# Backwards Integration and Downstream Competition

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Abstract

We analyze the effects of one or more downstream firms' acquisition of pure cash flow rights in an upstream supplier, with price competition in both markets. With backwards acquisitions, downstream firms internalize the effects of their actions on their supplier's and thus, their rivals' sales, if these are supplied by the same (efficient) firm. Double marginalization is enhanced. While vertical integration would lead to decreasing downstream prices, passive backwards ownership in the efficient supplier leads to increasing downstream prices and is more profitable, as long as competition is sufficiently intensive. Downstream acquirers strategically abstain from vertical control, inducing the efficient upstream firm to commit to a high price. Forbidding upstream price discrimination is then pro-competitive. The central results are sustained when two part tariffs are allowed.

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# 1 Introduction

Passive ownership rights across firms, horizontal and even more so vertical ones, are very common, but have traditionally not been of welfare concern, and thus of competition policy.[1] While horizontal cross-shareholdings are a straightforward way to anti-competitively relax competition,[2] the competitive effects of vertical ownership arrangements are more controversial. Of prominent concern is foreclosure that restricts non-integrated firms' supply, or their access to customers. The classic Chicago challenge is that vertical mergers are competitively neutral at worst (Bork, 1978; Posner, 1976). Yet several arguments are around of how vertical mergers can yield higher consumer prices, or even foreclosure. They rely on particular assumptions, such as additional commitment power of the integrated firm (Ordover et al., 1990), secret contract offers (Hart and Tirole, 1990), or downstream buyer switching costs between upstream firms.[3]

In all these models, the authors compare allocations involving completely non-integrated with those involving fully integrated firms, where integration involves a move from no control of the target firm's instruments nor participation in its returns, to full control over the instruments employed by the target firm and full ownership of its returns. Partial ownership, either non-controlling or controlling, is not considered. Yet, even hindsight suggests that partial vertical ownership is the rule rather than the exception. This is amply supported in empirical studies (e.g. Allen and Phillips 2000; Fee et al. 2006). However, there is very little formal analysis on its competitive effects, and with it of the central question: Is passive partial backwards integration really as innocent as believed heretofore, with respect to anti-competitive effects such as increasing prices or foreclosure?

This is the question we address in the present paper. Our focus is on passive ownership interests that price setting downstream firms may hold in their suppliers, where passive ownership involves cash flow rights, i.e. claims on the target's profits, without controlling its decisions. We consider a dowstream market involving firms offering horizontally differentiated products, and an upstream market with firms characterized by differing efficiency levels. Under effective upstream competition, where the cost differences between suppliers are not large, the efficient upstream supplier serving all downstream firms is restricted in his price setting by the second efficient competitor.

While increasing passive ownership of an upstream supplier in downstream firms tends to reduce double marginalization and thus downstream prices, passive ownership of downstream in upstream firms does not reduce, but exacerbate that. The reasons are as follows: an increasing participation in the profits of its upstream supplier leads the downstream firm to soften its reaction to an upstream price increase. The upstream supplier incorporates

[1] The subject made it only recently into public speeches. For instance, by Joaquim Almunia, the EU commissioner for competition policy, see XXXXXX

[2] See Flath (1991) for an early analysis of the profitability of horizontal partial ownership, and more recently Brito et al. (2010) or Karle et al. (2011).

[3] Other explanations include input choice specifications (Choi and Yi, 2000), two-part tariffs (Sandonis and Fauli-Oller, 2006), exclusive dealing contracts (Chen and Riordan, 2007), only integrated upstream firms (Bourreau et al., 2010) and information leakages (Allain et al., 2010).

this, and thus increases the upstream price. The two effects compensate each other. Yet, as naturally the downstream competitors are served by the same efficient upstream firm, the acquiring firm, via its participation in the upstream efficient firm's profits, incorporates indirectly the effect of its own actions on the downstream competitor(s) profits. That downstream firm now has an incentive to raise its price. In turn, strategic complementarity induces all downstream competitors to increase theirs.[4]

We also show that that the possibility to raise downstream prices incentivizes downstream firms to acquire passive interests in the efficient upstream supplier. In equilibrium, there will be backwards acquisition, as long as competition is sufficiently intense in both markets. Also, in contrast to what one might expect, partial backwards acquisition by one active firm does *not* invite the foreclosure of downstream competitors. Indeed, the competitors *benefit*, via increasing equilibrium prices, from the acquiring firm's decision.

This acquisition, however, *takes place short of a level at which the downstream firm takes control over the upstream target's pricing decisions*. If it did, the upstream firm would lose its power to commit to high prices, and thus all downstream prices would decrease. Hence in the world analyzed here, backwards acquisitions have an anti-competitive effect *only if they are passive*. In the extension, we show that backwards acquisition is more profitable for the particiapting firms than full merger, and that all the effects hold even when the upstream suppliers are allowed to charge two-part tariffs, that typically remove the double marginalization problem. In all, we claim that passive backwards integration should indeed be of concern to competition authorities.

The present analysis is related to Chen (2001) who, in a similar setting, investigates the effects of a full vertical merger. For a vertical merger to increase downstream prices, the unintegrated downstream rival needs to incur costs of switching between upstream suppliers. These switching costs allow the integrated firm to charge the downstream competitor an input price higher than that charged by the next efficient upstream supplier.

We show that for all downstream prices to increase, neither full vertical integration nor switching costs are necessary, nor does the input price charged to independent downstream firms need to increase. Indeed, partial backwards integration without the transfer of control rights is effective in raising consumer prices when full integration is not, i.e. when the Chicago argument about the efficiency increasing effect of vertical mergers does hold. The reason is that with passive ownership, only profit claims are transferred to downstream firms, but not control on upstream prices. In consequence, downstream firms can acquire profit claims of suppliers to relax downstream competition.

Separating control from ownership in order to relax competition is the general theme in

[4] Flath (1989) shows that with successive Cournot oligopolies, constant elasticity demand and symmetric passive ownership, these two effects cancel out, so in his model, passive backwards integration has no effect. Greenlee and Raskovich (2006) confirm this invariance result for equilibria involving an upstream monopoly and symmetric downstream firms under competition in both, price and quantity. These invariance results suggest that there is no need for competition policy to address passive vertical ownership. By contrast, we show that the invariance property of downstream prices does not apply within a more general industry structure involving upstream asymmetric Bertrand competition, where the upstream firms are characterized by differing efficiency levels in production.

the literature on strategic delegation. While that term was coined by Fershtman et al. (1991), our result is most closely related to the earlier example provided by Bonanno and Vickers (1988), where manufacturers maintain profit claims in their retailers through two-part tariffs, but delegate the control over retail prices, in order to induce a softer price setting of the competitor. In the present case, strategic delegation involves backwards oriented activities. The particular twist added to that literature is that *the very instrument firms use to acquire control is used short of implementing control*.

The competition dampening effect identified in the present paper relies on internalizing rivals' sales through a common efficient supplier. This relates to the common agency argument of Bernheim and Whinston (1985). Strategic complementarity is essential in the sense that rivals need to respond with price increases to the raider's incentive to increase price. Indeed, acquiring passive vertical ownership is a fat cat strategy, in the terms coined by Fudenberg and Tirole (1984).

A different kind of explanation for backward integration without control is that transferring residual profit rights can mitigate agency problems, for example when firm specific investments are decided upon under incomplete information (Riordan, 1991; Dasgupta and Tao, 2000). Güth et al. (2007) analyze a model of vertical cross share holding to reduce informational asymmetries, and provide experimental evidence.[5] While such potentially desirable effects of partial vertical ownership should be taken into account within competition policy considerations, we abstract from them for expositional clarity.

The remainder of this article is structured as follows: We introduce the model in Section 2. In Section 3, we solve and characterize the 3rd stage downstream pricing subgame. In Section 4, we solve for, and characterize the equilibrium upstream prices arising in Stage 2. In Section 5, we analyze a key element involved in the solution to the first stage of the game, namely the profitability of partial acquisitions. In the extension section 6, we first compare the results derived in the baseline model with those derived under full vertical integration. Second, we touch at the case in which upstream competition is ineffective, so the efficient firm can exercise complete monopoly power.[6] Third, we look at the effects of bans on upstream price discrimination common to many competition policy prescriptions. Fourth and fifth, we consider the effects of relaxing structural assumptions: We replace sequential by simultaneous pricing decisions, and then allow the upstream firms to charge two-part, rather than linear tariffs. The results remain unchanged. This is surprising in particular, since two part tariffs are considered to remove inefficiencies due to double marginalization. We conclude with Section 7. All relevant proofs are removed to an appendix.

[5] Höffler and Kranz (2011a,b) investigate how to restructure former integrated network monopolists. They find that passive ownership of the upstream bottleneck (legal unbundling) may be optimal in terms of downstream prices, upstream investment incentives and prevention of foreclosure. However, a key difference to our setting is that they keep upstream prices exogenous. In a companion paper Hunold et al. (2012), we discuss the effects of backwards and forwards ownership and control when there is no effective upstream competition, so the efficient upstream firm can set prices monopolistically.

[6] In a companion paper (Hunold et al., 2012), we focus on ineffective competition and compare the effects ot passive and controlling partial backward and forward integration.

# 2 Model

Two symmetric downstream firms $i, i \in \{A, B\}$ competing in prices $p_i$ produce and sell imperfect substitutes obeying demands $q_i(p_i, p_{-i})$ that satisfy

**Assumption 1.** $1 > -\partial_{p_i} q_i(p_i, p_{-i}) > \partial_{p_{-i}} q_i(p_i, p_{-i}) > 0$ *(product substitutability),*

where $\partial_p q$ denotes the first derivative of q with respect to $p$.[7]

The production of one unit of downstream output requires one unit of a homogenous input produced by two suppliers $j \in \{U, V\}$ with marginal costs $c^j$, who again compete in prices. Assume that $c^U \equiv 0$ and $c^V \equiv c > 0$, so that firm $U$ is more efficient than firm $V$, and $c$ quantifies the difference in marginal costs between $U$ and its less efficient competitor.[8] All other production costs are normalized to zero. Upstream suppliers are free to price discriminate between the downstream firms. Let $x_i^j$ denote the quantities firm $i$ buys

to be maximized with respect to its own price $p_i$, subject to the constraint $\sum x_i^j \geq q_i$, so that input purchases are sufficient to satisfy quantity demanded.

We use the term *partial ownership* for an ownership share strictly between zero and one. We call *passive* an ownership share that does *not* involve control over the target firm's pricing strategy, and *active* one that does. The possibility to control the target's instruments is treated as independent of the ownership share in the target. With this we want to avoid the discussion of at which level of shareholdings control arises. That depends on institutional detail and the distribution of ownership share holdings in the target firm. See O'Brien and Salop (1999), as well as Hunold, Röller and Stahl (2012) for a discussion of this issue. Finally, we define an allocation to involve *effective* (upstream) *competition,* if the efficient upstream firm is constrained in its pricing decision by its upstream competitor, i.e. can charge an effective unit input price, as perceived by downstream firm $i$, no higher than $c$.[11]

An equilibrium in the third, downstream pricing stage is defined by downstream prices $p_A$ and $p_B$ as functions of the upstream prices $w_i^j$ and ownership shares $\delta_i^j$, $i \in \{A, B\}$; $j \in \{U, V\}$ held by the downstream in the upstream firms, subject to the condition that upstream supply satisfies downstream equilibrium quantities demanded. In order to characterize that equilibrium, it is helpful to impose the following conditions on the profit functions:

**Assumption 2.** $\partial^2_{p_i p_i}\Pi_i(p_i, p_{-i}) < 0$ *(concavity)*

**Assumption 3.** $\partial^2_{p_i p_{-i}}\Pi_i(p_i, p_{-i}) > 0$ *(strategic complementarity)*

**Assumption 4.** $\partial^2_{p_i p_{-i}}\Pi_i(p_i, p_{-i})/\partial^2_{p_i p_i}\Pi_i(p_i, p_{-i}) > \partial^2_{p_{-i} p_{-i}}\Pi_{-i}(p_i, p_{-i})/\partial^2_{p_i p_{-i}}\Pi_{-i}(p_i, p_{-i})$ *(stability)*[12]

An equilibrium in the second, upstream pricing stage specifies prices $w_i^j$ conditional on ownership shares $\delta_i^j$, $i \in \{A, B\}$; $j \in \{U, V\}$.

We sometimes wish to obtain closed form solutions for the complete game with ownership trade. Towards those we use the linear demand specification

$$q_i(p_i, p_{-i}) = \frac{1}{(1+\gamma)}\left(1 - \frac{1}{(1-\gamma)}p_i + \frac{\gamma}{(1-\gamma)}p_{-i}\right), \quad 0 < \gamma < 1, \tag{3}$$

with $\gamma$ quantifying the degree of substitutability between the downstream products. With this demand specification, Assumptions 1 to 4 are satisfied.[13]

[11] The case of ineffective competition, in which the efficient supplier can charge monopoly prices, is discussed in our companion paper Hunold et al. (2012).

[12] The stability assumption implies that the best-reply function of $i$ plotted in a $(p_i, p_{-i})$ diagram is flatter than the best-reply function of $-i$ for any $p_{-i}$, implying that an intersection of the best reply functions is unique.

[13] Ass. 1: $-\partial_{p_i}q_i(p_i,p_{-i}) = \frac{1}{(1-\gamma^2)} > \frac{\gamma}{(1-\gamma^2)} > 0$, Ass. 2: $\partial_{p_i p_i}\Pi_i(p_i,p_{-i}) = -\frac{2}{(1-\gamma^2)} < 0$, Ass. 3: $\partial_{p_i p_{-i}}\Pi_i(p_i,p_{-i}) = \frac{\gamma}{(1-\gamma^2)} > 0$, Ass. 4: $\left(\frac{2}{(1-\gamma^2)}\right)^2 > \left(\frac{\gamma}{(1-\gamma^2)}\right)^2$.

# 3 Stage 3: Supplier choice and the determination of downstream prices

Downstream firm $i$'s cost of buying a unit of input from supplier $j$ is obtained by differentiating the downstream profit with respect to the input quantity $x_i^j$, i.e.

$$\partial_{(x_i^j)}\Pi_i = \underbrace{w_i^j}_{\text{unit price}} + \underbrace{\delta_i^j\left(w_i^j - c^j\right)}_{\text{upstream profit effect}}.$$

Thus, if holding shares in upstream supplier $j$ from which it purchases input, the unit input price $w_i^j$ faced by downstream firm $i$' is reduced by the contribution of that purchase to supplier $j$'s profits. Call this the *effective input price* downstream firm $i$ is confronted with when purchasing from firm $j$. The minimal effective input price for downstream firm $i$ is given by

$$w_i^e \equiv \min\left\{w_i^U\left(1-\delta_i^U\right), w_i^V\left(1-\delta_i^V\right)+\delta_i^V c\right\}. \tag{4}$$

As natural in this context, firm $i$ buys from the upstream supplier $j$ offering the minimal effective input price. If both suppliers charge the same effective input price, we assume that $i$ buys all inputs from the efficient supplier $U$ as that supplier could slightly undercut to make its offer strictly preferable. Let $j(-i)$ denote the supplier $j$ from which the other downstream firm $-i$ buys its inputs. Differentiating downstream profits with respect to the own downstream price yields the two first order conditions

$$\partial_{p_i}\Pi_i = (p_i - w_i^e)\,\partial_{p_i}q_i(p_i, p_{-i}) + q_i(p_i, p_{-i}) + \delta_i^{j(-i)}\,(w_{-i}^{j(-i)} - c^{j(-i)})\partial_{p_i}q_{-i}(p_{-i}, p_i) = 0,$$
$$i \in \{A, B\}. \tag{5}$$

Observe that whenever $\delta_i^{j(-i)} > 0$, downstream firm $i$ takes into account that changing its sales price affects the upstream profits earned not only via sales quantities $q_i$ to itself, but also via sales quantities $q_{-i}$ to its competitor. By Assumptions 1-4, the equilibrium of the downstream pricing game is unique, stable and fully characterized by the two first order conditions, for effective upstream prices satisfying $0 \leq w_i^e \leq c$ and ownership shares $0 \leq \delta_i^j \leq \bar{\delta}$.

Note that strategic complementarity holds under the assumption of product substitutability if margins are non-negative and $\partial^2_{p_i p_{-i}} q_{-i}$ is not too negative (cf. Equation (5)). Also observe that if prices are strategic complements at $\delta_A = \delta_B = 0$, then strategic complementarity continues to hold for small partial ownership shares.

# 4 Stage 2: Determination of upstream prices under passive partial ownership

$V$ cannot profitably sell at a (linear) price below its marginal production cost $c$. $U$ as the more efficient supplier can profitably undercut $V$ at any positive upstream price. This implies

that, in equilibrium, $U$ supplies both downstream firms, and this at effective prices at most as high as $c$. Another obvious implication is that none of the downstream firms has an interest in obtaining shares from the unprofitable upstream firm $V$. To simplify notation, let henceforth $\delta_i \equiv \delta_i^U$ and $w_i \equiv w_i^U$. Let $p_i(w_i, w_{-i}|\delta_A, \delta_B)$ denote the equilibrium prices of the downstream subgame as a function of input prices. Formally, $U$'s problem is

$$\max_{w_A, w_B} \pi^U = \sum_{i=A,B} w_i\, q_i \left(p_i(w_i, w_{-i}|\delta_A, \delta_B), p_{-i}(w_{-i}, w_i|\delta_A, \delta_B)\right)$$

subject to the constraints $w_i(1-\delta_i) \leq c$, $i \in \{A, B\}$. Differentiating the reduced-form profit $\pi^U(w_i, w_{-i})$ with respect to $w_i$ yields

$$\partial_{w_i}\pi^U = q_i(p_i, p_{-i}) + w_i \frac{dq_i(p_i, p_{-i})}{dw_i} + w_{-i}\frac{dq_{-i}(p_{-i}, p_i)}{dw_i}. \tag{6}$$

Starting at $w_i = w_{-i} = 0$, it must be profit increasing for $U$ to marginally increase upstream prices, because both $q_i > 0$ and $q_{-i} > 0$. By continuity and boundedness of the derivatives, this remains true for small positive upstream prices. Hence the constraints are strictly binding for any partial ownership structure, so there is *effective upstream competition*, if $c$ is sufficiently small. In this case, equilibrium upstream prices are given by

$$w_i^* = c/(1-\delta_i). \tag{7}$$

We assume this regime to hold in the core part of the paper.[14] In this regime, $U$'s profits are uniquely given by

$$\pi^U = \frac{c}{(1-\delta_A)}\, q_A(p_A, p_B) + \frac{c}{(1-\delta_B)}\, q_B(p_B, p_A), \tag{8}$$

and $V$'s profits are zero. We summarize in

**Lemma 1.** *The efficient upstream firm U supplies both downstream firms at any given passive partial backwards ownership shares* $(\delta_A, \delta_B)$*. Under effective competition, i.e. for sufficiently small c,* $U$ *charges prices* $w_i^* = c/(1-\delta_i), i \in \{A, B\}$*, so that the effective input prices are equal to the marginal cost* $c$ *of the less efficient supplier* $V$*.*

Downstream profits reduce to

$$\Pi_i = (p_i - c)\, q_i(p_i, p_{-i}) + \delta_i \frac{c}{1-\delta_{-i}} q_{-i}(p_{-i}, p_i) \tag{9}$$

Observe that if firm $i$ holds shares in firm $U$, so that $\delta_i > 0$, its profit $\Pi_i$, via its upstream holding, *increases* in the quantity demanded of its rival's product $q_{-i}$. All else given, this provides for an incentive to raise the price for its own product. Formally, firm $i$'s marginal profit

[14] Clearly, if $\pi^U(w_A, w_B)$ is concave, one, or both of the constraints does not bind for $c$ sufficiently large, in which case $U$ can charge one, or two monopoly prices below $c$.

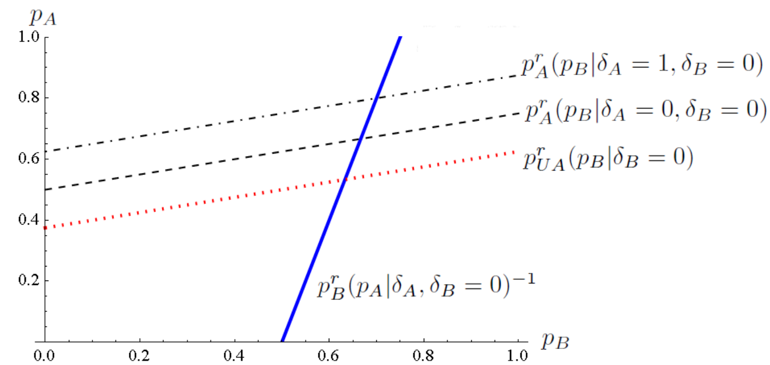


Figure 1: Best-reply functions of downstream firms $A$, $B$ and the vertically integrated unit $UA$ for linear demand as in (3), with $\gamma = 0.5$ and $c = 0.5$.

$$\partial_{p_i}\Pi_i = q_i(p_i, p_{-i}) + (p_i - c)\,\partial_{p_i}q_i(p_i, p_{-i}) + \delta_i \frac{c}{1 - \delta_{-i}}\,\partial_{p_i}q_{-i}(p_{-i}, p_i) \tag{10}$$

increases in $\delta_i$. Note that if $\delta_i > 0$, the marginal profit of $i$ also increases in $\delta_{-i}$, as this increases the upstream margin earned on the product of $-i$. Finally, since $\partial_{p_i}q_{-i}(p_{-i}, p_i)$ increases when the products $(i, -i)$ become closer substitutes, the external effect internalized via the cash flow right $\delta_i$ becomes stronger, and with it the effect on equilibrium prices.

In all, this yields the following central result:

**Proposition 1.** *Let Assumptions 1-4 hold and upstream competition be effective. Then*

*(i) both equilibrium downstream prices $p_i$ and $p_{-i}$ increase in both $\delta_i$ and $\delta_{-i}$ for any non-controlling ownership structure*

*(ii) the increase is stronger when the downstream products are closer substitutes.*

**Corollary 1.** *Any increase in passive ownership in $U$ by one or both downstream firms is strictly anti-competitive.*

Proposition 1 is illustrated in Figure 1 for the case $\delta_A > \delta_B = 0$. The solid line is the inverted best-reply function $p^r_B(p_A)^{-1}$ of $B$ at a given $\delta_A > 0$. The dashed line is $A$'s best reply $p^r_A(p_B)$ for $\delta_A = 0$, and the dashed-dotted line above this is $A$'s best reply for $\delta_A = 1$. Hence, choosing $\delta_A$ amounts to choosing the best-reply function $p^r_A(p_B)$ in the subsequent pricing game. This becomes central when analyzing the profitability of acquisitions in the next section.

# 5 Stage 1: Acquisition of shares by downstream firms

In this section, we assess the profitability of backward acquisitions, in form of passive stakes by downstream firms in upstream firms. We restrict our attention to the acquisition of stakes in firm $U$. This is easily justifiable within the context of our model: Since both downstream firms decide to acquire input from the more efficient firm, the less efficient firm $V$ does not earn positive profits in equilibrium. Also, the equilibrium of the pricing game is independent

of downstream (passive) ownership interests in $V$. Hence, there is no scope for downstream firms to acquire passive interests in $V$.

Rather than specifying how bargaining takes place and conditioning the outcome on the bargaining process, we determine the central incentive condition for backwards acquisitions to materialize, namely that there are gains from trading claims to profits in $U$ between that upstream firm and one of the downstream firms.

In order to enhance the intuition, fix for the moment stakes held by firm $B$ at $\delta_B = 0$. Gains from trading stakes between $A$ and $U$ arise if the the joint profit of $A$ and $U$,

$$\Pi_A^U(\delta_A|\delta_B = 0) \equiv (1-\delta_A)\pi^U + \Pi_A = p_A q_A + c q_B,$$

is higher at some $\delta_A \in (0,\bar{\delta}]$ than at $\delta_A = 0$, where $p_A$, $q_A$ and $q_B$ all are functions of $\delta_A$. The drastic simplification of this expression results from the obvious fact that a positive $\delta_A$ just redistributes profits between $A$ and $U$. The gains from trade between $A$ and $U$ can thus arise only via indirect effects on prices and quantities that are induced by increases in $\delta_A$. Why should there be such gains from trade at all?

The vertical effects of an increase in $\delta_A$ between $A$ and $U$ are exactly compensating. All that changes are $A$'s marginal profits. They increase, because with an increasing $\delta_A$ an increasing share of $U$'s sales to $B$ is internalized. This leads $A$ to increase $p_A$, which in turn induces $B$ to increase $p_B$. That price increase is not only profitable to $B$, but eventually yields a net benefit to $A$ and $U$. Intuition suggests that this competition softening effect is likely to be profitable to the industry if competition is fierce, i.e. $c$ is sufficiently small. Indeed, evaluating $d\Pi_A^U/d\delta_A$ at small $c$ yields

**Proposition 2.** *Increasing partial passive ownership stakes of firm $i$ firm in firm $U$ increase the combined profits of $i$ and $U$, if upstream competition is sufficiently intense.*

This argument continues to hold for trades in upstream ownership shares involving both downstream firms, under the obvious restrictions that $\delta_A + \delta_B \leq 1$ and $\delta_i \leq \bar{\delta}$, so that control is *not* transferred from $U$ to any one of the downstream firms.[15]

**Corollary 2.** *Increasing partial passive ownership stakes of firms i and -i in firm U increases the industry profit $\Pi_{AB}^U \equiv p_A q_A + p_B q_B$, if upstream competition is sufficiently intense.*

Using the linear demand example introduced in (3), we can make explicit how our case assumption that upstream competition is effective relates to the intensity of downstream competition, and in addition derive optimal shareholdings by the downstream firms. The joint profits of firms $i$ and $U$ are maximized at a positive passive ownership share $\delta_i$, given $\delta_{-i} = 0$, if $c < \gamma^2/4$. Recall that a large $\gamma$ corresponds to strong competition downstream, and a small $c$ to strong competition upstream. Hence if overall competition is strong, it is profitable to acquire passive ownership as this increases downstream prices. Since the upper

[15] In Subsection 6.1, we consider the effect of a transfer of control, and compare the outcome with the present one.

bound monotonically increases in $\gamma$, the range of $c$ in which this result holds increases in $\gamma$. At any rate, under this condition, the ownership share maximizing $\Pi_i^U$ is given by

$$\delta_i|_{\delta_{-i}=0} = \min\left(\frac{4c\gamma(1+\gamma)+\gamma^2(2-\gamma-\gamma^2)-8c}{4c\gamma(2-\gamma^2)}, \bar{\delta}\right).$$

Since a firm's backwards interests confer a positive externality on the second firm's profits, the industry profits $p_A q_A + p_B q_B$ are maximized at positive passive ownership shares if the less restrictive condition $c < \gamma/2$ holds.[16] Under this condition, the industry profit is maximized at

$$\delta_A = \delta_B = \min\left(\frac{\gamma-2c}{\gamma-2c+2c\gamma}, \bar{\delta}\right)$$

with the natural restriction that $\bar{\delta} < 1/2$.

# 6 Extensions

## 6.1 Effects of control

In this extension, we compare the effects of passive partial backwards integration with those generated by full vertical integration (i.e. a vertical merger) between one of the downstream firms, say $A$, and the efficient upstream firm $U$. We first consider full vertical integration.

Let the ownership structure under vertical integration be described by $\{\delta_A = 1, \delta_B = 0\}$, and let $A$ control $U$'s pricing decisions. Since $U$ continues to be more efficient than $V$, the vertically integrated firm continues to have the incentive to meet any positive price $w_B^V$ charged by $V$. For sufficiently intense upstream competition, it is again optimal to set $w_B^U = c$. By contrast, $A$, within the vertically integrated firm, now takes account of the true input cost normalized to zero.[17]

Consider now the effect of vertical integration on downstream prices. Still faced with marginal input costs of $c$, vertical integration does not change the best response function of $B$. However, vertical integration has two countervailing effects on the setting of $p_A$. Upward price pressure arises because the integrated unit fully internalizes the upstream profit from selling to firm $B$, that is $c\,q_B(p_B, p_A)$. Conversely, downward price pressure arises because double marginalization on product $A$ is eliminated, as the downstream costs $c\,q_A(p_A, p_B)$ under separation are decreased to zero. Indeed, it can be shown that the downward pressure is stronger, yielding

**Proposition 3.** *Under Assumptions 1 to 4, a vertical merger between one downstream firm and $U$ decreases both downstream prices, as compared to complete separation.*

As another consequence, observe that foreclosure does not arise under vertical integration.

[16] Observe that $\gamma^2/4 < \gamma/2$. This indicates the internalization of the positive externality on the competitor when both downstream firms acquire interests in the efficient upstream firm.

[17] In line with the literature - examples are Bonanno and Vickers (1988) or Chen (2001) - we assume here that under vertical integration, the upstream firm is unable to commit to an internal transfer price to the vertically integrated downstream firm that is higher than its true marginal cost.

Returning to Figure 1, note that for any $\delta_A > 0$, the best response of the merged entity, $p^r_{UA}(p_B)$, represented by the dotted line in Figure 1, is located below the one arising under separation.

Proposition 3 is also contained in Chen (2001). Yet for an anti-competitive increase in downstream prices to occur in that model, Chen needs to assume that $B$ has to make supplier specific investments to buy from $U$, such that the integrated firm can set $w^U_B > c$, and still continue to be the exclusive supplier of $B$. By contrast, as we state in Proposition 1, downstream prices increase even without switching costs once we allow for the separation of profit claims, and control of the target. Summarizing:

**Corollary 3.** *Under Assumptions 1 to 4 and effective upstream competition, a vertical merger between one of the downstream firms and the efficient upstream firm leads to a decrease of all downstream prices when compared to those arising under vertical separation, whence any passive partial backwards ownership of one or both firms in the efficient upstream firm $U$ leads to an increase in all downstream prices.*

We now turn to a comparison of the combined profits of $A$ and $U$ under full vertical separation and full integration. By Proposition 3, vertical integration decreases both downstream prices. This is not necessarily desirable for $A$ and $U$ when the overall margins earned under vertical separation are below the industry profit maximizing level. In order to assess whether separation increases the combined profits $\Pi^U_A$, we ask the following question: Starting at vertical separation, is it profitable to move towards integration? Indeed, it can be shown that this is initially strictly unprofitable for $\Delta c$ sufficiently small. By continuity, there exists an interval $(0, \bar{c}]$ such that for any $c$ in this interval vertical separation is more profitable than integration. Hence

**Lemma 2.** *Complete vertical separation of $A$ and $U$ is more profitable than a merger between $A$ and $U$ if upstream competition is sufficiently intense.*

Combining Proposition 2 and Lemma 2 yields

**Corollary 4.** *Passive partial backwards integration of firm i into firm U leads to higher profits than vertical integration, if upstream and downstream competition are sufficiently intense. Under these conditions, downstream firms have the incentive to acquire maximal backwards interests, short of controlling the upstream firm U.*

As emphasized before, this result is nicely related to the literature on strategic delegation. The particular twist here is that *the very instrument intended to acquire control, namely the acquisition of equity in the target firm, is employed short of controlling the target. While this benefits the industry, it harms consumer welfare.*

## 6.2 Ineffective competition

In the baseline model, we have emphasized the effects of passive partial backwards integration when there is *effective upstream competition,* as generated by a relatively small difference

between the efficient firm $U$'s and the less efficient firm $V$'s marginal cost. We only sketch the case where $c$ is large. The case is discussed in detail in our companion paper Hunold, Röller and Stahl (2012). At any rate, in this case $U$ can behave as an unconstrained monopolist, so it can increase prices such that marginal profits are zero. As before, an increase in $\delta_i$, the passive backwards ownership share in the supplier, softens the acquiring downstream firm $i$'s best response to increases in the input price, as the effective input price decreases in $\delta_i$. In addition, partial upstream ownership induces the acquiring downstream firm to internalize its rivals' sales. Both effects are internalized and thus counterbalanced by the upstream now monopolist's reaction, leading to an increase in the upstream price. For symmetric passive ownership by downstream firms, Greenlee and Raskovich (2006) show that upstream and downstream reaction exactly compensate, so downstream prices stay the same, independent of the magnitude of partial ownership. Yet asymmetric equilibria are vastly affected by the move from effective to ineffective competition. In particular, the incentive to passive

is not anti-competitive under a non-discrimination rule.[18]

### 6.4 Simultaneous price setting

So far, we have assumed that upstream prices are set before downstream prices. Consider now that all prices are set simultaneously. In this situation, upstream firms take downstream prices as given. For $U$, increasing effective prices up to $c$ does not affect quantity. Hence, effective equilibrium upstream prices must be equal to $c$. However, with simultaneous price setting, an equilibrium does only exist as long as the participation constraints (normalized to zero here) of downstream firms are not violated at effective upstream prices of $c$.

**Lemma 3.** *Under effective competition, sequential and simultaneous setting of up- and downstream prices are outcome equivalent.*

Note that as long as the participation constraints of downstream firms do not bind, the simultaneous price setting is equivalent to the case in which downstream prices are set first, followed by upstream prices and, finally, downstream firms choose where to buy inputs.

### 6.5 Two-part tariffs

The assumption of linear upstream prices is clearly restrictive, as argued already in Tirole (1988). One is tempted to argue that if the upstream firms would be allowed to offer contracts from a more general pricing regime, such as two part tariffs, double marginalization would be removed, and with them the anti-competitive effect of passive partial backwards integration discussed here. However, we show that under vertical separation, the efficient firm does optimally charge a linear tariff even if a two-part tariff is admissible, as long as competition is sufficiently strong. This result extends naturally into passive backwards ownership in the efficient supplier. Therefore, this leads to increases in downstream prices harming consumer welfare even when two-part tariffs are admitted.[19]

Let us first consider two-part tariffs within the present model. We maintain the assumption that downstream firms can source from both upstream firms simultaneously, i.e. tariff offers are non-exclusive. A tariff offered by supplier $j$ to downstream firm $i$ is summarized by $\{f_i^j, w_i^j\}$, where $f_i^j$ is the fixed fee downstream firm $i$ has to pay the upstream firm $j$ upon acceptance of the contract, and $w_i^j$ continues to be the (nominal) unit price. Denote by $\pi_i(w_i^j, w_{-i}^k)$, $j, k \in \{U, V\}$ firm $i$'s reduced form downstream profits as a function of the marginal input prices relevant for each downstream firm, net of any fixed payment. With the model constructed as in the main part of the paper, the Bertrand logic still holds: $U$ can still always profitably undercut any (undominated) offer by $V$, so in equilibrium $U$ exclusively

[18] $U$ wants to serve both downstream firms for a small $\delta_i$, given $\delta_{-i} = 0$. Once $\delta_i$ becomes large, $U$ may find it profitable set a high nominal price at which only $i$ wants to purchase. This makes $-i$ dependent on $V$. In turn, $V$ can raise the price charged to $-i$ above $c$, yielding partial foreclosure. However, it is unclear whether partial foreclosure is an equilibrium. In a forthcoming paper, we will discuss in detail the effects of non-discrimination rules in the different case situations.

[19] Fauli-Oller & Sandonis (2006) analyze two-part tariffs in a similar setting with linear demand and a focus on Cournot competition, not considering partial ownership.

supplies both downstream firms. Yet if upstream competition is effective, $U$ is restricted by $V$ in its price setting.

We start from complete vertical separation, so $\delta_A = \delta_B = 0$. It strikes us as helpful to consider extreme cases of downstream competition, before moving to the relevant intermediate case. Let downstream firms' demands first be independent. In this case, there are no contracting externalities downstream, i.e. a contract offer by $j \in \{U, V\}$ to $i$ has no effect on $-i$. Against the efficient firm $U$, the best $V$ can do is to offer the zero profit tariff $(f_i^V, w_i^V)$ that maximizes downstream firm $i$'s profit. This is tantamount to maximizing firm $i$'s profit subject to the the constraint $f_i^V = x_i(p_i(w_i^V))(c - w_i^V)$, where $x_i(p_i(w_i^V))$ is the quantity procured by downstream firm $i$ given the tariff proposed by upstream firm $V$. This yields a profit to downstream firm $i$ of $(p_i(w_i^V) - w_i^V)x_i(p_i(w_i^V)) - f_i^V = (p_i(w_i^V) - w_i^V)x_i(p_i(w_i^V)) - x_i(p_i(w_i^V))(c - w_i^V) = (p_i(w_i^V) - c)x_i(p_i(w_i^V))$, after inserting upstream firm $V$'s profit constraint. Since $V$ wants to offer the best possible alternative to the typical downstream firm, the unique maximizer of that last expression is $w_i^V = c$. Hence the best offer $V$ can make is $\{0, c\}$. In consequence, if procuring from $V$, downstream firm $i$ would obtain maximal profits $\pi_i(c) = (p_i(c) - c)x_i(p_i(c))$.

What is the best offer $U$ can make against this? Suppose $U$ would match $V$'s offer by setting $\{0, c\}$. Then $U$ would leave downstream profits unchanged, and obtain $\pi^U(0, c) = cx_i(p_i(c))$ from firm $i$. Suppose alternatively that $U$ would set $w_i^U = w_{-i}^U = 0$ implying $p_i = p_{-i} = p^M$, i.e. the monopoly prices that induce the industry profit maximizing outcome. Then, in order to match the profits generated downstream under $V$'s offer, $U$ must set $f_i^U = f_{-i}^U = p_i(0)x_i(p_i(0)) - (p_i(c) - c)x_i(p_i(c)) > cx_i(p_i(c))$. Hence $U$ prefers to set $\{f_i^U, 0\}$, with $f_i^U = p_i(0)x_i(p_i(0)) - (p_i(c) - c)x_i(p_i(c))$. In this case the tariff is "extremely nonlinear", and $U$'s profit opportunities are constrained by $V$'s downstream profit maximizing zero profit programme, that induces downstream profits $\pi_i(c)$ per firm $i$. In a nutshell, when downstream demands are independent and this downstream firms charge monopoly prices, $U$ cannot do better than removing double marginalization by setting the marginal price to zero, and absorbing as much of the downstream firms' profit as admitted by the outside option offered by $V$.

Let now downstream competition be perfect, such that when faced with equal input prices, downstream firms make zero profits. This obviously implies that $U$ cannot absorb downstream profits via the fixed part $f$ of a two-part tariff. Under effective competition implying $c$ such that $\arg\max_p (p - c)x_i(p, p) < p^M$, $U$ wants the downstream prices to be as high as possible, and therefore sets $w_i^U = w_{-i}^V = c$, so $p_i = p_i(c, c) = c$ and $f_i^U = f_{-i}^V = 0$, which automatically satisfies all relevant profit constraints.

From all this, we expect that when downstream competition is away from, but close to perfect, the upstream efficient supplier forfeits the possibility to charge a non-linear price and sticks to the maximal linear one.

More formally, for a given contract offer of $V$ to firm $i$, $U$'s problem, realistically assuming

that $U$ supplies $i$, is

$$\max_{f_A^U, f_B^U, w_A^U, w_B^U} \pi^U = \sum_{i \in \{A,B\}} \left[ w_i^U x_i + f_i^U \right]$$
$$s.t. \qquad \pi_i\left(w_i^U, w_{-i}^U\right) - f_i^U \geq \pi_i\left(w_i^V, w_{-i}^U\right) - f_i^V. \tag{12}$$

In equilibrium, the profit constraints of both downstream firms $i \in \{A, B\}$ must be binding, for otherwise $U$ could profitably raise the respective fixed fee $f_i^U$, until downstream firm $i$ is indifferent between its and $V$'s contract offer. Note that setting a marginal input price $w_i^U > c$ with $f_i^U < 0$ would not be profitable, as downstream firm $i$ could accept and buy a very small quantity, and $V$ could profitably offer $f_i^V = 0$, $w_i^V \in (c, w_i^U)$ and be the (almost) exclusive supplier. Also, upstream competition requires that $V$'s equilibrium offers, if accepted, yield it non-negative profits. Finally, the equilibrium contract offers made by $V$ must be best replies to $U$'s equilibrium contract offers. Together with strategic complementarity of the downstream prices, this implies

**Lemma 4.** *Let $U$ offer optimal two-part tariffs with $w_i^U \leq c$. Then $\{0, c\}$ is $V$'s unique counteroffer that maximizes the downstream firms' profits and yields $V$ a non-negative profit.*

Using these insights and letting $w_i \equiv w_i^U$ and $f_i \equiv f_i^U$ to simplify notation, $U$'s problem reduces to

$$\max_{w_A, w_B} \pi^U = \sum_{i \in \{A,B\}} \left[ w_i q_i + \pi_i\left(w_i, w_{-i}\right) - \pi_i\left(c, w_{-i}\right) \right]. \tag{13}$$

subject to the no-arbitrage constraint $w_i \leq c$.

Recalling the previous extreme examples with monopolies and perfect competition downstream, one might expect that $U$'s optimal contract offer is given by $\{0, c\}$, as long as $c$ satisfies $p_i(c, c) < \arg\max_p p\, q_i(p, p)$, i.e. the resulting downstream prices are below the industry profit maximizing level. However, lowering $w_i$ below $c$ may increase $U$'s profit even if industry profits decrease. The rationale is that the outside option of downstream firm $i$, i.e. the profit $\pi_i(c, w_{-i})$ in case of a deviation to supplier $V$, tends to decline in $i$'s resulting cost disadvantage $c - w_{-i}$. This disadvantage increases as $w_{-i}$ decreases. In turn, $U$ is able to extract more profits through the fixed payment from each downstream firm.[20]

However, it can be shown that for $c$ sufficiently small, this motive of devaluing the contract partners' outside options is dominated by the incentive to increase double marginalization, yielding the result that *upstream tariffs are endogenously linear*. We summarize in

**Proposition 4.** *If upstream competition is sufficiently intense, then under vertical separation, $\{0, c\}$ is the unique symmetric equilibrium two-part tariff offered by $U$ to both downstream firms.*

As before, *sufficient intensity* of upstream competition is to be seen relative to the intensity of downstream competition. In our linear demand example, it suffices to have $c < \gamma^2/4$

[20] See for Sandonis and Fauli-Oller (2006) for a more detailed discussion of this issue in the context of Cournot competition and linear demand.

that, in passing, was also the condition ensuring the profitability of unilateral passive backwards integration.

What does change if we allow for passive partial backwards integration? Nothing, we claim. Under the conditions given, passive backwards integration does not change the efficient upstream firm's incentive to charge linear prices even if allowed to charge non-linear ones. Hence

**Corollary 5.** *If upstream competition is sufficiently intense, then also under passive partial backwards integration,* $\{0, c\}$ *is the unique symmetric equilibrium two-part tariff offered by* $U$ *to both downstream firms.*

As contracts remain linear, Proposition 2 still applies and we obtain

**Corollary 6.** *Even if two-part tariffs are allowed for, increasing partial passive ownership stakes of firms i and -i in firm U increase the industry profit* $\Pi^U_{AB} \equiv p_A q_A + p_B q_B$*, if upstream competition is sufficiently intense.*

Hence the results derived in the main part of the paper are upheld even if two-part tariffs are allowed for.

## 7 Conclusion

In this paper, we consider a vertical structure with differentiated, price setting downstream firms that produce with inputs from upstream firms supplying a homogenous input at differing marginal costs. We analyze the effect of one or more downstream firms holding passive, that is non-controlling ownership shares in the efficient, and therefore common, supplier. In sharp contrast to related studies, we find that if competition is sufficiently intense, *passive ownership leads to increased downstream prices and thus is strictly anti-competitive*. Also, *passive ownership is anti-competitive where a full vertical merger would be pro-competitive*. Confronted with the choice between passive backwards integration and a full vertical merger, the firms prefer the former short of joint control, that would do away with the upstream efficient supplier's power to commit to a high industry profit increasing price: The very instrument typically employed to obtain control is used up to the point where control is not attained. This brings an additional feature to the strategic delegation literature.

Our result is driven primarily by a realistic assumption on the upstream market structure, in which an efficient supplier faces less efficient competitors, allowing it to increase upstream prices only when the price increasing effect is absorbed by the downstream firm(s), via their claims on upstream cash flows. We show the result to be robust to changes in other assumptions such as linear upstream prices, and sequential price setting upstream and then downstream. Indeed, once allowing upstream firms to offer two-part tariffs, we find that the equilibrium contracts are endogenously linear if competition is sufficiently intense. Interestingly enough, under effective upstream competition, passive ownership in suppliers tends *not*

to be anti-competitive under a non-discrimination clause.[21]

For competition policy, it is important to recognize that anti-competitive passive ownership in common suppliers is profitable when both up- and downstream competition are sufficiently strong, i.e. when foreclosure is likely *not* to be a threat. Most importantly, proposing passive backwards ownership in a supplier as a remedy to a proposed vertical merger tends *not* to benefit competition but eventually worsens the competitive outcome, as long as downstream competition is strong and the upstream supplier serves competitors of the raider. The reason is that full vertical integration tends to remove double marginalization via joint control, whilst partial backwards integration tends to enhance that.

Finally, in the present setting, we abstract from other, potentially socially desirable motives for partial backwards ownership. A particularly important effect is the mitigation of agency problems in case of firm-specific investments (Riordan, 1991; Dasgupta and Tao, 2000) such as investment in specific R&D. Indeed, Allen and Phillips (2000) show for a sample of US companies that vertical partial ownership is positively correlated with a high R&D intensity. Yet such potentially pro-competitive effects need to be weighed against the anti-competitive effects of passive backwards integration presented here.

[21] By contrast, we show in Hunold, Röller and Stahl (2012), that when upstream competition is ineffective, a non-discrimination clause is *the cause* of anti-competitive effects.

# Appendix A: Proofs

*Proof of Proposition 1.* (i) Suppose for the moment that only downstream firm $i$ holds shares in $U$, i.e. $\delta_i > \delta_{-i} = 0$. The first order condition $\partial_{p_{-i}} \Pi_{-i} = 0$ implied by (10) and, hence, the best-reply $p^r_{-i}(p_i)$ of $-i$ is independent of $\delta_i$. In contrast, the marginal profit $\partial_{p_i} \Pi_i$ increases in $i$'s ownership share $\delta_i$. This implies a higher best reply $p^r_i(p_{-i}|\delta_i)$ for any given $p_{-i}$. By continuity, $\partial_{\delta_i} p^r_i(p_{-i}|\delta_i) > 0$. Strategic complementarity of downstream prices implies that an increase in $\delta_i$ increases both equilibrium prices. This argument straightforwardly extends to the case where both firms hold shares in $U$ because $\partial_{p_i \delta_{-i}} \Pi_i \geq 0$. □

*Proof of Proposition 2.* Differentiating the combined profits of $A$ and $U$ with respect to $\delta_A$ at $\delta_B = 0$ yields

$$\frac{d\Pi^U_A}{d\delta_A} = (p_A\, \partial_{p_A} q_A + q_A + c\, \partial_{p_A} q_B)\, \frac{dp_A}{d\delta_A} + (p_A\, \partial_{p_B} q_A + c\, \partial_{p_B} q_B)\, \frac{dp_B}{d\delta_A}. \tag{14}$$

Clearly, at $c = 0$, the derivative is equal to zero as $dp_i/d\delta_A = 0$ (the upstream margin is zero). To assess the derivative for small, but positive $c$, further differentiate with respect to $c$ to obtain

$$\begin{aligned} \frac{d^2\Pi^U_A}{d\delta_A dc} &= d_c\, (p_A\, \partial_{p_A} q_A + q_A + c\partial_{p_A} q_B)\, \tfrac{dp_A}{d\delta_A} + d_c\, (p_A\, \partial_{p_B} q_A + c\, \partial_{p_B} q_B)\, \tfrac{dp_B}{d\delta_A} \\ &\quad + (p_A\, \partial_{p_A} q_A + q_A + c\partial_{p_A} q_B)\, \tfrac{d^2 p_A}{d\delta_A dc} + (p_A\, \partial_{p_B} q_A + c\, \partial_{p_B} q_B)\, \tfrac{d^2 p_B}{d\delta_A dc}. \end{aligned}$$

Evaluating this derivative at $c = 0$ yields

$$\frac{d^2\Pi^U_A}{d\delta_A dc}|_{c=0} = p_A \partial_{p_B} q_A\, \frac{d^2 p_B}{d\delta_A dc}|_{c=0},$$

because $\frac{dp_A}{d\delta_A}|_{c=0} = \frac{dp_B}{d\delta_A}|_{c=0} = 0$ and $p_A\, \partial_{p_A} q_A + q_A = 0$ (this is the FOC of $\pi_A$ with respect to $p_A$ at $c = 0$). Recall that $\frac{dp_B}{d\delta_A} > 0$ for $c > 0$ (Proposition 1) while $\frac{dp_B}{d\delta_A} = 0$ at $c = 0$. By continuity, this implies $\frac{d^2 p_B}{d\delta_A\, dc}|_{c=0} > 0$. It follows that $\frac{d^2\Pi^U_A}{d\delta_A dc}|_{c=0} > 0$ which, by continuity, establishes the result. □

*Proof of Proposition 3.* The best response function of $A$ under complete separation is characterized by

$$\partial_{p_A} \Pi_A = (p_A - c)\, \partial_{p_A} q_A(p_A, p_B) + q_A(p_A, p_B) = 0. \tag{15}$$

When maximizing the integrated profit $p_A q_A + w_B q_B$, it is - as argued before - still optimal to serve $B$ at $w_B \geq c$ and, hence, the corresponding downstream price reaction is characterized by

$$p_A \partial_{p_A} q_A(p_A, p_B) + q_A(p_A, p_B) + w_B\, \partial_{p_A} q_B(p_B, p_A) = 0. \tag{16}$$

Subtract the left hand side (LHS) of (15) from the LHS of (16). This yields

$$\Delta \;=\; c\,\partial_{p_A} q_A(p_A, p_B) + w_B\,\partial_{p_A} q_B(p_B, p_A).$$

The symmetric fixed point under separation ($\delta_A = \delta_B = 0$) must have $p_A = p_B$. This implies $\partial_{p_A} q_B(p_B, p_A) = \partial_{p_B} q_A(p_A, p_B)$. Hence, at equal prices $\Delta$ is negative as $\partial_{p_A} q_A(p_A, p_B) > \partial_{p_B} q_A(p_A, p_B) > 0$ by Assumption 1 and $w_B \leq c$. A negative $\Delta$ implies that the marginal profit of $A$ under integration is lower and thus the integrated $A$ wants to set a lower $p_A$. Recall that under complete separation, the best-reply function of $B$ is characterized by

$$\partial_{p_B} \Pi_B = (p_B - c)\,\partial_{p_B} q_B(p_B, p_A) + q_B(p_B, p_A) = 0 \tag{17}$$

and under integration of $A$ and $U$ by

$$\partial_{p_B} \Pi_B = (p_B - w_B)\,\partial_{p_B} q_B(p_B, p_A) + q_B(p_B, p_A) = 0 \tag{18}$$

subject to $w_B \leq c$. Clearly, the marginal profit of $B$ is (weakly) lower under integration. Strategic complementarity and concavity of $\Pi_i$ imply that the unique fixed point of the downstream prices under integration must lie strictly (reNote thatcall that $\Delta$ is strictly negative) below that under separation. □

*Proof of Lemma 2.* Related to the logic of the Proof to Proposition 1 in Bonanno and Vickers (1988), we look at the change in the joint profit of $A$ and $U$, $\Pi_A^U$, when we move from vertical separation to vertical integration. Recall that under effective competition, the upstream firm, whether integrated or not, will always set the maximal input price $w_B = c$ when selling to firm $B$, and this independently of any choice of $w_A$. Recall that $\Pi_A^U = p_A\,q_A(p_A,\,p_B) + c\,q_B(p_B, p_A)$ and let the equilibrium downstream prices as a function of input prices be given by $p_A(w_A, c) \equiv \arg\max_{p_A}\, p_A\,q_A(p_A, p_B) + c q_B - w_A\,[q_A + q_B]$ and $p_B(c, w_A) \equiv \arg\max_{p_B}\,(p_B - c)\,q_B(p_B, p_A)$. Note that $w_A = 0$ yields the downstream prices under integration and $w_A = c$ those under separation.

The effect of an increase of $w_A$ on $\Pi_A^U$ is determined by implicit dmost attractiveifferentiation. This yields

$$\frac{d\Pi_A^U}{dw_A} = \frac{d\Pi_A^U}{dp_A}\,\frac{dp_A}{dw_A} + \frac{d\Pi_A^U}{dp_B}\,\frac{dp_B}{dw_A}.$$

First, Assumptions 1-4 imply that at $w_A = c$ and hence $p_A = p_B$, we have both $\frac{dp_A}{dw_A} > 0$ and $\frac{dp_B}{dw_A} > 0$ for $c \geq 0$. Second,

$$\frac{d\Pi_A^U}{dp_A} = \underbrace{\partial_{p_A}(p_A - c)\,q_A(p_A, p_B)}_{=0} + c\,\underbrace{[\partial_{p_A} q_A + \partial_{p_A} q_B]}_{<0\,at\,p_A = p_B} < 0,$$

but approaches $0$ as $c$ goes to zero. Third, $\frac{d\Pi_A^U}{dp_B} = p_A \partial_{p_B} q_A + c\,\partial_{p_B} q_B(p_B, p_A)$ is strictly

positive for $c$ sufficiently close to zero. In consequence, $\left[\frac{d\Pi_A^U}{dp_B}\frac{dp_B}{dw_A}\right]_{w_A=c} > 0$ dominates $\left[\frac{d\Pi_A^U}{dp_A}\frac{dp_A}{dw_A}\right]_{w_A=c} < 0$ as $c$ goes to zero. Summarizing, $\frac{d\Pi_A^U}{dw_A}|_{w_A=c} > 0$ for $c$ sufficiently small. By continuity, decreasing $w_A$ from $c$ to 0 decreases $\Pi_A^U$ for $c$ sufficiently small which implies that moving from separation to integration is strictly not profitable. □

*Proof of Lemma 4.* Suppose that firm $i$ sources only from $U$, but $i$ deviates to sourcing from $V$. Clearly, the most attractive contract must yield $V$ zero profits, i.e. $f_i^V = x_i^V\,(c - w_i^V)$ with $x_i^V$ denoting the quantity sourced by $i$ from $V$. Given $w_i^U \le c$, the arbitrage possibility due to multiple sourcing renders unfeasible contracts with $w_i^V > c$. Recall that $p_i(w_i, w_{-i})$ denotes the downstream equilibrium price of $i$ as a function of the marginal input prices. The net profit of $i$ when buying all inputs from $V$ is given by

$$\Pi_i = (p_i(w_i^V, w_{-i}^U) - w_i^V)\, q_i(p_i(w_i^V, w_{-i}^U), p_{-i}(w_{-i}^U, w_i^V)) - f_i^V.$$

Substituting for $f_i^V$ using the zero profit condition of $V$ yields

$$\Pi_i = (p_i(w_i^V, w_{-i}^U) - c)\, q_i(p_i(w_i^V, w_{-i}^U), p_{-i}(w_{-i}^U, w_i^V)).$$

Increasing $w_i^V$ at $w_i^V = c$ is profitable if $d\Pi_i/dw_i^V|_{w_i^V=c} > 0$. Differentiation yields

$$d\Pi_i/dw_i^V = \frac{d\Pi_i}{dp_i}\frac{dp_i}{dw_i^V} + \frac{d\Pi_i}{dp_{-i}}\frac{dp_{-i}}{dw_i^V}.$$

Optimality of the downstream prices implies $\frac{d\Pi_i}{dp_i} = 0$. Moreover, $\frac{dp_{-i}}{dw_i^V} > 0$ follows from the strategic complementarity of downstream prices, and with it, the supermodularity of the downstream pricing subgame. Finally, $\frac{d\pi_i}{dp_{-i}} > 0$ follows directly from $\partial_{p_{-i}} q_i > 0$ (substitutable products). Combining these statements yields

$$d\Pi_i/dw_i^V|_{w_i^V=c} = \frac{d\Pi_i}{dp_{-i}}\frac{dp_{-i}}{dw_i^V} > 0.$$

This implies that raising $w_i^V$ above $c$ would be profitable for $i$. However, the no arbitrage condition and $w_i^U \le c$ renders this impossible. Analogously, decreasing $w_i^V$ below $c$ and adjusting $f_i^V$ to satisfy zero profits of $V$ is not profitable for $i$. In consequence, the contract offer of $V$ most attractive to any downstream firm $i$ is given by $\{0, c\}$. □

*Proof of Proposition 4.* Let $\delta_A = \delta_B = 0$ and suppose that $A$ and $B$ face input prices $w_A$ and $w_B$, respectively. Recall that $p_i(w_i, w_{-i})$ denotes $i$'s equilibrium price. Recall that $\pi_i(w_i, w_{-i}) \equiv [p_i(w_i, w_{-i}) - w_i]\; q_i\left(p_i(w_i, w_{-i}), p_{-i}(w_{-i}, w_i)\right)$. Using (13), solving the (binding) constraint for $f_i^U$ and substituting in the objective function yields

$$\pi^U = \sum_i [p_i(w_i, w_{-i})\; x_i\left(p_i(w_i, w_{-i}), p_{-i}(w_{-i}, w_i)\right) - (p_i(c, w_{-i}) - c)\; x_i\left(p_i(c, w_{-i}), p_{-i}(w_{-i}, c)\right)].$$

The first term captures the industry profits and the second, since $\{0, c\}$ is $V$'s tariff that maximizes the downstream firms' profit, the value of each of the downstream firms' outside option. An obvious candidate equilibrium tariff of $U$ is $\{f = 0, w = c\}$ to both downstream firms. This results in $\pi^U = 2c\,q_i(p(c,c), p(c,c))$. Let $\{f, w\}$ denote alternative symmetric equilibrium candidates offered by $U$. Recall that $w > c$ with $f < 0$ is not feasible, as then the downstream firms would source essentially from $V$. Towards assessing whether $U$ would benefit from lowering $w$ below $c$ (and increasing $f$), we differentiate $\pi^U$ with respect to $w$ at $w = c$. If that sign is positive for $w_i, i \in \{A, B\}$ separately and jointly, then $U$ has no incentive to decrease its price below $c$. Differentiation of $\pi^U$ with respect to $w_i$ at $w_i = c$ yields

$$\frac{\partial p_i}{\partial w_i}x_i + p_i[\frac{\partial x_i}{\partial p_i}\frac{\partial p_i}{\partial w_i} + \frac{\partial x_i}{\partial p_{-i}}\frac{\partial p_{-i}}{\partial w_i}] + \frac{\partial p_{-i}}{\partial w_{Ai}}x_{-i} + p_{-i}[\frac{\partial x_{-i}}{\partial p_i}\frac{\partial p_i}{\partial w_i} + \frac{\partial x_{-i}}{\partial p_{-i}}\frac{\partial p_{-i}}{\partial w_i}] - \frac{\partial p_{-i}}{\partial w_i}x_{-i} - [p_{-i} - c][\frac{\partial x_{-i}}{\partial p_{-i}}\frac{\partial p_{-i}}{\partial w_i} + \frac{\partial x_{-i}}{\partial p_i} \dots$$

Simplifying, and sustracting and adding $c\frac{\partial x_i}{\partial p_i}\frac{\partial p_i}{\partial w_i}$, and making use of downstream firm $i$'s FOC with respect to its price, we obtain

$$c[\frac{\partial x_i}{\partial p_i}\frac{\partial p_i}{\partial w_i} + \frac{\partial x_{-i}}{\partial p_{-i}}\frac{\partial p_{-i}}{\partial w_i}] + [p_i\frac{\partial x_i}{\partial p_{-i}}\frac{\partial p_{-i}}{\partial w_i} + c\frac{\partial x_{-i}}{\partial p_i}\frac{\partial p_i}{\partial w_i}]$$

The first bracket is negative, and the second positive. When $c \to 0$, the first negative bracket converges to zero, and the first component of the second bracket yields the expression strictly positive. □

## Appendix B: Calculations with linear demand

*Derivation of the ownership share $\delta_i$ that maximizes $\Pi_A^U$.* Substituting the linear demand expression (3) into the derivative of joint profits (14) yields

$$\frac{d(\Pi_A^U)}{d\delta_A} = \frac{c\gamma\,((-4c + \gamma^2)(-2 + \gamma + \gamma^2) - 4c\gamma\,(-2 + \gamma^2)\,\delta_A)}{(-4 + \gamma^2)^2\,(-1 + \gamma^2)}.$$

The second derivative is given by

$$\frac{d^2(\Pi_A^U)}{(d\delta_A)^2} = \frac{4c^2\gamma^2\,(2 - \gamma^2)}{(-4 + \gamma^2)^2\,(1 - \gamma^2)}.$$

It is negative for the relevant parameter ranges $0 < \gamma < 1$ and $c > 0$ which implies that the combined profit of $U$ and $A$ is concave in $\delta_A$. The root of the first derivative is unique and given by

$$\delta_A^U = \left(\gamma^2 - 4c\right)\frac{(\gamma + \gamma^2 - 2)}{4c\gamma\left(\gamma^2 - 2\right)}.$$

$\delta_A^U$ is negative for $\gamma^2/4 < c$ and positive if the inequality is reversed. $\delta_A^U$ exceeds 1 for $c < \frac{\gamma^2\left(2-\gamma-\gamma^2\right)}{4(2-\gamma(\gamma+\gamma^2-1))}$. □

*Derivation of the ownership shares $\delta_i, \delta_{-i}$ that maximize $\Pi_{A,B}^U$.* Substituting the linear demand specification (3) into the reduced form profit $\Pi_{A,B}^U$ and using the insight that a profit maximizing passive ownership structure must have $\delta_A = \delta_B \equiv \delta$, the objective function becomes

$$\Pi_{A,B}^U = \frac{2(1 - c - \delta + c(1-\gamma)\delta)(1 + c - \gamma - (1+c)(1-\gamma)\delta)}{(2-\gamma)^2(1+\gamma)(1-\delta)^2}.$$

The FOC with respect to $\delta$ is uniquely solved by

$$\delta_{A,B}^U = \frac{\gamma - 2c}{\gamma - 2c(1-\gamma)}.$$

$\delta_{A,B}^U$ is positive for $\gamma > 2c$. It is straightforward to show that the objective function is locally concave in $\delta^*$. Hence, $\delta^*$ is a local maximizer. As the objective function is continuous and there are no other extrema $\delta^*$ must also be a global maximizer. □

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