}{\partial w_B^{ef}} \frac{\partial w_B^{ef}}{\partial w_B}$, $\frac{\partial w_A^{ef}}{\partial w_A} = (1-\alpha)$. In a symmetric equilibrium, we have $w_A = w_B$. Hence, we can write $w_A^{ef} = (1 - \alpha(1+\Gamma)) w_A$ and rearrange the above inequality

$$\begin{aligned}
& (1-\alpha)\,\sigma p_B \left(\frac{\partial^2 q_B(p_B,p_A)}{\partial^2 p_A} \pm \frac{\partial^2 q_B(p_B,p_A)}{\partial p_A \partial p_B}\right)\frac{\partial p_A}{\partial w_A^{ef}} \\
+ & (1-\sigma)\,w_B \left(\frac{\partial^2 q_B(p_B,p_A)}{\partial^2 p_A} \pm (1-\alpha)\frac{\partial^2 q_B(p_B,p_A)}{\partial p_A \partial p_B}\right)\frac{\partial p_A}{\partial w_A^{ef}} \\
+ & (1-\alpha\sigma)\,w_A^{ef}\left(\frac{\partial^2 q_A(p_A,p_B)}{\partial^2 p_A}\frac{\partial p_A}{\partial w_A^{ef}} \pm \left(\frac{1-\sigma}{1-\alpha(1+\Gamma)} + \sigma(1-\alpha)\frac{\partial p_A}{\partial w_A^{ef}}\right)\frac{\partial^2 q_A(p_A,p_B)}{\partial p_A \partial p_B}\right) \\
> & \pm\left(2(1-\sigma) + \sigma(1-\alpha)\frac{\partial p_A}{\partial w_A^{ef}}\right)\frac{\partial q_A(p_A,p_B)}{\partial p_B} + (1-\alpha\sigma)\frac{\partial q_A(p_A,p_B)}{\partial p_A},
\end{aligned} \tag{77}$$

where the sign "±" is "+" if the second element of the Hessian is positive and "−" if it is negative. If condition (77) holds, there exists a perfect Bayesian equilibrium with passive beliefs and partial vertical ownership. Under vertical separation, the same condition as in Rey and Vergé (2004) emerges (as $w_i = 0$ in this case). For partial ownership structures, the input prices are above the supplier's marginal costs and equilibrium existence additionally depends on the curvature of the demand function. In general, it is more difficult to fulfill the condition if demand is convex.

With linear demand, the left-hand side of condition (77) is zero. Moreover, we $\partial^2\Omega^U/\partial w_A \partial w_B > 0$ due to the assumption that the cross-price effect on the demand is positive. The equilibrium condition (77) simplifies to

$$0 \;>\; \left(2(1-\sigma) + \sigma(1-\alpha)\frac{\partial p_A}{\partial w_A^{ef}}\right)\frac{\partial q_A(p_A,p_B)}{\partial p_B} + (1-\alpha\sigma)\frac{\partial q_A(p_A,p_B)}{\partial p_A}. \tag{78}$$

Using the definitions of the demand elasticities (Equation (73)), this can be written as

$$\epsilon_S \;<\; \frac{(1-\alpha\sigma)\,\epsilon}{\left(2(1-\sigma) + \sigma(1-\alpha)\frac{\partial p_A}{\partial w_A^{ef}}\right)}. \tag{79}$$

If condition (77) is fulfilled, we characterize the equilibrium prices for small degrees of forward internalization σ, while keeping α constant. Recall that the supplier's first-order condition with respect to w_A in Equation (69) is

$$\left(\sigma p_B + \frac{(1-\sigma)\,w_B}{1-\alpha}\right)\frac{\partial q_B(p_B,p_A)}{\partial p_A} \quad + \quad \frac{(1-\alpha\sigma)\,w_A^{ef}}{1-\alpha}\frac{\partial q_A(p_A,p_B)}{\partial p_A} = 0, \tag{80}$$

and that for $\sigma = 0$, the supplier sets effective input prices equal to its marginal costs in order to maximize the bilateral profit with each downstream firm. Using the fact that $w^{ef}(\alpha,\sigma) = (1-\alpha(1+\Gamma))\,w(\alpha,\sigma)$ and that $w(\alpha,0) = w^{ef}(\alpha,0) = 0$, implicit differentiation yields

$$\begin{aligned}\left.\frac{\partial w^{ef}(\alpha,\sigma)}{\partial\sigma}\right|_{\sigma=0} &= (1-\alpha(1+\Gamma))\left.\frac{\partial w(\alpha,\sigma)}{\partial\sigma}\right|_{\sigma=0} \\ &= -(1-\alpha(1+\Gamma))\frac{p_B\cdot(\partial q_B(p_B,p_A)/\partial p_A)}{\partial^2\Omega/\partial^2 w_A+\partial^2\Omega/\partial w_A\partial w_B} > 0.\end{aligned} \tag{81}$$

By continuity and because $(1-\alpha(1+\Gamma)) > 0$, we conclude that the downstream price $w^{ef}(\alpha,\sigma)$ increases in σ if σ is not too large and for all degrees of backward internalization $\alpha \in [0,1/2]$. As there is a one-to-one mapping between downstream prices and the effective input prices, this implies that also the symmetric downstream price $p(\alpha,\sigma)$ increases in σ. This establishes the result. □

Corollary 4. *Suppose there is Cournot competition and the supplier charges unobservable two-part tariffs. Effective input prices increase in the share of backward ownership with proportional influence ($\alpha > 0$, $\sigma = \alpha/(1-2\alpha(1-\alpha))$) and reach the industry-maximizing level as α approaches 50%.*

Proof of Corollary 4. In order to assess a joint change in forward and backward internalization, we analyze the case in which backward ownership confers proportional influence over the target firm: $\sigma = \alpha/(1-2\alpha(1-\alpha))$. We can re-write the first-order condition in 60 as

$$\frac{\partial\Omega^U}{\partial q_A} = \underbrace{\frac{\alpha}{1-2\alpha(1-\alpha)}}_{\text{pos. derivative in }\alpha}\frac{\partial\pi^I(q_A,q_B)}{\partial q_A} + \underbrace{\frac{1-2\alpha}{1-2\alpha(1-\alpha)}}_{\text{neg. derivative in }\alpha}\frac{\partial\pi_A^U(q_A)}{\partial q_A} = 0. \tag{82}$$

Denote the symmetric equilibrium quantity as $q(\alpha)$. As α approaches $1/2$ (that is the case that both downstream jointly own all the shares of supplier U), the first-order condition simplifies to $\partial\pi^I(q_A,q_B)/\partial q_A = 0$, which implies that the downstream quantity (and thus effective input price) maximizes the industry profit. For $\alpha < 1/2$, the first-order condition also contains the partial derivative of the joint profit of U and A $\left(\partial\pi_A^U/\partial q_A\right)$, which is negative for the quantity that maximizes the industry profit and hence induces a higher quantity.

To derive the comparative static $\partial q(\alpha)/\partial\alpha$, note that, for $\alpha \in [0, 1/2]$, an increase in the ownership share α increases the weight on the industry profit π^I and decreases the weight on the bilateral profit π_A^U. The decrease in $q(\alpha)$ corresponds to higher effective input prices. By the implicit function theorem, we obtain

$$\frac{\partial q(\alpha)}{\partial\alpha} = -\frac{1}{1-2\alpha(1-\alpha)} \frac{(1-2\alpha^2)\,\partial\pi^I(q_A, q_B)/\partial q_A - 4\alpha(1-\alpha)\,\partial\pi_A^U(q_A)/\partial q_A}{\partial^2\Omega/\partial^2 q_A + \partial^2\Omega/\partial q_A\partial q_B} < 0, \tag{83}$$

By Lemma 5, the denominator is negative. Equation 82 shows that a larger ownership share α leads to a higher weight on the industry profit (which has a weakly positive derivative in q for $\alpha \in [0, 1/2]$) and a lower weight on the joint profit between U and A (which has a weakly negative derivative in q for $\alpha \in [0, 1/2]$). Hence, the downstream quantity decreases, which implies that the corresponding effective input price $w(\alpha)$ increases in the ownership share α. This establishes the result of Corollary 3 for the case of Cournot competition. □

Corollary 5. *Suppose there is Bertrand competition, the supplier charges unobservable two-part tariffs, and that there is backward ownership with proportional influence ($\alpha > 0$, $\sigma = \alpha/(1-2\alpha(1-\alpha))$) . Starting at $\alpha = 0$, the effective input prices increase when marginally increasing α and reach the industry-maximizing level as α approaches* 50%.

Proof of Corollary 5. We assess the competitive effects of partial vertical ownership by imposing a proportional relationship between the profit share and the corporate influence ($\sigma = \alpha/(1-2\alpha(1-\alpha))$). Equation (69) becomes

$$\begin{aligned} \frac{\partial\Omega^U}{\partial w_A} &= \frac{1}{1-2\alpha(1-\alpha)}(\alpha p_B + (1-2\alpha)w_B)\frac{\partial q_B(p_B, p_A)}{\partial p_A} \\ &+ \frac{(1-\alpha)w_A^{ef}}{1-2\alpha(1-\alpha)}\frac{\partial q_A(p_A, p_B)}{\partial p_A} = 0. \end{aligned} \tag{84}$$

By the same reasoning as for the Cournot case, for $\alpha = 1/2$ this is

$$\frac{\partial\Omega^U}{\partial w_A} = p_B\frac{\partial q_B(p_B, p_A)}{\partial p_A} + w_A^{ef}\frac{\partial q_A(p_A, p_B)}{\partial p_A} = 0, \tag{85}$$

and the downstream jointly obtain all profits of supplier U. By Equation (68), it holds that $q_A + p_A \cdot (\partial q_A(p_A, p_B)/\partial p_A) = w_A^{ef} \cdot (\partial q_A(p_A, p_B)/\partial p_A)$. Hence, we can re-write the first order-condition as

$$\frac{\partial \Omega^U}{\partial p_A} = p_B \frac{\partial q_B\left(p_B, p_A\right)}{\partial p_A} + q_A + p_A \frac{\partial q_A\left(p_A, p_B\right)}{\partial p_A} = 0, \tag{86}$$

and note that this is the optimality condition for the maximal industry profit $\left(\partial \pi^I / \partial p_A = 0\right)$. Thus the supplier sets effective input prices in order to induce the maximal industry profit π^I when α equals 50%.

For $\alpha = 0$, the supplier's optimality condition is as under vertical separation and the input prices are equal to the supplier's marginal costs if an equilibrium exists. We evaluate the comparative static of the downstream price $p\left(\alpha\right)$ with respect to α for small partial ownership shares. For $\alpha = 0$, it holds that $w_A^{ef} = \left(1-\alpha\right) w_A - \alpha w_B \Gamma$. As $w_i = 0$ under separation, implicit differentiation of Equation (84) at $\alpha = 0$ yields

$$\left.\frac{\partial w\left(\alpha\right)}{\partial \alpha}\right|_{\alpha=0} = \left.\frac{\partial w^{ef}\left(\alpha\right)}{\partial \alpha}\right|_{\alpha=0} = -\frac{1-2\alpha^2}{\left(1-2\alpha+2\alpha^2\right)^2} \frac{p_B \cdot \left(\partial q_B\left(p_B, p_A\right) / \partial p_A\right)}{\partial^2 \Omega^U / \partial^2 w_A + \partial^2 \Omega^U / \partial w_A \partial w_B} > 0. \tag{87}$$

By continuity, we conclude that the effective input price $w^{ef}\left(\alpha\right)$ and thus the downstream price $p\left(\alpha\right)$ increase for small degrees of partial vertical ownership. This establishes the result. □

A5: Profitability of partial vertical ownership and consumer surplus

We demonstrate here which externalities can arise when the supplier establishes a bilateral ownership link with one downstream firm and offers discriminatory input prices to the downstream firms. Building on the results in Section 6.2, we analyze the effect of a 15% partial backward ownership share between U and A whereas there is no ownership link between U and B.[38] In our parametric example (Table 4), partial ownership is bilaterally profitable for the owners of firms U and A. Partial vertical ownership is thus a plausible market outcome even if the industry as a whole cannot agree on a vertical ownership arrangement.

[38] Proportional influence yields that the supplier internalizes a share $\sigma_{UA} = \alpha_{AU} / \left(1 - \alpha_{AU}\left(1-\alpha_{AU}\right)\right) = 17.2\%$ of downstream firm A's profits.

We assess the effect of such an ownership arrangement on the joint profit of U and A, the profit of the independent downstream firm B, and on consumer surplus (CS). The linear demand stems from a representative consumer who has a quadratic utility function (Eq. (15) with $\gamma = 7/10$) and downstream firms compete in prices.[39] We compare the firm's profits π_A^U and π_B, and the consumer surplus CS under this ownership structure to the benchmark case of vertical separation.

Table 4 shows that, with linear tariffs, partial vertical ownership between U and A has a weak positive effect on the joint profit between U and A (+0.8%) and an (almost) zero effect on B's profit. The consumer surplus increases by 4% due to the lower price level. This result is in line with Panel (a) in Figure 1, which documents that under linear tariffs it is mainly the decrease in the input prices for A which drives the effect. In contrast to linear tariffs, the joint profit π_A^U increases by 11.6% under two-part tariffs, whereas the profit π_B decreases by -9.9%. As the overall price level increases, this ownership structure decreases consumer surplus (-5.1%).

Table 4: Bilateral profit and consumer surplus under asymmetric ownership

	π_A^U	π_B	Consumer surplus CS
Linear tariffs (upstream monopoly)	0.78%	-0.05%	3.95%
Two-part tariffs (upstream comp., $c = 0.3$)	11.6%	-9.9%	-5.1%

The table shows the relative changes in firm profits and consumer surplus for a partial backward ownership share of $\alpha_{AU} = 15\%$ with prop. influence (and $\alpha_{BU} = 0\%$) compared to vertical separation. The first line shows the results under linear input prices and for upstream monopoly (i.e., a sufficiently large c). The second line shows the results for two-part tariffs when the competitive fringe is a relevant supply alternative (with $c = 0.3$). Competition is in prices with demand defined in Eq.(17) and $\gamma = 7/10$.

[39]See fn. 27. Qualitatively, the results hold for all degrees of product substitutability γ.

Appendix B

B1: Unobservable two-part tariffs under wary beliefs

A second belief refinement are wary beliefs that we consider here. We focus on pure forward internalization as this is the channel that allows the supplier to commit to higher input prices (Lemma 3). Wary beliefs are defined as follows (see McAfee and Schwartz 1994; Rey and Vergé 2004):

Definition 2. When downstream firm i receives a contract $t_i = (w_i, f_i)$, it believes that

(i) the manufacturer expects it to accept this contract,

(ii) the manufacturer offers downstream firm $j \neq i$ the contract $(W_j(w_i), F_j(w_i))$[40] that is best for the monopolist, given that firm i accepts (w_i, f_i), from among all contracts acceptable to firm j, and

(iii) downstream firm j reasons the same way.

With partial vertical ownership, a supplier's optimal contract offer to one firm generally depends on the supply contract it has offered to the other firm, both with downstream price and quantity competition (see Section 6.1). This is in contrast to the result, that a supplier's contract offer is not affected from the other contract in the case of vertical separation with Cournot competition (Hart et al., 1990; Rey and Vergé, 2004). With wary beliefs, we account for the fact that a downstream firm updates its belief about the competitor's contract offer. In particular, given its own contract offer, a downstream firm with wary beliefs anticipates that the supplier will behave optimally as regards the other downstream firm.

In this appendix, we derive the perfect Bayesian equilibrium for the Cournot game under forward internalization if downstream firms hold wary beliefs. The Cournot case offers a good benchmark when studying wary beliefs because wary beliefs and passive beliefs coincide for vertical separation as contracts enter the supplier's maximization problem in a separable way. We therefore focus on Cournot competition in this extension.

By Definition 2, (say) downstream firm A believes that the supplier charges its competitor

[40] We follow Rey and Vergé (2004) and restrict attention to beliefs that depend on the input price w_i and not the fixed fee f_i.

B an input price $W_B(w_A)$ that is optimal given w_A:

$$\begin{aligned} W_B(w_A) &= \arg\max_{w_B} \quad \pi^U(q_A(w_A), q_B(w_B)) + (1-\sigma)(f_A + f_B) \\ &\quad\quad +\sigma(\pi_A(q_A(w_A), q_B(w_B)) + \pi_B(q_B(w_B), q_A(w_A))) \\ &\quad s.t. \\ &\quad\quad f_B \leq \pi_B(q_B(w_B), Q_A(W_A(w_B))), \end{aligned} \tag{88}$$

with $\pi^U(q_A(w_A), q_B(w_B)) = \sum_{i\in\{A,B\}} p_i(q_i(w_i), q_{-i}(w_{-i}))\, q_i(w_i)$, and $\pi_i(q_i(w_i), q_{-i}(w_{-i})) = (p_i(q_i(w_i), q_{-i}(w_{-i})) - w_i)\, q_i(w_i)$. Solving the participation constraints with equality and substituting for the fixed fees yields the supplier's reduced objective function

$$\begin{aligned} \Omega^U(w_A, w_B) &= \pi^U(q_A(w_A), q_B(w_B)) \\ &+ (1-\sigma)(\pi_A(q_A(w_A), Q_B(W_B(w_A))) + \pi_B(q_B(w_B), Q_A(W_A(w_B)))) \\ &+ \sigma(\pi_A(q_A(w_A), q_B(w_B)) + \pi_B(q_B(w_B), q_A(w_A))). \end{aligned} \tag{89}$$

The definition of wary beliefs implies $\frac{\partial\Omega^U(w_A=W_A(w_B),w_B)}{\partial w_A} = 0$ and $\frac{\partial\Omega^U(w_A,w_B=W_B(w_A))}{\partial w_B} = 0$. The resulting first-order condition of Ω^U with respect to (say) w_A is

$$\begin{aligned} \frac{\partial\Omega^U}{\partial w_A} &= \left(\frac{\partial\pi^U(q_A(w_A), q_B(w_B))}{\partial q_A} + \frac{\partial\pi_A(q_A(w_A), Q_B(W_B(w_A)))}{\partial q_A}\right)\frac{\partial q_A(w_A)}{\partial w_A} \\ &+ \left(\sigma\left(1 - \frac{\partial W_B}{\partial w_A}\right) + \frac{\partial W_B}{\partial w_A}\right)\frac{\partial\pi_A(q_A(w_A), Q_B(W_B(w_A)))}{\partial Q_B}\frac{\partial q_A(w_A)}{\partial w_A} = 0. \end{aligned} \tag{90}$$

For $\sigma = 0$, we know that that a downstream firm's belief about the competitor's input price does not change if its own input price changes: $\partial W_B(w_A)/\partial w_A = 0$. Hence, we obtain, as with passive beliefs, that the supplier optimally sets $w_i = 0$, $i \in \{A, B\}$ in order to maximize the bilateral profit $\pi^U + \pi_i$ (Rey and Vergé, 2004).

For $\sigma > 0$, it is in general not true that the belief does not depend on the own contract offer. In order to assess the first-order condition for $\sigma > 0$, we therefore evaluate how downstream firm A updates its belief $W_B(w_A)$ if the input price w_A changes. Differentiating $\frac{\partial\Omega^U(w_A=W_A(w_B),w_B)}{\partial w_A} = 0$ with respect to w_B is zero by definition of wary beliefs. That is,

$$\frac{\partial^2\Omega^U\left(w_A, w_B = W_B\left(w_A\right)\right)}{\partial w_B \partial w_A} = \frac{\partial^2\Omega^U\left(w_A, w_B = W_B\left(w_A\right)\right)}{\partial^2 W_B}\frac{\partial W_B\left(w_A\right)}{\partial w_A} + \frac{\partial^2\Omega^U\left(w_A, w_B = W_B\left(w_A\right)\right)}{\partial w_B \partial w_A} = 0. \tag{91}$$

Evaluating this expression at the equilibrium input prices yields

$$\frac{\partial W_A\left(w_B\right)}{\partial w_B} = -\frac{\partial^2\Omega^U\left(w_A, w_B\right)/\partial w_B \partial w_A}{\partial^2\Omega^U\left(w_A, w_B\right)/\partial^2 w_B}. \tag{92}$$

Moreover, if the second-order condition of the supplier's maximization problem is fulfilled, we have

$$\left|\frac{\partial^2\Omega^U\left(w_A, w_B\right)}{\partial^2 w_B}\right| \geq \left|\frac{\partial^2\Omega^U\left(w_A, w_B\right)}{\partial w_A \partial w_B}\right|. \tag{93}$$

This implies

$$\left|\frac{\partial W_B\left(w_A\right)}{\partial w_A}\right| \leq 1. \tag{94}$$

The first-order condition in Equation (90) implies for the equilibrium input prices:

$$\frac{\partial w_i}{\partial \sigma} = -\frac{\left(1 - \frac{\partial W_B}{\partial w_A}\right)\left(\partial \pi_A\left(q_A\left(w_A\right), Q_B\left(W_B\left(w_A\right)\right)\right)\right)/\partial Q_B}{\partial^2\Omega^U/\partial^2 w = \partial^2\Omega^U/\partial^2 w_A + \partial^2\Omega^U/\partial w_A \partial w_B} \geq 0, \tag{95}$$

with $\partial^2\Omega^U/\partial^2 w_A + \partial^2\Omega^U/\partial w_A \partial w_B < 0$. The nominator is (weakly) positive as $\partial W_B\left(w_A\right)/\partial w_A \in [-1, 1]$ (see Equation (94)).

Moreover, we can add and subtract $\frac{\pi_B(q_B(w_B), q_A(w_A))}{\partial q_A}\frac{\partial q_A(w_A)}{\partial w_A}$ to Equation (90) and re-write it as

$$\frac{\partial \Omega^U}{\partial w_A} = \frac{\partial \pi^I\left(q_A\left(w_A\right), q_B\left(w_B\right)\right)}{\partial q_A}\frac{\partial q_A\left(w_A\right)}{\partial w_A} + (1-\sigma)\frac{\partial \pi_A\left(q_A\left(w_A\right), Q_B\left(W_B\left(w_A\right)\right)\right)}{\partial Q_B}\frac{\partial Q_B\left(W_B\left(w_A\right)\right)}{\partial W_B}\left(\frac{\partial W_B}{\partial w_A} - 1\right). \tag{96}$$

It is immediate that for $\sigma < 0$ the optimal input prices are below the industry-maximizing level as the second line is negative at $w_i = w_i^I$. We summarize in

Proposition 10. *Suppose supplier U internalizes $\sigma \in (0, 1)$ of the downstream firms' profits and charges secret two-part tariffs, whereas the downstream firms hold wary beliefs (Definition 2). In any equilibrium, the input prices are above the supplier's marginal* *costs and below the industry-maximizing level. The input prices increase in the degree of forward internalization σ.*

B2: Unobservable linear tariffs under passive beliefs

We briefly discuss the effect of forward internalization when contracts are linear ($f_i =$) and unobservable. Building on Gaudin (forthcoming), we restrict attention to the belief-refinement of passive beliefs and assume that the second-order conditions are fulfilled in the relevant range. Moreover, we restrict attention to pure forward internalization ($\alpha = 0$). We first derive the results first for the case of Cournot competition before turning to Bertrand competition. As in the case of two-part tariffs, we assume that supplier U is a monopolist ($c = \infty$).

Supplier U offers each firm a contract which consists only of the linear input price w_i. Each firm sets

$$q_i\left(w_i\right) = \arg\max_{q_i} \left(p_i\left(q_i, Q_{-i}\right) - w_i\right) q_i, \tag{97}$$

which depends on its own input price w_i and the (passive) belief Q_{-i} about its rival's quantity choice. We can write U's objective function as

$$\begin{aligned} \Omega^U &= w_A q_A\left(w_A\right) + w_B q_B\left(w_B\right) \\ &+ \sigma\left[\left(p_A\left(q_A\left(w_A\right), q_B\left(w_B\right)\right) - w_A\right) q_A\left(w_A\right)\right] \\ &+ \sigma\left[\left(p_B\left(q_B\left(w_B\right), q_A\left(w_A\right)\right) - w_B\right) q_B\left(w_B\right)\right]. \end{aligned} \tag{98}$$

The first-order condition, $\partial\Omega^U/\partial w_i = 0$ $i \in \{A, B\}$, can be written as

$$q_i\left(w_i\right) + w_i \frac{\partial q_A\left(w_i\right)}{\partial w_i} + \sigma\left[\underbrace{-q_i\left(w_i\right)}_{\partial\pi_i/\partial w_i} + \underbrace{q_{-i}\left(w_{-i}\right)\frac{p_{-i}\left(q_{-i}\left(w_{-i}\right), q_i\left(w_i\right)\right)}{\partial q_i}\frac{\partial q_i\left(w_i\right)}{\partial w_i}}_{\partial\pi_i/\partial w_{-i}}\right] = 0 \tag{99}$$

Denote the symmetric input price that solves the system of first-order conditions with $w_A\left(\sigma\right) = w_B\left(\sigma\right) = w\left(\sigma\right)$. The terms in brackets correspond to $\partial\pi_i/\partial w_i + \partial\pi_{-i}/\partial w_i$ $i \in \{A, B\}$, which is negative by Assumption (1) at a symmetric equilibrium. By the same reasoning as in the proof of Proposition 2, we therefore obtain that a larger degree of partial forward internalization leads to lower input prices.

Similarly, with price competition, each downstream firm sets

$$p_i(w_i) = \arg\max_{p_i} (p_i - w_i)\, q_i(p_i, P_{-i})$$

and the supplier's problem is

$$\begin{aligned} \Omega^U &= w_A q_A(p_A(w_A), p_B(w_B)) + w_B q_B(p_B(w_B), p_A(w_A)) \\ &+ \sigma[(p_A(w_A) - w_A)\, q_A(p_A(w_A), p_B(w_B))] \\ &+ \sigma[(p_B(w_B) - w_B)\, q_B(p_B(w_B), p_A(w_A))]. \end{aligned} \tag{100}$$

Again, the FOCs are defined as $\partial\Omega^U/\partial w_i = 0$ $i \in \{A, B\}$ and the FOC with respect to (say w_A) can be written as

$$\begin{aligned} \frac{\partial\Omega^U}{\partial w_A} &= q_A(p_A(w_A), p_B(w_B)) + w_A \frac{\partial q_A(p_A(w_A), p_B(w_B))}{\partial p_A} \frac{\partial p_A(w_A)}{\partial w_A} \\ &+ w_B \frac{\partial q_B(p_B(w_B), p_A(w_A))}{\partial p_A} \frac{\partial p_A(w_A)}{\partial w_A} \\ &+ \sigma\left[-q_A(w_A) + (p_B(w_B) - w_B) \frac{\partial q_B(p_B(w_B), p_A(w_A))}{\partial p_A} \frac{\partial p_A(w_A)}{\partial w_A}\right] = 0. \end{aligned} \tag{101}$$

By the same reasoning as above, the term in brackets is negative at a symmetric equilibrium and therefore the input prices are lower than under vertical separation ($\sigma = 0$). We summarize the results in

Proposition 11. *Suppose supplier U is a monopolist ($c = \infty$) and charges unobservable linear tariffs ($f_i = 0$). Then, pure forward internalization leads to lower input prices.*

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