Düsseldorf Institute
for Competition Economics

DISCUSSION PAPER

No 281

Supply Chain Innovations and Partial Ownership

Matthias Hunold,
Shiva Shekhar

February 2018

HEINRICH HEINE
UNIVERSITÄT DÜSSELDORF

d|u|p düsseldorf university press

IMPRINT

DICE DISCUSSION PAPER

Published by

düsseldorf university press (dup) on behalf of
Heinrich-Heine-Universität Düsseldorf, Faculty of Economics,
Düsseldorf Institute for Competition Economics (DICE), Universitätsstraße 1,
40225 Düsseldorf, Germany
www.dice.hhu.de

Editor:

Prof. Dr. Hans-Theo Normann
Düsseldorf Institute for Competition Economics (DICE)
Phone: +49(0) 211-81-15125, e-mail: normann@dice.hhu.de

DICE DISCUSSION PAPER

ISSN 2190-9938 (online) – ISBN 978-3-86304-280-6

Supply Chain Innovations and Partial Ownership

Matthias Hunold and Shiva Shekhar*

February 2018

Abstract

We show that competing downstream firms may rather invest in their inefficient inhouse production than help improve the technology of the efficient supplier, even if this is costless. Even worse, a downstream firm can have strong incentives to decrease the efficiency of the supplier in order to improve its outside options. We demonstrate that non-controlling partial backward ownership can align the incentives of the supplier and its customers with respect to supply chain innovations.

JEL classification: L22, L40

Keywords: knowledge spillover, innovation, minority shareholdings, supply chain efficiency, vertical partial ownership

*Both authors are at the Düsseldorf Institute for Competition Economics (DICE) of the Heinrich-Heine-Universität (HHU) Düsseldorf, Universitätsstr. 1, 40225 Düsseldorf, Germany; hunold@dice.hhu.de, shekhar@dice.hhu.de. We thank Toker Doganoglu, Paul Heidhues, Ismael Martínez-Martínez, Daniel Müller, Hans-Theo Normann, Frank Schlütter, Joel Stiebale, Tim Thomes, as well as seminar participants at DICE and the University of Würzburg for helpful comments and discussions.

1 Introduction

Cooperation among suppliers and their buyers is essential to improve supply chains. An important element is knowledge sharing as this can reduce inefficiencies which arise due to factors such as the inability to correctly forecast future demand, low production technologies and incompatible quality control measures.[1] For example, a downstream firm using an input might gain knowledge about how the supplier could produce the inputs more efficiently, either due to its experience in other markets or own research and development activities.[2] The tacit nature of some of these supply chain relations can lead to situations where cooperative actions are non-contractible as their success is difficult to verify in court. For instance, knowledge sharing might involve exploratory discussions and collaborations between the engineers of the customer and its supplier.[3] In such situations, it is crucial that there are incentives to share knowledge.

In this article, we first show that if supply chain cooperation is not contractible, it may not take place, even when it is costless and increases efficiency and industry profits. The reason is that the improved efficiency of a supplier can reduce the downstream firm's profit. This occurs when the increased efficiency enables the supplier to serve also competing downstream firms in a better way, for instance, at lower costs. Even though the industry profit may increase when efficiency is higher, the downstream firms' threat point when bargaining with the supplier may be worse. Sourcing from an alternative, less efficient source becomes less attractive when the competitors are at the same time served with better or cheaper inputs from the efficient supplier. The incentives of downstream firms with respect to supply chain improvements are thus not aligned with the objectives of industry profit maximization. In particular, we show that downstream firms may rather invest in improving an inefficient alternative supply source than improving the supplier from which they actually source. Even worse, the downstream firms can have strong incentives to decrease the efficiency of their supplier.

In a second step, we look at instruments that can help overcome this inefficiency in supply chains. We show that non-controlling partial backward ownership which the downstream firms hold of their supplier, can align the incentives with respect to supply chain cooperation. The intuition is that with partial backward ownership a downstream firm benefits from a decrease in the costs of its supplier and thus has incentives to foster such innovations

[1] Hartley (2000) and Kwon and Suh (2004) show that information sharing between firms builds stronger supply chain relationships. Lee et al. (1997) suggest that information sharing by downstream firms to upstream firms can mitigate the bullwhip effect.

[2] Honda, for example, organizes Kaizen (continuous improvement) events at suppliers' facilities. Similarly, Toyota teaches the suppliers its famed Toyota Production System. The company has also set up Jishuken, or study group teams, as a way to help the manufacturer and its suppliers learn together how to improve operations. Executives and engineers who work for Toyota and its suppliers meet under the direction of a Toyota sensei and go from plant to plant improving suppliers' processes.

[3] See "Building Deep Supplier Relationships", Jeffrey Liker and Thomas Y. Choi, Harvard Business Review, December 2004 (https://hbr.org/2004/12/building-deep-supplier-relationships, last access February 2018). This article contains the example of Honda of America sending an engineer to spend a year with a Cleveland based company, Atlantic Tool and Die, where he offered suggestions which led to marked improvements on the shop floors.

– if the share is sufficiently high. In particular, if each of the n symmetric downstream firms has a non-controlling backward ownership share of $1/n$, all downstream firms have incentives to foster innovations that reduce the costs of their common supplier. In addition, no downstream firm has an incentive to invest inefficiently in an inferior alternative input production technology.

2 Related literature

The starting point of our analysis is the observation that a downstream firm may be in a position to help its supplier improve its efficiency. The relevance of this channel is well documented in the literature. For instance, Kotabe et al. (2003) study knowledge exchange in the U.S. and Japanese automotive industries and argue that transferring productive knowledge between a buyer and the supplier is associated to performance improvements of the latter. Dyer and Hatch (2004) explain that Toyota encouraged knowledge sharing with its suppliers. They argue that this has led to an increased efficiency of their own suppliers compared to suppliers of rival car producers and resulted in a significant competitive advantage for Toyota. Bönte and Keilbach (2005) investigate formal and informal modes of vertical R&D-cooperation among firms in Germany and their decisions to engage in such cooperation. They provide evidence that informal R&D-cooperation is the most relevant cooperation mode and find that the ability of firms to protect knowledge is a key determinant of formal and informal cooperation.

A downstream firm's incentives to share knowledge that increases the efficiency of its supplier has also been studied theoretically. Hughes and Kao (2001) analyze the incentives of competing downstream firms to share knowledge with their common supplier. They argue that retailers might be less willing to share knowledge when the supplier has an own downstream business, as this could enjoy a competitive advantage when obtaining the knowledge of its rivals. Bönte and Wiethaus (2007) study the case that knowledge sharing of a downstream firm does not only decrease the supplier's production costs, but also the production costs of downstream rivals – for a given input price. They conclude that this direct strengthening of a rival can prevent knowledge dissipation. In a complementary article, Wiethaus (2005) shows that competing firms choose identical R&D approaches in order to maximize knowledge flows between each other.

The present article is related to two strands of literature that involve partial vertical ownership. The first strand focuses on the competitive effects of partial vertical ownership, whereas the second strand focuses on the effects on investments in a supply chain, but mostly abstracts from competition.

There is a growing literature that has identified various (anti-) competitive effects of partial vertical ownership. One anti-competitive effect is market foreclosure. Baumol and Ordover (1994), Spiegel (2013) and Gilo et al. (2016) mainly consider the effects of controlling an upstream (or downstream) firm via partial ownership. They emphasize that with controlling partial acquisitions, a firm only internalizes parts of another firm's profits and losses, although it can fully distort its strategy to increase its own profit. Therefore, dedicated foreclosure strategies (refusal to supply or bad terms of trade) can be more attractive when compared to full integration. Hunold (2017) has shown that also non-controlling backward ownership in combination with uniform upstream prices can deter competition of downstream firms and decrease consumer surplus.

Besides foreclosure, non-controlling forward ownership with linear tariffs can reduce double marginalization and downstream prices, to the benefit of customers (Flath, 1989). Ownership stakes that downstream firms hold of upstream firms (backward ownership) tend to have no effect on downstream prices when there is an upstream monopolist (Greenlee and Raskovich, 2006). However, backward ownership can lead to higher prices with both upstream competition and downstream competition in prices as downstream firms internalize each other's demand through the margin on input sales (Hunold and Stahl, 2016).[4] To abstract from these pricing effects and focus on cooperation incentives, we use downstream quantity competition as a benchmark in the present article.

Dasgupta and Tao (2000) show that a supplier has more incentives to make relationship specific investments when the customer holds a non-controlling ownership share of the supplier. The reason is that general investments, which lead to an input that the supplier can also sell on other markets, become less attractive for the supplier once the customer participates in the profits of such alternative sales of the input because the supplier's bargaining position is worse in this case.[5] Similarly, Choi et al. (2014) consider that an upstream firm can sell exactly one indivisible unit of input to one of two different customers, which do not compete downstream. They assume the customer that values the input more can make a costly investment that increases the value for both customers. As they assume that the price which this customer has to pay is the value for the other customer (the resource is auctioned off), the spillover reduces the investment incentives because investments then increase the price. With partial backward ownership, the customer pays effectively less because it gets part of the price back through the profit participation, which can again increase the investment incentive. However, partial backward ownership is not a solution if the supplier makes take-it-or-leave-it (TIOLI) offers, if each customer can buy a unit of the input, or if both customers have symmetric investment capabilities. Instead, we consider a setting where a supplier sells inputs do different, and possibly competing, downstream firms and show that partial ownership can be helpful in all these cases.

Besides supply chain relations, it is worth mentioning that non-controlling partial ownership among firms which are (potential) competitors can also facilitate efficiency enhancing cooperation, and in particular knowledge sharing, albeit with the possible side effect of reducing product market competition. (Mathews, 2006; Ghosh and Morita, 2017).

Allen and Phillips (2000) empirically study partial ownership held by corporations in U.S.

[4] In certain situations with asymmetric information between a manufacturer and its exclusive customer, non-controlling forward ownership of the manufacturer in its customer may also allow them to commit to higher prices (Fiocco, 2016).

[5] In particular, the customer's outside option option in case of general inputs is not zero anymore, but positive, which reduces the gains from trade with the supplier and thus leads to a more favorable Nash-bargaining outcome for the customer.

firms and identify many instances where downstream firms hold ownership stakes of upstream firms. They find that such partial ownership combined with product market relationships in R&D-intensive industries is associated with improvements in operating performance and substantial increases in investment expenditures by target firms. Their findings are consistent with our theory that partial backward ownership facilitates cooperation, and in particular technology transfer to the target firm. More generally, their findings underline the importance of understanding also conceptually the relationship between partial ownership and supply chain cooperation.

3 Market structure and strategy

There are $n > 1$ symmetric downstream firms. The production of one unit of downstream output requires one unit of a homogeneous input, produced either by supplier U or inhouse. The marginal cost of supplier U is $c^U = \tilde{c} > 0$, and that of the inhouse production of each downstream firm is $c^I = \tilde{c} + c$, where $c > 0$ is the difference in marginal costs between U and the less efficient inhouse production.[6] All other production costs are assumed to be zero.

The upstream supplier charges two-part tariffs with a fixed fee f_i and a marginal price w_i to the n downstream firms indexed $i \in \{1, .., n\}$.[7] We start with the case where downstream firms produce homogeneous products, compete in quantities, and where there are no ownership links between the firms. The game has three stages:

1. Each downstream firm decides whether to induce an innovation at supplier U or its inhouse supply. If the innovation is induced, the marginal cost of either supplier U or the inhouse production decreases by $k \in (0,\ c)$ to $c^U = \tilde{c} - k$ or $c^I = \tilde{c} + c - k$, respectively.[8] The resulting marginal costs become public knowledge.

2. Supplier U offers secret two-part contracts $\{f_i,\ w_i\}$ to each downstream firm. Downstream firms individually and simultaneously decide whether to accept or reject the contract offered by U. The acceptance decisions become public, but not the contract terms.

3. Downstream firms simultaneously buy input quantities x_i^U from supplier U, produce x_i^I input quantities inhouse, produce output quantities q_i and sell them.

As regards stage 1, we mainly analyze how profits before any innovation costs change with such innovations. At this point, we abstract away from costs of innovation.

[6]This way of modeling upstream competition is used by, for instance, Chen (2001), Sandonis and Fauli-Oller (2006) as well as Hunold and Stahl (2016). One can also think of inhouse production as a competitive fringe supply. A potential difference only arises if a downstream firm induces innovations at only its inhouse supply or a fringe that is used also by others, but this is not essential for our arguments.

[7]See Villas-Boas (2007) and Bonnet and Dubois (2010) for empirical evidence of non-linear wholesale tariffs.

[8]We assume that $\tilde{c}$ is sufficiently large such that c^U remains positive. Otherwise, the supplier might want to produce an infinite amount of inputs.

Supplier U's profit is given by

$$\pi^U = \sum_{i=1}^{n} \left(w_i - c^U\right) x_i^U + f_i \tag{1}$$

if all downstream firms accept its contract offer.

The downstream price is a function of the total output $Q = \sum_{i=1}^{n} q_i$ and given by $P(Q)$ with $P' < 0$. Downstream firm i's profit before the fixed fee f_i in case it accepts the contract of U is given by

$$\pi_i \;\; = \;\; P(Q)\, q_i - w_i\, x_i^U - c^I\, x_i^I. \tag{2}$$

Each downstream firm maximizes its profit subject to the constraint $x_i^U + x_i^I \geq q_i$, whereby input purchases are sufficient to satisfy the quantity demanded.

Before the downstream firms order and sell quantities in stage 3, acceptance or rejection decisions of the wholesale contracts become public, but the actual supply conditions of the contracts remain secret. A breakdown in negotiations between supplier U and a customer is assumed to be observable but not verifiable (in court), and therefore cannot be contracted upon.[9] It seems plausible that in many instances, an industry insider can find out which upstream firm supplies a competitor, whereas it tends to be harder to learn about the exact contract terms. However, one might wonder whether secret contracts are still as plausible when downstream firms hold non-controlling ownership stakes of a supplier. In any case, we show in the extension section that one can also obtain our main results when the contract terms are observable, or completely unobservable.

We study symmetric Perfect Bayesian Equilibria in which downstream firms do not revise their beliefs about the offer made to the other downstream firms when receiving an out-of-equilibrium offer (passive beliefs).[10] For what follows, we assume that the profit functions satisfy standard regularity conditions such that the equilibrium is characterized by first order conditions and downstream quantities are strategic substitutes.[11] Denote by $\pi(y, z)$, the resulting equilibrium flow profit $(P(Q) - y)\, q_i$ when it is common knowledge that firm i has marginal costs of y and all the $n - 1$ other downstream firms have marginal costs of z. Assume that the profit decreases when all costs increase uniformly from the same level: $\partial\pi(s, s)/\partial s < 0$, and increases by a finite amount when the competitors' marginal costs increase if there is competition: $\infty > \partial\pi(y, z)/\partial z > 0$. All these assumptions are fulfilled for the linear demand $P(Q) = 1 - Q$.

We study pricing, output decision and innovation incentives absent partial ownership in Section 4. Afterwards, we introduce partial ownership and study how it affects the market outcome in Section 5. In Section 6, we show that ownership arrangements which increase

[9]See Caprice (2006) for a similar setup. Our results are qualitatively the same if the contract acceptance is not observable. See Annex B for details.

[10]See Nocke and Rey (2014) as well as Hart and Tirole (1990); O'Brien and Shaffer (1992); McAfee and Schwartz (1994); Caprice (2006); Rey and Tirole (2007); Arya and Mittendorf (2011) for a similar approach.

[11]It is sufficient that profits are strictly concave in own quantities and the cross derivatives negative: $\partial^2\pi_i/(\partial q_i \partial q_{-i}) < 0$ for $i \neq -i$.

innovation incentives can be profitable for the industry and the involved owners.

In the above setting, supplier U is assumed able to make take-it-or-leave-it offers to the downstream firms. This endows the supplier with all the bargaining power. We show in Section 6 that our results also hold in cases where bargaining power is more balanced.

4 Innovation without partial ownership

4.1 Market prices and quantities

For the case without partial ownership, we first derive the output choices and equilibrium contracts which supplier U charges the downstream firms when the terms of the wholesale contracts remain secret (stages 2 and 3 of the game).

With passive beliefs, upon receiving a contract offer each downstream firm anticipates that its rivals will stick to the anticipated equilibrium quantity Q^*_{-i}. Moreover, the profit which supplier U can obtain from the other downstream firms is unaffected by a change in the marginal price that U charges downstream firm i, as this price is unobserved by the rivals which can thus not condition their output decisions on it. Given the contracts with the other downstream firms, supplier U chooses the tariff for downstream firm i as if U and i were an integrated entity. Supplier U can influence the quantity choice of downstream firm i through w_i and can adjust the fixed fee f_i accordingly, and therefore sets w_i to maximize $(P(q_i + Q^*_{-i}) - c^U)\ q_i$. Downstream firm i exactly maximizes this profit if $w_i = c^U$. This is essentially the marginal cost pricing result obtained for secret contracts and passive beliefs when competition is in quantities, as in Hart and Tirole (1990) and Rey and Vergé (2004).

Lemma 1. *Without partial ownership, supplier U charges tariffs with marginal prices w_i equal to marginal costs c^U.*

Proof. See Annex A. □

Total output equals the output of a Cournot oligopoly with n firms that all have marginal costs of c^U. The flow profit of a downstream firm is thus $\pi(c^U,\ c^U)$. Supplier U extracts the downstream profits through the fixed fees, but it has to leave each downstream firm the profit that this firm could earn when producing inhouse. This deviation profit equals $\pi(c^I,\ c^U)$ because the non-deviating downstream firms all have marginal costs c^U and (as contract acceptance becomes public) are aware when setting quantities in stage 3 that the deviating firm sources inhouse at costs c^I.[12]

Lemma 2. *In equilibrium, all downstream firms accept the wholesale contract $\{w^* = c^U,\ f^* = \pi(c^U,\ c^U) - \pi(c^I,\ c^U)\}$. Supplier U's profit is $\pi^U = n \cdot f^* = n\left[\pi(c^U,\ c^U) - \pi(c^I,\ c^U)\right]$, and a downstream firm's profit is $\pi(c^I,\ c^U)$.*

[12]When contract acceptance is unobservable, the deviation profit still has the features that it decreases in the fringe costs c^I and increases in the cost c^U of supplier U. See Annex B.

As we show in the extensions, our results do not rely on the assumption of secret two-part tariffs. Analogous results can be obtained for observable two-part tariffs and also for the case that the supplier does not sell inputs on a per-unit basis, but can sell to each downstream firm a machine that allows it to produce inputs at marginal costs of c^U instead of c^I. Moreover, most results are also obtained with linear tariffs. What matters for our analysis are two things. First, the profit of the downstream firm consists (at least partly) of the value of its outside option, that is the profit it can obtain when it produces the inputs inhouse while the other downstream firms still source from the efficient supplier U. Second, it is important that the industry profits increase when the marginal costs of the efficient supplier U decrease.

4.2 Innovation incentives

Let us now turn to the innovation incentives in stage 1. We consider innovations that reduce the marginal input costs. Our leading example is knowledge that a downstream firm has gained when using the inputs in its production process. This could be knowledge about how the input can be produced in a more efficient way. Transferring this knowledge to the supplier might involve exploratory discussions and collaborations of the engineers of the customer and its supplier, and the causal success of these might be difficult to measure. Consequently, such knowledge might be rather implicit and difficult to contract upon. Therefore, our main assumption is that the supplier and customer cannot contract upon the innovation. This makes the issue of whether the innovation takes place interesting.

For the moment, we analyze the incentives of one downstream firm, taking as given that the other downstream firms do not induce innovations. We also assume for simplicity that inducing the innovation (for instance through knowledge transfer) is costless for the downstream firm, as is the innovation itself. This generalizes to the case that there is a cost, as long as this is not too large. We generally allow the downstream firm to simultaneously induce innovations at supplier U and inhouse (to exclude this, one could assume sharply increasing incremental costs of inducing innovations). Recall that if downstream firm i decides to transfer knowledge, this results in a decrease of the marginal cost of supplier U from $c^U = \tilde{c}$ to $c^U = \tilde{c} - k$. We assume for now that the supplier can serve all downstream firms equally at the lower costs in case of innovation.[13]

Let us now analyze the incentive of a downstream firm to share information. Recall from Lemma 2 that the profit of a downstream firm is its outside option profit $\pi(c^I, c^U)$. This profit increases in the marginal costs c^U of the competitors in case they all source from U, while this downstream firm produces the input inhouse at costs of c^I. In turn, a decrease of the cost c^U decreases the equilibrium profit of a downstream firm. This yields

Proposition 1. *Without backward ownership, a downstream firm has no incentive to induce an innovation which reduces its supplier's marginal costs c^U. A downstream firm has an incentive to reduce the inhouse production costs c^I.*

[13]We generalize this in Subsection 7.2.

The downstream firm i does not obtain any of the benefits from the sharing of cost reducing technology. Even worse, the downstream firm only gets its outside option profit, which decreases as the marginal prices offered by U to its downstream rivals fall in response to a decrease in the production costs c^U. This yields

Corollary 1. *A downstream firm does not induce innovations that reduce the costs of supplier U if the supplier makes take-it-or-leave-it wholesale tariff offers and there are no ownership links among the firms, even if inducing the innovations is costless.*

Note that these results hold both if the supplier can use the innovation provided by one downstream equally for reducing the costs of supplying that downstream firm and its competitors, or whether the cost reduction for supplying competitors is smaller (partial spillover). See Subsection 7.2 for details.

Rent extraction and inefficient innovations. It is an interesting insight that a downstream firm has incentives to improve its inefficient inhouse production, but no incentives to help improve the efficiency of its supplier. Even worse: The downstream firm has strict incentives to decrease the efficiency of the efficient supplier, whereas it has strict incentives to improve the inhouse supply even if it is certain that this remains the less efficient supply source that will ultimately not be used for production. This means that technology development could just be a means for a downstream firm to extract rents from its supplier by improving the threat point in negotiations, with no effects on industry profits and consumer surplus. The technology sharing incentives of the customer and its supplier are clearly misaligned in the industry.

Consider the case that innovation is costly and the downstream firm has to choose whether to help innovate the production of the efficient supplier or its (in any case) less inefficient inhouse supply (for example, there might be only one busy engineer who knows about the innovation potential and can either implement it here or there). If the innovation costs are not too high, the downstream firm will innovate and reduce the costs of its inhouse supply. This is socially inefficient as it does not reduce the actual production costs.[14] It does though improve the firm's outside option to sourcing from the efficient supplier and by this induces a shift of rents from the supplier to the customer. At the same time, a socially desirable innovation and thus cost reduction in the actual supply chain will not be undertaken. This is a clear inefficiency.

Contracting upon innovations. For reference, assume that the supplier and customer can contract upon the success of the innovation, so that the supplier can commit to compensate the downstream firm for actions that lead to lower upstream production costs.

[14] At least as long as the inhouse production remains less efficient than supplier U. Even if it becomes more efficient, this remains an sub-optimal investment if the alternative would have been to further reduce the costs of the more efficient supplier U.

The joint profit of a downstream firm and supplier U is

$$\pi^U + \pi_i - f_i = n\left[\pi(c^U, c^U) - \pi(c^I, c^U)\right] + \pi(c^I, c^U)$$
$$= n\,\pi(c^U, c^U) - (n-1)\,\pi(c^I, c^U). \qquad (3)$$

As $\pi(c^U, c^U)$ decreases in c^U and $\pi(c^I, c^U)$ increase in c^U, the joint profit clearly increases as c^U decreases. This means that it is profitable for supplier U and the downstream firm to write an enforceable contract which rewards the downstream firm with a transfer $t \geq \pi(c^I, \tilde{c}) - \pi(c^I, \tilde{c} - k)$ for conducting the cost decreasing innovation.

5 Innovation with partial backward ownership

We now analyze how the pricing and the incentives to induce innovations change when there is backward ownership. Each downstream firm $i \in \{1, 2..n\}$ may now have a partial non-controlling ownership share of supplier U, which we denote by $\delta_i \in [0, 1)\ \forall i$. *Partial ownership* refers to an ownership share strictly below one. *Backward* means that a downstream firm holds shares of an upstream firm. *Non-controlling* refers to ownership that does *not* involve control over the target firm's pricing strategy (such as pure financial interests, non-voting shares) and *controlling* refers to one that does. Unless indicated otherwise, in the following analysis ownership is non-controlling, no matter how large the share is.[15]

5.1 Equilibrium prices and quantities

We first show that supplier U charges tariffs with marginal prices equal to marginal costs even with *non-controlling partial backward ownership.* We then characterize the resulting fixed fees and equilibrium profits for the subgame consisting of stages 2 and 3.

The total profit of a downstream firm is the sum of the previous downstream profit and the upstream participation: $\pi_i - f_i + \delta_i \pi^U$. If all downstream firms source from supplier U, the profit of downstream firm i equals

$$\Pi_i = (P(q_i^{BR} + Q_{-i}^*) - (1-\delta_i)w_i)\ q_i^{BR} + \delta_i \sum_{j \neq i}^{n} [(w_j^* - c^U)\ q_j^* + f_j] - (1-\delta_i) f_i,$$

where q_i^{BR} is the optimal quantity set by firm i given its input costs and the anticipated output of the other firms, that is $Q_{-i}^* = \sum_{j \neq i}^{n} q_j^*$. Note that for a positive ownership share δ_i, firm i gets a discount of δ_i not only on the upstream margin $w_i - c^U$, but also on the fixed fee f_i.

[15]This avoids the discussion concerning the level of shareholdings at which control arises, which depends on corporate law, shareholder agreement and the distribution of ownership share holdings in the target firm.

Supplier U offers each downstream firm i a contract $\{w_i,\ f_i\}$ that maximizes its profit

$$\begin{aligned} \pi^U = \quad & (w_i - c^U)\ q_i^{BR} + f_i + \textstyle\sum_{j\neq i}[(w_j - c^U)\ q_j^* + f_j] \\ \text{subject to} \quad & \Pi_j \geq \Pi_j^{\text{inhouse}}\, \forall j. \end{aligned}$$

A downstream firm's anticipated profit when sourcing inhouse is

$$\Pi_i^{\text{inhouse}} = \max_{q_i} \left[\left(p(q_i + Q_{-i}^{*\text{DEV}}) - c^I \ \right) q_i \right] + \delta_i \sum_{j\neq i} [(w_j^* - c^U)\ q_j^{*\text{DEV}} + f_j].$$

This is the outside option profit of a downstream firm when sourcing inhouse at cost c^I. As a breakdown in negotiations is observable, the anticipated quantities set by firm $j \neq i$ are denoted as $q_j^{*\text{DEV}}$. This is the optimal quantity for firm j when the input costs of firm i are c^I and anticipating that everyone else obtains equilibrium prices w_k^* for $k \neq i$. We define $Q_{-i}^{*\text{DEV}} := \sum_{j\neq i} q_j^{*DEV}$.

Given the contracts offered to the other downstream firms, it is still optimal for supplier U to offer a downstream firm a contract with a marginal price equal to its marginal costs c^U. As a result, partial backward ownership does not affect the equilibrium quantities of the subgame starting in stage 2. This implies that partial ownership δ_i affects the downstream profit only through the fixed fee.

Lemma 3. *For any structure of non-controlling backward ownership shares $\delta_i \in [0, 1)$, supplier U offers tariffs with marginal prices equal to marginal costs, $w_i = c^U$, and serves all downstream firms. The fixed fees are given by $f_i = \left[\pi(c^U, c^U) - \pi(c^I, c^U)\right]/(1 - \delta_i)$, and the downstream profit is given by*

$$\pi_i - f_i = \pi(c^I, c^U) \left[1 - \delta_i \sum_{j\neq i} \frac{1}{1-\delta_j} \right] + \pi(c^U, c^U) \left[\delta_i \sum_{j\neq i} \frac{1}{1-\delta_j} \right]. \tag{4}$$

Proof. See Annex A. □

5.2 Innovation incentives

We now study how partial ownership affects the innovation incentives. For $\delta_i > 0$, the equilibrium downstream profit is a weighted sum of the flow profit in case of a deviation, $\pi(c^I, c^U)$, and the actual flow profit on the equilibrium path, $\pi(c^U, c^U)$ – see equation (4). Recall that when c^U decreases, the deviation profit $\pi(c^I, c^U)$ decreases, but the actual flow profit $\pi(c^U, c^U)$ increases. As δ_i increases, the weight of the deviation profit $\pi(c^I, c^U)$ in a downstream firm's profit decreases, and that of the actual flow profit $\pi(c^U, c^U)$ increases. Downstream firm i benefits more, or at least suffers less, from a decrease in c^U as its backward ownership share δ_i increases.

Proposition 2. *For a sufficiently high partial ownership share δ_i, downstream firm i benefits from a decrease in the costs c^U of supplier U and thus has incentives to induce an innovation, at least if this is costless.*

Proof. The profit of a downstream firm is given by (4) and increases when the marginal costs of supplier U, c^U, decrease if the weight attached to the deviation profit $\pi(c^I, c^U)$ is sufficiently low. The weight is given by $1 - \delta_i \sum_{j \neq i} \frac{1}{1-\delta_j}$ and is, other things equal, highest for $n = 2$ and $\delta_j = 0$ with $j \neq i$. In this case the weight is $[1 - \delta_i]$. This yields

$$\Pi_i = \pi_i - f_i = \pi(c^I, c^U)\,[1 - \delta_i] + \pi(c^U, c^U)\,[\delta_i]\,.$$

As the derivative $\partial\pi(c^I, c^U)/\partial c^U$ is bounded away from ∞ and $\partial\pi(c^U, c^U)/\partial c^U < 0$, there exists a $\delta_i \in [0, 1)$ such that the marginal profit $\partial\Pi_i/\partial c^U$ is negative at this share and all larger shares. For a discrete change of c^U from $\tilde{c}$ to $\tilde{c} - k$, there, thus, exists a sufficiently large ownership share δ_i such that inducing such a decrease in the costs c^U is profitable for downstream firm i. □

Proposition 2 shows that it is possible to provide one downstream firm with the incentives to reduce the costs of supplier U by means of an appropriately sized partial ownership share. However, it might be that potentially all downstream firms could induce such innovations. For instance, each downstream firm could, with certainty or some probability, induce a different innovation, such that cost reductions add up. One could also imagine that there is complementarity across downstream firms such that each firm needs to have incentives to cooperate in order to achieve an upstream innovation.[16] In this case it is desirable to align the incentives of all downstream firms. The next proposition shows that this is feasible.

Proposition 3. *Suppose that each downstream firm has a symmetric non-controlling backward ownership share of* $1/n$. *A downstream firm's equilibrium profit is* $\pi(c^U, c^U)$ *and each downstream firm is willing to induce innovations that reduce the costs* c^U *of supplier* U*, while no downstream firm has an incentive to reduce the inhouse production costs* c^I.

Proof. Suppose that all downstream firms have the same ownership share δ. The profit of a downstream firm stated in (4) reduces to

$$\pi_i - f_i = \pi(c^I, c^U)\left[1 - (n-1)\frac{\delta}{1-\delta}\right] + \pi(c^U, c^U)\left[(n-1)\frac{\delta}{1-\delta}\right].$$

If the term in the first bracket is zero, only the second summand remains. This is the case for

$$1 - (n-1)\frac{\delta}{1-\delta} = 0 \implies \delta = \frac{1}{n}.$$

In this case, the profit of a downstream firm reduces to $\pi(c^U, c^U)$ and clearly increases as c^U decreases, and is unaffected by c^I. □

[16] Instead, if the downstream firms have perfectly substitutable knowledge (or similar inputs for upstream innovation), it might be sufficient to incentivize one downstream in order to achieve an improvement of supplier U. However, this leaves potentially inefficient investments in inferior supply sources, which alter the outside options and thus terms of trade.

The intuition behind this result is that by acquiring a large enough partial ownership in the supplier, the downstream firm becomes the residual claimant of a proportion of the industry profit. This aligns the incentives of the downstream firms with those of supplier U and thus induces cost reducing technology transfer to the efficient supplier U, and prevents inefficient investment in less efficient supply sources. It is remarkable that the situation where each of n downstream firms has a share of $1/n$, the downstream firms jointly own supplier U, similar to a joint venture.[17] Note that a share of $1/n$ perfectly aligns the incentives with respect to industry profits. Still, according to Proposition 2, a smaller share can already be sufficient for downstream profits to increase if supplier U becomes more efficient.

6 Profitability of ownership acquisitions

Let us investigate whether non-controlling backward ownership arrangements are profitable, first for the industry as a whole, and then for the owners of two firms which create a backward ownership link.

The total industry profit is given by $n \cdot \pi(c^U, c^U)$. The flow profit of a downstream firm (before subtracting the fixed fee) is $\pi(c^U, c^U)$. It is plausible (and we have assumed) that this profit increases if the costs of all downstream firms (that is c^U) decrease by the same amount. For instance, this is the case with linear demand.

Non-controlling backward ownership only affects the industry profit by increasing the incentives of the downstream firms to help decrease the costs c^U of the efficient upstream supplier U.[18] In situations where the downstream firms can potentially help decrease the cost, it is therefore profitable for the industry to have backward ownership. If the owners of all the firms in the industry (or at least those of U and all downstream firms) can efficiently arrange ownership links (as with Coasian bargaining), one should expect to backward ownership in the industry.

If efficient bargaining (and possibly contracting) between all industry players is not possible, it is interesting to study whether backward ownership arrangements also arise if only decentral ownership trade is feasible. Let us study the case that there are initially no ownership links between firms in the industry and that each firm is owned by a separate outside investor. Consider that the owners of supplier U and downstream firm i negotiate bilaterally about a sale of a profit participation $\delta > 0$ of U to firm i in return for a lump sum transfer to the initial owner of U. This is a profitable trade if the joint profit of U and i is higher in case of this backward ownership arrangement. Their joint profit is

$$\pi\left(c^U, c^U\right) + (n-1)\left[\pi\left(c^U, c^U\right) - \pi\left(c^I, c^U\right)\right]. \tag{5}$$

Note that this profit is not a function of δ as this is just a redistribution of shares from the

[17] We abstract here from the question of corporate control of U, which is not central to our main arguments but of course immediate the n downstream together have all profit rights of U (of course, an outside investor with no or hardly any profit rights may still hold a golden share or have other rights of control).

[18] When downstream firms compete in price, backward ownership can further increase profits by increasing the downstream prices, see Subsection 7.6.

initial owner of U to firm i. The first part is the profit obtained from sales of firm i and the second part is the profit which supplier U obtains of the other $n-1$ downstream firms (the flow profit minus the alternative sourcing profit). The flow profit $\pi\left(c^U, c^U\right)$ increases as c^U decreases and also $\pi\left(c^I, c^U\right)$ decreases as c^U decreases. This implies that the total profit of firms U and i increases as c^U decreases. When c^U decreases, this profit increases even more than the total industry profit because supplier U benefits from decreasing the outside option profits $\pi\left(c^I, c^U\right)$ of the other $n-1$ downstream firms (a redistribution effect).

Lemma 4. *Both the total industry as well as the pair of one downstream firm and the efficient supplier benefit from non-controlling backward ownership arrangements which align the incentives of downstream firms with respect to efficiency increases of their supplier.*

Recall that the bilateral profit in (5) is the same as in the reference case in Section 4 where we discussed the difficulties of contracting on actions that foster innovations (equation (3)). In this perspective, backward ownership is an alternative way to write a contract that changes the cooperation incentives of a downstream firm. This is valuable when directly contracting upon certain cooperative actions and their success is practically impossible.

7 Further analyses

7.1 Bargaining over wholesale tariffs

We have so far assumed that supplier U can make take-it-or-leave-it offers. This implies that U has the bargaining power to extract the industry profit, except for the downstream firms' outside options. In this subsection, we relax this assumption and look at the case when the downstream firms have more bargaining power and ask the question: Can downstream bargaining power induce knowledge sharing of downstream firms similar to partial ownership?

Starting from the case that the downstream firms have no bargaining power, we find that up to a critical level of bargaining power, there is no sharing of technology and we get the result of inefficient vertical innovation incentives as before. For higher levels of downstream bargaining power, the downstream firms have incentives to reduce the costs of the efficient supplier even without vertical ownership.

Suppose each downstream firm has bargaining power of $\beta \in [0,1]$, so that the efficient supplier's bargaining power is $1-\beta$. These power shares determine the split of the additional rents from trading between the parties. We maintain the assumption of secret wholesale contracts. The equilibrium tariffs solve the corresponding Nash bargaining problem

$$\max_{w_i, f_i} (\pi_i(w_i, w^*_{-i}) - f_i - \Pi_i^{inhouse})^{\beta} (\pi^U - \pi^{U,DEV})^{(1-\beta)},$$

where given passive beliefs, upon receiving a contract offer each downstream firm anticipates input costs w^*_{-i} of all other downstream firms. The anticipated upstream profit in case of a breakdown in negotiation is

$$\pi^{U,DEV} = \sum_{j \neq i} [(w_j^* - c^U)\ q_j^{DEV} + f_j^*]$$

and q_j^{DEV} is the quantity ordered by its rivals in case of breakdown in negotiations with firm i. By the same logic as in the case where supplier U makes take-it-or-leave-it offers, we obtain

Lemma 5. *Bilateral bargaining between supplier U and each downstream firm over secret two-part tariffs yields contracts with marginal prices that equal marginal costs of U.*

Proof. See Annex A. □

Again, bargaining in two-part tariffs results in marginal wholesale prices that maximize the additional bilateral surplus of the two negotiating firms. As contracts are secret, the actual marginal wholesale price does not affect the output choices of the other downstream firms. Hence, the upstream and the downstream firm act like an integrated entity when setting wholesale prices and set the marginal wholesale price equal to the supplier's marginal costs – independent of the distribution of bargaining power.

The associated fixed fees are given as

$$f_i^* = (1 - \beta) \left(\pi(c^U, c^U) - \pi(c^I, c^U) \right). \tag{6}$$

One can see that the fixed fee decreases as the bargaining power β of the downstream firm increases. The fixed fees are always weakly positive.

The net downstream profit is a weighted sum of the equilibrium flow profit and the outside option profit:

$$\pi_i - f_i = \beta\ \pi(c^U, c^U) + (1 - \beta)\ \pi(c^I, c^U). \tag{7}$$

If a downstream firm has no bargaining power with respect to the supplier ($\beta = 0$), it obtains the outside option profit which decreases as c^U falls, as in case of take-it-or-leave-it offers by supplier U analyzed before. Instead, when the downstream firm has all the bargaining power ($\beta = 1$), it obtains the full flow profit $\pi(c^U, c^U)$. In the latter case, the downstream firm clearly has an incentive to increase the actual flow profits by inducing cost reducing innovation at supplier U.

As the downstream profit stated in (7) is continuous in β, we can show the existence of a $\beta = \tilde{\beta}$, such that for all $\beta > \tilde{\beta}$, it holds that $\frac{\partial(\pi_i - f_i)}{\partial c^U} > 0$. Hence, a downstream firm has incentives to induce cost reducing innovation upstream for large enough bargaining power. We summarize the result in

Proposition 4. *A downstream firm has incentives to foster upstream innovation if it has sufficient bargaining power.*

It is important to note that the mere fact that a downstream firm has some level of bargaining power ($\beta > 0$) does not ensure that a downstream firm has incentives to foster upstream innovation. The bargaining power needs to be large enough to incentivize the downstream firms. Hence, there is scope for partial backward ownership to align the incentives as long as the insufficient downstream bargaining power.

It is intuitive to see from the expression of the net profit in equation (7) that as the downstream bargaining power β rises the downstream firm cares more about the actual flow profits than its outside option. So, the negative effect from a fall in c^U is lower than the positive effect induced for β large enough. In this case, the downstream firm has incentives to induce cost-reducing innovation.

In general, bargaining power is the ability of an economic agent to obtain rents from a trade. A profit maximizing agent therefore does not easily give up this power.[19] In view of non-contractible supply chain cooperation, such as knowledge sharing, it might though be beneficial for an upstream firm to endow the downstream firms with some bargaining power in order to induce non-contractible supply chain innovations. The question is how a firm can commit to "fair" supply terms in the future. One possibility could be long-term framework agreements, but these may not be renegotiation proof.

Another solution is backward ownership which – similar to downstream bargaining power – can align the incentives of downstream firms. An obvious advantage of ownership shares is that they are structural arrangements, which are in place independent of supply contracts. For example, a customer might disregard a promise of a supplier to "fair" terms of trade as "cheap talk". Instead, ownership shares are contractual rights, which the supplier (or its initial owner) can sell to a downstream firm. As this aligns the incentives with respect to upstream innovation in a credible way, it should also be easier for the (initial owner of the) supplier to cash part of the additional economic value of this arrangement from the downstream firm through the sales price of the ownership stake.

7.2 Limited innovation spillovers to rivals

So far, we have assumed that when a downstream firm induces an innovation at its supplier, this reduces the marginal production costs for all downstream firms equally. Suppose we relax this assumption and assume that if technology is shared, the rivals can only benefit from a proportion $\sigma \in [0, 1)$ of the cost reduction, whereas so far we analyzed the case of $\sigma = 1$. It is straightforward to show that for any σ the wholesale prices (w_i) are equal to marginal costs and the profit of a downstream firm without backward ownership is the outside option value

$$\pi(c^I, \tilde{c} - \sigma k). \tag{8}$$

For $\sigma > 0$, the downstream profit decreases in case of an innovation absent partial ownership. For $\sigma = 0$, the downstream profit, given by (8), does not change and a downstream firm is indifferent between sharing and not sharing the technology with the upstream supplier. We have shown before that even for the case of $\sigma = 1$, a downstream firm's profits decrease the most when it induces an innovation, partial backward ownership can align incentives of the

[19] In terms of Nash bargaining: adjust β to the own disadvantage.

downstream firm with the industry profit and hence induce cooperation (Propositions 2 and 3). Consequently, also for any $\sigma \in [0, 1)$ it is possible to find a level of backward ownership such that technology sharing is induced.

7.3 Monopolistic downstream firms

If the downstream firms do not compete or do not have the same supplier, an improvement in the input costs of the supplier does not harm a downstream firm. If the supplier makes a take-it-or-leave-it offer that sets the downstream firm indifferent to sourcing from its best alternative, the downstream firm's resulting profit is independent from the supplier's costs.

If the downstream firm has some bargaining power, it will obtain part of the gains from trade with the supplier. These gains are higher if the supplier's costs are lower. As a consequence, a downstream firm has incentives to foster efficiency improvements of its supplier. This differs from the case of competing downstream firms with a common supplier, where sufficient bargaining power of the downstream firm is necessary to align its incentives (Proposition 4).

7.4 Public wholesale tariffs

Suppose that the supply contracts are public. In order to maximize the industry profit, an unconstrained monopolist offers observable two-part tariffs to competing downstream firms with marginal prices above marginal costs. Interestingly, when competing against a competitive fringe, it can be optimal for the constrained monopolist to charge marginal wholesale prices below the alternative sourcing costs c^I, even if this leads to total output above the industry profit maximizing level. The intuition is that the upstream firm reduces wholesale prices to reduce the outside option of the competing downstream firms in order to extract more profits through the fixed fees.

We assume that marginal prices cannot be below marginal costs ($w_i \geq c^U$) and show that there exists a level of alternative sourcing costs c^I below which the corner solution of setting the marginal price w_i equal to c^U is optimal for the efficient supplier U, both without and with partial backward ownership. This implies that one can obtain the same results on innovation incentives and partial backward ownership with observable wholesale tariffs. To show that the main results can also be obtained with public contracts, we only analyze the case where marginal cost pricing results in this extension. We conjecture that one can obtain similar results also for the case where prices are above marginal costs. For the main results to hold, are positive relationship between marginal costs and the resulting sales prices is important. It is not necessary that the prices are equal to marginal costs.

No partial ownership. If all downstream firms source from supplier U, the downstream firm sets quantities that solve the first order conditions

$$\frac{\partial \pi_i}{\partial q_i} = P'(Q)\ q_i + P(Q) - w_i = 0,\ i \in \{1...n\}.$$

The solution to the n first order conditions gives us equilibrium quantities and profits for given marginal input prices which we denote by $q_i^*(w_i, \boldsymbol{w_{-i}})$, $Q^*(w_i, \boldsymbol{w_{-i}})$ and $\pi^*(w_i, \boldsymbol{w_{-i}})$, where $\boldsymbol{w_{-i}}$ is the vector of the wholesale prices charged to the firms other than i. As the contracts are public, unlike before, the equilibrium quantities and profits of each firm i depend directly on all the actual marginal wholesale prices set by supplier U. The outside option profit of firm i is $\pi_i^*(c^I, \boldsymbol{w_{-i}})$. The fixed fees are $f_i = \pi^*(w_i, \boldsymbol{w_{-i}}) - \pi_i^*(w_i = c^I, \boldsymbol{w_{-i}})$.

The supplier solves

$$\max_{w_i,\ \boldsymbol{w_{-i}}} \pi^U = (P(Q^*) - c^U)\ Q^*(w_i, \boldsymbol{w_{-i}}) - \sum_{i=1}^{n} \pi_i^*(w_i = c^I, \boldsymbol{w_{-i}})$$

subject to $w_i \geq c^U\ \forall i$. The following lemma characterizes the parameter range in which marginal cost pricing occurs also with public contracts.

Lemma 6. *There exists a cost level $c^I = \hat{c}$, such that for all $c^I < \hat{c}$, the supplier sets wholesale prices equal to marginal costs. The contracts then are the same as in the case of secret contracts. Hence, the downstream firm has no incentive to induce an innovation which reduces the marginal costs of the efficient supplier U.*

Proof. See Annex A. □

The intuition is as with secret contracts. A reduction in costs of the supplier reduces the rival's input prices and thus worsens the outside option of a downstream firm.

Partial ownership.

We now show that partial ownership aligns incentives of the downstream firms with industry surplus also in case of public wholesale contracts. For expositional purposes, let us assume that there are two firms ($n = 2$) which both have partial ownership $\delta_i = \delta$ of the supplier. Consequently, the profit of firm i is

$$(P(q_1 + q_2) - w_i)\ q_i + \delta \sum_{j=1}^{2} [(w_j - c^U)\ q_j + f_j] - f_i\ \forall i \in 1, 2.$$

Let us denote the equilibrium quantities as $(q_1^*,\ q_2^*)$ and the total quantity in the market as $Q^* = q_1^* + q_2^*$.

The outside option of firm i is to source inhouse, which yields a profit of

$$\Pi_i^{inhouse} = (P(q_i + q_j) - c^I)\ q_i + \delta[(w_j - c^U)\ q_j] + \delta\ f_j.$$

Moving on to the contracting stage, the supplier sets $(w_i,\ f_i)$ for $i \in 1, 2$. The supplier's problem is to

$$\max_{(w_1,\ f_1),(w_2,\ f_2)} \pi^U = [(w_1 - c^U)\ q_1^* + (w_2 - c^U)\ q_2^* + f_1 + f_2]$$
$$\textit{subject to} \qquad \pi_i - f_i \geq \pi_i(c^I, w_j)\ \forall\ i \in 1, 2.$$

The fixed fees are set such that the participation constraint of the downstream firms are binding, which yields $f_i = \frac{\pi_i - \pi_i^{inhouse}(c^I, w_j)}{1-\delta}$ $\forall i$.[20] The supplier's maximization problem becomes

$$\max_{w_1,w_2} \pi^U = \frac{\left(P(Q^*) - c^U\right) Q^* + \delta \sum_{i=1}^{2} (w_i - c^U)\ q_i^* - \sum_{i=1}^{2} \pi_i^{inhouse}}{1-\delta}.$$

The following proposition characterizes the parameter space when the supplier uses marginal cost pricing in wholesale pricing strategy.

Proposition 5. *For $c^I < \hat{c}$, the supplier sets wholesale prices equal to marginal costs. For sufficiently large partial ownership shares, the downstream firm's equilibrium profit is $\pi(c^U, c^U)$ and each downstream firm is willing to induce innovations that reduce the costs c^U of supplier U. In this case, no downstream firm has an incentive to reduce the inhouse production costs c^I.*

Proof. See Annex A. □

For $c^I < \hat{c}$, the supplier charges marginal prices equal to its marginal cost. Under this parameter restriction, the results are as in the case with secret contracts. Similar to the proof of Proposition 3, one can show that for $\delta = \frac{1}{2}$, the downstream profits and industry profits are aligned. Downstream firms are the residual claimants of a proportion of the industry profit and hence would like to reduce the costs of the incumbent supplier U. For larger alternative sourcing costs, we do not provide a formal proof at this point, but we conjecture that one can obtain similar results.

7.5 Linear upstream prices and partial ownership

So far, we have considered that supplier U offers two-part tariffs. Let us now look at the case of linear tariffs, which means $f_i = 0$. For simplicity, suppose that the marginal wholesale prices are observable. As the linear wholesale prices w_i are the only source of income for supplier U, it clearly has an incentive to raise them above its marginal costs c^U. Absent partial backward ownership and if the inhouse supply is sufficiently attractive, which means that the cost difference $c^I - c^U$ is not too large, it is optimal for U to charge $w_i = c^I$. With input costs of c^I when sourcing from U, the profit of a downstream firm does not depend on whether it sources from U or produces the inputs inhouse. As a consequence, the equilibrium profit equals the outside option profit $\pi(c^I, c^I)$. As with two part tariffs, the profit of a downstream firm does not increase as its supplier's costs (c^U) decrease.[21] This means that there is no incentive for the downstream firm to invest in the supply relationship in a way that reduces the input costs of supplier U. There is, however, again an incentive to reduce the inhouse production costs c^I if a lower input cost level for all downstream firms leads to higher profits.

[20] Note here that in the term $\pi_i - \pi_i^{inhouse}(c^I, w_j)$, the fixed fees f_j cancel out.

[21] At least as long as the change is not so large that the supplier becomes an unconstrained monopolist.

With partial ownership of firm i, its downstream profit when all firms source from U is given by

$$(P(q_i + Q_{-i}) - w_i)q_i + \delta_i \sum_{j=1}^{n}(w_j - c^U)q_j.$$

Its marginal profit is

$$P'\,q_i + (P - w_i) + \delta_i(w_i - c^U).$$

Firm i receives a per unit discount of $(w_i - c^U)$ on each unit bought. As a consequence, supplier U can raise w_i until the effective input price is again c^I. If the inhouse supply is sufficiently attractive, which means that the cost difference $c^I - c^U$ is not too large, it is optimal for U to charge $w_i = \frac{c^I - c^U\delta_i}{1-\delta_i}\ \forall i$.[22] An increase of the linear wholesale price in the backward ownership share has also been shown by, for instance, Flath (1989); Greenlee and Raskovich (2006); Hunold and Stahl (2016). This result is consistent with empirical evidence. Gans and Wolak (2013) study passive backward integration of a large Australian electricity retailer into a baseload electricity generation plant and report a significant increase in the wholesale price.[23]

Note that the input prices for other firms do not affect the marginal profit of firm i. The resulting downstream quantities are thus the same as without partial ownership. The resulting equilibrium downstream profit of firm i is

$$\pi(c^I, c^I) + \delta_i \sum_{j\neq i} \frac{c^I - c^U}{1-\delta_j}\ q_j. \tag{9}$$

In equilibrium, the per firm output equals $1/n$ times the total Cournot output when all downstream firms have effective input costs of c^I.

With partial ownership, the profit of a downstream firm as stated in (9) increases as the supplier's costs (c^U) decrease. A downstream firm thus has incentives to reduce the supplier's costs when $\delta_i > 0$ and $n > 1$. This would not be the case if there were no other downstream firms as long as supplier U charges an input price of c^I, similar to the case of non-linear tariffs (although in this case a sufficiently higher partial backward ownership share is necessary for incentives to reduce c^U).

7.6 Downstream competition in prices and partial ownership

One can also obtain the general result that a downstream firm may have no incentive to invest in improving the efficiency of its supplier when there is price competition downstream. As we will see, backward ownership has an additional effect of relaxing competition downstream. To keep the exposition simple, we focus on linear tariffs.[24] This case is more general than

[22] This follows from $c^I = w_i - \delta_i(w_i - c^U)$.

[23] Gans and Wolak build their theory using a model of fixed-price forward contracting. Nevertheless, their empirical finding of a price increase is also consistent with our theory.

[24] Determining the equilibrium with unobservable two-part tariffs is involved. See Rey and Vergé (2004) who find that passive beliefs are often not a plausible equilibrium concept in case of price competition downstream.

it may seem at first sight. Non-exclusive observable two-part tariffs can lead to tariffs with effective marginal prices equal to the cost of the alternative supply source if this source is sufficiently attractive, even with backward ownership (see Proposition 5 and Lemma 4 in Hunold and Stahl (2016)).

Assume that the demand of a downstream firm is now given by q_i, with q_i decreasing in the own price p_i and increasing in the competitors' prices p_j, $j \neq i$. Assume further that price competition is imperfect such that we obtain smooth best response functions and interior optima with prices above marginal costs. The profit of a downstream firm which has an ownership share δ_i of the efficient supplier U and sources all of its inputs from U is given by

$$\underbrace{(p_i - w_i) \cdot q_i}_{\text{operational profit}} + \underbrace{\delta_i \left(\sum_{j=1}^{n} (w_j - c^U) q_j \right)}_{\text{upstream profit share}}. \tag{10}$$

Differentiating this profit with respect to p_i yields the first order condition

$$q_i + (p_i - w_i) \frac{\partial q_i}{\partial p_i} + \delta_i \left(w_i - c^U \right) \frac{\partial q_i}{\partial p_i} + \delta_i \underbrace{\sum_{j \neq i} (w_j - c^U) \frac{\partial q_j}{\partial p_i}}_{\text{additional effect}} = 0. \tag{11}$$

Supplier U still has an incentive to charge the highest possible price of $w_i = \frac{c^I - c^U \delta_i}{1 - \delta_i}$ $\forall i$ under the assumption of effective upstream competition ($c^I - c^U$ not too large), as in the case of quantity competition and linear tariffs considered before. Condition (11) thus becomes

$$q_i + \left(p_i - c^I \right) \frac{\partial q_i}{\partial p_i} + \delta_i \sum_{j \neq i} \left(\frac{c^I - c^U}{1 - \delta_j} \right) \frac{\partial q_j}{\partial p_i}, \tag{12}$$

and the downstream profit of firm i is given by

$$\left(p_i - c^I \right) q_i + \delta_i \sum_{j \neq i} \left(\frac{c^I - c^U}{1 - \delta_j} \right) q_j.$$

Also with downstream quantity competition, the profit of downstream firm i is only affected by the supplier's actual costs c^U if firm i has partial ownership ($\delta_i > 0$) and the supplier serves other downstream firms. In this case, the downstream firm has incentives to reduce the supplier's costs.

With price competition there is the *additional effect* that the marginal profit increases with partial ownership as $\partial q_j / \partial p_i > 0$ for $i \neq j$, which typically leads to higher final prices in the industry (see Hunold and Stahl, 2016 for a complete analysis).

8 Conclusion

We have studied the incentives of competing downstream firms to foster supply chain innovations that increase their supplier's efficiency. Our leading example is knowledge about how the supplier could produce the inputs more efficiently, which a downstream firm has gained when using the inputs. Knowledge sharing might involve exploratory discussions and collaborations of the engineers of the downstream firm and its supplier. Such knowledge sharing might be rather implicit, and its success might be difficult to measure. We have therefore focused on the case that firms cannot contract upon these actions and outcomes.

We have illustrated that a downstream firm may have no incentive to induce an innovation that reduces its supplier's marginal costs if the supplier makes take-it-or-leave-it wholesale tariff offers. Even worse, a downstream firm can have strong incentives to decrease the efficiency of its supplier's input production. At the same time, a downstream firm has incentives to improve its inefficient inhouse production. These incentives can induce costly and inefficient investments.

The distorted incentives arise because when the efficient supplier makes a competitive contract offer, the downstream firm earns a profit that equals its outside option of sourcing inputs from the less efficient source while its competitors source from the efficient supplier. The value of sourcing alternatively becomes less attractive when the efficient supplier's costs decrease, as the marginal sourcing costs of the downstream competitors decrease in response to that.

Non-controlling backward ownership shares, which the downstream firms hold of their common supplier, can solve this problem and induce efficient innovation incentives. With a sufficiently high ownership share, a downstream firm benefits from a decrease in the costs of its supplier and thus has incentives to foster such innovations. Moreover, if each of n symmetric downstream firms has non-controlling backward ownership share of $1/n$, all downstream firms have incentives to foster innovations that reduce the costs of their common supplier. In addition, no downstream firm has an incentive to invest inefficiently in an inferior alternative input production technology.

In summary, the argument that non-controlling backward ownership induces efficient supply chain innovations applies to markets with the following characteristics. First, the downstream firms are potentially capable of supporting the supplier in improving its efficiency, for instance using the inputs they gain knowledge about how produce the inputs better. Second, it is difficult to write complete contracts which in return for fostering upstream innovation appropriately to compensate a downstream firm (also for negative competitive externalities). Third, downstream firms have limited bargaining power beyond threatening the primary supplier to obtain their inputs from less efficient sources. Finally, competing downstream firms source from the same supplier. Downstream competition is only necessary for the result that the downstream firms have strict incentives to decrease the efficiency of their own supplier absent backward ownership.

Managers as well as competition authorities can benefit from a more thorough understanding of the incentives to foster supply chain innovations and the role of non-controlling backward ownership in this respect. For managers, it is important to recognize that industrial customers may have no incentives to help improving their supplier's efficiency, but may instead have incentives to worsen it. At the same time, industrial customers may have strong incentives to invest inefficiently even in inferior alternative sourcing options. This may also include sharing trade secrets of their supplier with its (potential) upstream competitors. For such situations, a management implication is to consider equity transactions that endow the downstream firms with financial interests in their suppliers. This can align the supply chain incentives and by this foster supply chain cooperations and boost efficiency, industry profits and social welfare. It should thus in principle be possible to find a fair price for such an equity transaction and, if necessary, convince competition authorities of its social benefits.

The effects of non-controlling backward ownership may also be achieved with influential forward ownership. An ownership link which enables the supplier to influence the downstream firm in order to increase the upstream profit can have the same effect as an arrangement where the downstream firm directly obtains a profit share of the supplier. Influential forward ownership can thus be equivalent to non-controlling backward ownership. A forward ownership acquisition can therefore be an alternative instrument for a downstream firm to align the downstream incentives. An advantage of a forward acquisition may be that is not necessary to convince the downstream firm to purchase shares of the supplier in the first place. See Hunold and Schlütter (2018) for a further discussion.

Assessing the pro- and anti-competitive effects of ownership acquisitions is also important for merger control. While there are jurisdictions that already control minority acquisitions, it is not yet the case at the European level.[25] Whether to include minority acquisitions in the merger control of the European Commission is an ongoing discussion.[26] Both for assessing the relevance of controlling partial vertical ownership and for assessing individual cases, it is important to better understand its effects. The present article complements the growing literature on the (anti-)competitive effects of vertical partial ownership by characterizing situations in which non-controlling backward ownership can have important pro-competitive effects by fostering supply chain innovations through knowledge spillovers and other forms of vertical collaborations.

[25] See Annex II "Non-controlling minority shareholdings and EU merger control" of the European Commission Staff Working Document "Towards more effective EU merger control" of 2013 (http://ec.europa.eu/competition/consultations/2013_merger_control/consultation_annex2_en.pdf, last access August 2017).

[26] See the "European Commission Staff Working Document: Towards more effective EU merger control" of 2013 (http://ec.europa.eu/competition/consultations/2013_merger_control/merger_control_en.pdf, last access August 2017).

References

Allen, J.W. and G.M. Phillips, "Corporate equity ownership, strategic alliances, and product market relationships," *The Journal of Finance*, 2000, *55* (6), 2791–2815.

Arya, A. and B. Mittendorf, "Disclosure standards for vertical contracts," *The RAND Journal of Economics*, 2011, *42* (3), 595–617.

Baumol, W.J. and J.A. Ordover, "On the perils of vertical control by a partial owner of a downstream enterprise," *Revue d'Économie Industrielle*, 1994, *69* (1), 7–20.

Bonnet, C. and P. Dubois, "Inference on vertical contracts between manufacturers and retailers allowing for nonlinear pricing and resale price maintenance," *The RAND Journal of Economics*, 2010, *41* (1), 139–164.

Bönte, W. and L. Wiethaus, "Knowledge disclosure and transmission in buyer–supplier relationships," *Review of Industrial Organization*, 2007, *31* (4), 275–288.

_ **and M. Keilbach**, "Concubinage or marriage? Informal and formal cooperations for innovation," *International Journal of Industrial Organization*, April 2005, *23* (3-4), 279–302.

Caprice, S., "Multilateral vertical contracting with an alternative supply: the welfare effects of a ban on price discrimination," *Review of Industrial Organization*, 2006, *28* (1), 63–80.

Chen, Y., "On vertical mergers and their competitive effects," *The RAND Journal of Economics*, 2001, *32* (4), 667–685.

Choi, J. P., A. Ghosh, S. Niu, and H. Morita, "Vertical learning alliances and partial equity ownership in the presence of performance spillovers," Technical Report, mimeo 2014.

Dasgupta, S. and Z. Tao, "Bargaining, bonding, and partial ownership," *International Economic Review*, 2000, *41* (3), 609–635.

Dyer, J. H. and N. W. Hatch, "Using supplier networks to learn faster," *MIT Sloan Management Review*, 2004, *45* (3), 57.

Fiocco, R., "The strategic value of partial vertical integration," *European Economic Review*, 2016, *89*, 284–302.

Flath, D., "Vertical integration by means of shareholding interlocks," *International Journal of Industrial Organization*, 1989, *7* (3), 369–380.

Gans, Joshua S and Frank Wolak, "A comparison of ex ante versus ex post vertical market power: evidence from the electricity supply industry," *Working paper available at SSRN 1288245*, 2013.

Ghosh, A. and H. Morita, "Knowledge transfer and partial equity ownership," *The RAND Journal of Economics*, 2017, *48* (4), 1044–1067.

Gilo, D., N. Levy, and Y. Spiegel, "Partial Vertical Integration, Ownership Structure and Foreclosure," 2016.

Greenlee, P. and A. Raskovich, "Partial vertical ownership," *European Economic Review*, 2006, *50* (4), 1017–1041.

Hart, O. and J. Tirole, "Vertical integration and market foreclosure," *Brookings Papers on Economic Activity. Microeconomics*, 1990, pp. 205–286.

Hartley, J. L., "Collaborative value analysis: Experiences from the automotive industry," *Journal of Supply Chain Management*, 2000, *36* (3), 27–32.

Hughes, J. S. and J. L. Kao, "Vertical integration and proprietary information transfers," *Journal of Economics & Management Strategy*, 2001, *10* (2), 277–299.

Hunold, M., "Backward ownership, uniform pricing and entry deterrence," *DICE Discussion Paper No. 250*, 2017.

_ **and F. Schlütter**, "Vertical financial interest and control," *mimeo*, 2018.

_ **and K. Stahl**, "Passive vertical integration and strategic delegation," *The RAND Journal of Economics*, 2016, *47* (4), 891–913.

Kotabe, M., X. Martin, and H. Domoto, "Gaining from vertical partnerships: knowledge transfer, relationship duration, and supplier performance improvement in the US and Japanese automotive industries," *Strategic Management Journal*, 2003, *24* (4), 293–316.

Kwon, I.-W. G. and T. Suh, "Factors affecting the level of trust and commitment in supply chain relationships," *Journal of Supply Chain Management*, 2004, *40* (1), 4–14.

Lee, H. L., V. Padmanabhan, and S. Whang, "Information distortion in a supply chain: The bullwhip effect," *Management Science*, 1997, *43* (4), 546–558.

Mathews, Richmond D, "Strategic alliances, equity stakes, and entry deterrence," *Journal of Financial Economics*, 2006, *80* (1), 35–79.

McAfee, R. P. and M. Schwartz, "Opportunism in multilateral vertical contracting: Nondiscrimination, exclusivity, and uniformity," *The American Economic Review*, 1994, pp. 210–230.

Nocke, V. and P. Rey, "Exclusive Dealing and Vertical Integration in Interlocking Relationships," 2014.

O'Brien, D. P. and G. Shaffer, "Vertical control with bilateral contracts," *The RAND Journal of Economics*, 1992, pp. 299–308.

Rey, P. and J. Tirole, “A primer on foreclosure,” *Handbook of Industrial Organization*, 2007, *3*, 2145–2220.

_ **and T. Vergé**, “Bilateral control with vertical contracts,” *RAND Journal of Economics*, 2004, pp. 728–746.

Sandonis, J. and R. Fauli-Oller, “On the competitive effects of vertical integration by a research laboratory,” *International Journal of Industrial Organization*, 2006, *24* (4), 715–731.

Spiegel, Y., “Backward integration, forward integration, and vertical foreclosure,” 2013.

Villas-Boas, S. B., “Vertical relationships between manufacturers and retailers: Inference with limited data,” *The Review of Economic Studies*, 2007, *74* (2), 625–652.

Wiethaus, L., “Absorptive capacity and connectedness: Why competing firms also adopt identical R&D approaches,” *International Journal of Industrial Organization*, 2005, *23* (5), 467–481.

Annex A: Proofs

Proof of Lemma 1. It is common knowledge that there is no vertical ownership. Let us first suppose that each firm believes that the equilibrium contracts given to all firms $j \in \{1, 2..n\}$ are (w_j^*, f_j^*). Let us then denote the quantities demanded by each firm j under these contracts as q_j^* where $\boldsymbol{w_{-j}^*}$ is the vector of the wholesale prices charged to the firms other than j. With passive beliefs, for any contract received by firm i, it expects that all the other firms $j \neq i \in \{1...n\}$ choose the quantity q_j^*. This is due to the assumption that firm j cannot observe changes in contracts offered to firm i. Essentially, this means a firm's conjecture on the contracts offered to its rivals does not change when being offered an off-equilibrium contract. Hence, as a result, firm i chooses the quantity q_i^{BR} that solves the FOC

$$P'(q_i + Q_{-i}^*)q_i + P(q_i + Q_{-i}^*) - w_i = 0, \tag{13}$$

where Q_{-i}^* is the sum of expected quantity of the other downstream firms when they believe the equilibrium contracts (w_j^*, f_j^*) for $j \neq i \in \{1..n\}$ are offered. The profit of firm i is given as

$$(P(q_i^{BR} + Q_{-i}^*) - w_i)q_i^{BR} - f_i$$

If i rejects the contract offer, its profit is given as

$$\Pi_i^{\text{inhouse}} = \max_{q_i} \left(p(q_i + Q_{-i}^{*\text{DEV}}) - c^I \right) \ q_i.$$

where $Q_{-i}^{*\text{DEV}}$are quantities demanded by the rival firms when the set of wholesale prices are $(w_i^* = c^I, \boldsymbol{w_{-i}^*})$. This is because of our assumption that a breakdown in negotiations is observable after the contracting stage. Supplier U sets the fixed fee for a given marginal price such that a downstream firm's profit equals its outside option. This implies

$$f_i = (P(q_i^{BR} + Q_{-i}^*) - w_i) \ q_i^{BR} - \Pi_i^{\text{inhouse}}.$$

The supplier's profits are then given as

$$\begin{aligned} \pi^U = \ & (w_i - c^U) \ q_i^{BR} + (P(q_i^{BR} + Q_{-i}^*) - w_i) \ q_i^{BR} \\ & -\Pi_i^{\text{inhouse}} + \textstyle\sum_{j\neq i}[(w_j^* - c^U) \ q_j^* + f_j]. \end{aligned}$$

Differentiating with respect to w_i yields the FOC

$$\frac{\partial q_i^{BR}}{\partial w_i} \ \left[P'(q_i^{BR} + Q_{-i}^*) \ q_i^{BR} + P(q_i^{BR} + Q_{-i}^*) - c^U \right] = 0.$$

Using the FOC (13) of downstream firm i yields

$$(w_i - c^U) \ \frac{\partial q_i^{BR}}{\partial w_i} = 0.$$

The above equation utilizes the envelope theorem when differentiating with respect to w_i. This implies $w_i^* = c^U$. By symmetry, supplier U offers contracts to all downstream firms in which the marginal price w_i equals its marginal costs c^U. □

Proof of Lemma 3. It is common knowledge when prices are determined that each firm holds a non-controlling share $\delta_i \in [0, 1)$ of the upstream firm U. Apart from this, the setting is the same as without vertical ownership. We therefore build on the proof of lemma 1 and focus on differences to the previous case. As we can maintain the assumption of passive beliefs, for any contract received by firm i, it expects that all the other firms $j \neq i \in \{1...n\}$ choose the quantity q_j^*. In turn, firm i chooses the best-response quantity q_i^{BR} which now solves the expression

$$P'(q_i + Q_{-i}^*)\ q_i + P(q_i + Q_{-i}^*) - w_i + \delta_i(w_i - c^U) = 0. \tag{14}$$

A downstream firm takes into account that it obtains a "rebate" δ_i on the upstream margin of U. The profit of firm i when accepting $U's$ contract is given as

$$(P(q_i^{BR} + Q_{-i}^*) - w_i)\ q_i^{BR} + \delta_i \sum_{j=1}^{n} [(w_j^* - c^U)q_j^* + f_j] - f_i.$$

If i rejects the contract offer, its profit is given as

$$\Pi_i^{\text{inhouse}} = \max_{q_i} \left[\left(p(q_i + Q_{-i}^{*\text{DEV}}) - c^I \right)\ q_i \right] + \delta_i \sum_{j \neq i} [(w_j^* - c^U)\ q_j^{*\text{DEV}} + f_j].$$

Supplier U sets the fixed fee for a given marginal price such that a downstream firm's profit equals its outside option. This yields

$$f_i = \frac{(P(q_i^{BR} + Q_{-i}^*) - w_i)q_i^{BR} + \delta_i(w_i - c^U)q_i^{BR} + \delta_i \sum_{j \neq i}[(w_j^* - c^U)q_j^* + f_j] - \Pi_i^{\text{inhouse}}}{1 - \delta_i}.$$

The resulting upstream profit is

$$\begin{aligned} \pi^U = & \quad (w_i - c^U)\ q_i^{BR} + \textstyle\sum_{j \neq i}[(w_j^* - c^U)\ q_j^* + f_j] \\ + & \quad \frac{(P(q_i^{BR}+Q_{-i}^*)-w_i)\ q_i^{BR}+\delta_i(w_i-c^U)\ q_i^{BR}+\delta_i \sum_{j\neq i}[(w_j^*-c^U)\ q_j^*+f_j]-\Pi_i^{\text{inhouse}}}{1-\delta_i}, \end{aligned}$$

which can be reduced to

$$\begin{aligned} \pi^U = & \ \tfrac{1}{1-\delta_i} \left[(P(q_i^{BR} + Q_{-i}^*) - c^U)\ q_i^{BR} \right] + \tfrac{\delta_i \sum_{j\neq i}[(w_j^*-c^U)\ q_j^*+f_j]-\Pi_i^{\text{inhouse}}}{1-\delta_i} \\ + & \quad \textstyle\sum_{j \neq i}[(w_j^* - c^U)\ q_j^* + f_j]. \end{aligned}$$

Differentiating with respect to w_i yields

$$\frac{\partial \pi^U}{\partial w_i} = \frac{\partial q_i^{BR}}{\partial w_i} \left[P'(q_i^{BR} + Q_{-i}^*)\ q_i^{BR} + P(q_i^{BR} + Q_{-i}^*) - c^U \right] = 0.$$

Using the FOC (14) yields

$$\frac{\partial q_i^{BR}}{\partial w_i} \left[(1 - \delta_i)\,(w_i - c^U) \right] = 0.$$

Hence, we again obtain $w_i^* = c^U$ for all downstream firms.

If all other downstream firms source from supplier U at marginal costs of c^U, the profit of downstream firm i which produces inputs inhouse at marginal costs c^I and has an ownership share δ_i is

$$\Pi_i^{\text{inhouse}} = \pi(c^I, c^U) + \delta_i \sum_{j \neq i} f_j.$$

If firm i sources from U at the tariff $\{w_i = c^U,\ f_i\}$, its profit is

$$\pi_i - f_i = \pi(c^U, c^U) - f_i + \delta_i [f_i + \sum_{j \neq i} f_j].$$

Supplier U can raise f_i until $\pi_i - f_i = \Pi_i^{\text{inhouse}}$.

$$\begin{aligned} \pi(c^U, c^U) - f_i + \delta_i [f_i + \sum_{j \neq i} f_j] &= \pi(c^I, c^U) + \delta_i \sum_{j \neq i} f_j \\ \implies\ f_i &= \frac{\pi(c^U, c^U) - \pi(c^I, c^U)}{1 - \delta_i}. \end{aligned}$$

The resulting profit of downstream firm i is obtained by noting that

$$\begin{aligned} \delta_i \sum_{j \neq i} f_j =& \delta_i \sum_{j \neq i} \frac{\pi(c^U, c^U) - \pi(c^I, c^U)}{1 - \delta_j} \\ =& \left[\pi(c^U, c^U) - \pi(c^I, c^U) \right] \delta_i \sum_{j \neq i} \frac{1}{1 - \delta_j}. \end{aligned}$$

This yields

$$\begin{aligned} \pi_i - f_i &= \pi(c^I, c^U) + \left[\pi(c^U, c^U) - \pi(c^I, c^U) \right] \delta_i \sum_{j \neq i} \frac{1}{1 - \delta_j} \\ &= \pi(c^I, c^U) \left[1 - \delta_i \sum_{j \neq i} \frac{1}{1 - \delta_j} \right] + \pi(c^U, c^U) \left[\delta_i \sum_{j \neq i} \frac{1}{1 - \delta_j} \right]. \end{aligned} \tag{15}$$

□

Proof of Lemma 5. Downstream firm i chooses the quantity q_i^{BR} that solves the FOC

$$P'(q_i + Q^*_{-i})q_i + P(q_i + Q^*_{-i}) - w_i = 0, \tag{16}$$

where $Q^*_{-i} = \sum_{j \neq i} q_j^*$ is the expected quantity of the other downstream firms when they believe the equilibrium contracts (w_j^*, f_j^*) are offered. The profit of firm i is given by

$$(P(q_i^{BR}(w_i, Q^*_{-i}) + Q^*_{-i}) - w_i)q_i^{BR} - f_i.$$

If i rejects the contract offer, its profit is given as

$$\Pi_i^{\text{inhouse}} = \max_{q_i} \left(p(q_i + Q_{-i}^{*\text{DEV}}) - c^I\right) q_i.$$

where $Q_{-i}^{*\text{DEV}}$are quantities demanded by the rival firms when the set of wholesale prices are $(w_i^* = c^I, \boldsymbol{w}^*_{-i})$. This is because of our assumption that a breakdown in negotiations is observable after the contracting stage. Supplier U and firm i set the fixed fee and marginal wholesale prices to maximize the Nash bargaining solution.

$$\max_{w_i, f_i}(\pi_i(w_i, \boldsymbol{w}^*_{-i}) - f_i - \Pi_i^{\text{inhouse}})^{\beta}((w_i - c^U)\ q_i^{BR} + f_i + \sum_{j \neq i}^{n}[(w_j^* - c^U)\ q_j^* + f_j^*] - \pi^{U,DEV})^{(1-\beta)}$$

where $\pi^{U,DEV} = \sum_{j \neq i}[(w_j^* - c^U)\ q_j^{DEV} + f_j^*]$. The first order condition of the Nash bargaining game with respect to f_i gives us

$$f_i = (1-\beta)[\pi_i(w_i, \boldsymbol{w}^*_{-i}) - \Pi_i^{\text{inhouse}}] - \beta[(w_i - c^U)q_i^{BR} + \sum_{j \neq i}^{n}[(w_j^* - c^U)q_j^* + f_j^*] - \pi^{U,DEV}].$$

Substituting this into the maximization problem and simplifying gives us the program

$$\max_{w_i} \beta^{\beta}(1-\beta)^{(1-\beta)}(\pi_i(w_i, \boldsymbol{w}^*_{-i}) - \Pi_i^{\text{inhouse}} + (w_i - c^U)q_i^{BR} + \sum_{j \neq i}^{n}[(w_j^* - c^U)\ q_j^* + f_j^*] - \pi^{U,DEV}).$$

Only the first and third term in the long parentheses of the above expression are a function of w_i. This is nothing but the bilateral profit of supplier U and firm i from sales of i. Taking first order conditions with respect to w_i, we get the familiar expression

$$(w_i - c^U)\frac{\partial q_i(w_i, \boldsymbol{w}^*_{-i})}{\partial w_i} = 0.$$

This implies $w_i^* = c^U$. By symmetry, supplier U offers contracts to all downstream firms in which the marginal price w_i equals its marginal costs c^U. The fixed fees are given as

$$f_i^* = (1-\beta)((\pi(c^U, \boldsymbol{w}^*_{-i} = \mathbf{c^U}) - \pi(c^I, \boldsymbol{w}^*_{-i} = \mathbf{c^U})). \tag{17}$$

□

Proof of Lemma 6. The supplier solves the program

$$\max_{w_i, \boldsymbol{w_{-i}}} \pi^U = (P(Q^*) - c^U)Q^*(w_i, \boldsymbol{w_{-i}}) - \sum_{i=1}^{n} \pi_i^*(w_i = c^I, \boldsymbol{w_{-i}})$$

subject to $w_i > c^U \; \forall i$. It is important to remember that fixed fees are such that the outside option of the downstream firms are binding. The optimal wholesale price solves the following first order conditions

$$\frac{\partial \pi^U}{\partial w_i} = \underbrace{(P'(Q^*)Q^* + (P(Q^*) - c^U))(\frac{\partial q_i^*}{\partial w_i} + \frac{\partial Q_{-i}^*}{\partial w_i})}_{A} - \sum_{j \neq i}^{n} \underbrace{\frac{\partial \pi_j^*(w_j = c^I, \boldsymbol{w_{-j}})}{\partial w_i}}_{B} = 0.$$

Focusing just on expression denoted as A, we can notice that it is the expression that maximizes industry profit. A can be rewritten as $(P'(Q^*)Q_{-i}^* + w_i - c^U)(\frac{\partial q_i^*}{\partial w_i} + \frac{\partial Q_{-i}^*}{\partial w_i})$ by substituting the first order conditions of the downstream firm i. We can clearly notice then that when $w_i = c^U$, $A|_{\{w_i = c^U\}} > 0$.[27] As a result, we show that industry surplus maximizing wholesale prices are higher than marginal costs. Let us denote the industry profit maximizing wholesale prices $w_i^* = w_{-i}^* := w^M$. The expression $B = \sum_{j \neq i}^{n} P'(Q^*(\boldsymbol{w_{-j}}, w_j = c^I)) \; \frac{\partial Q_{-j}^*(\boldsymbol{w_{-j}}, w_j = c^I)}{\partial w_i} \; q_j^*(w_j = c^I, \boldsymbol{w_{-j}}) > 0$ since $\frac{\partial Q_{-j}^*(\boldsymbol{w_{-j}}, w_j = c^I)}{\partial w_i} < 0$. It is easy to see that $\frac{\partial \pi^U}{\partial w_i}|_{\{w_i = w_j = w^M\}} < 0$ implying that in the presence of outside option or buyer power, wholesale prices are lower. Due to symmetry downstream, we will obtain symmetric wholesale prices and hence, we denote the optimal wholesale price as w^*. We can easily show then that as c^I falls wholesale prices are falling. When $c^I >> 0$, large enough such that $q_i^*(w_i = c^I, \boldsymbol{w_{-i}}) \leq 0$, the outside option is set at zero and $\frac{\partial \pi^U}{\partial w_i}|_{\{w_i = w_j = c^U\}} = ((P'(Q^*)Q_{-i}^* + w_i - c^U)(\frac{\partial q_i^*}{\partial w_i} + \frac{\partial Q_{-i}^*}{\partial w_i}) > 0$ implying $w^* > c^U$. At the other extreme case, when $c^I = c^U$, and $w = c^U$, $\frac{\partial \pi^U}{\partial w_i}|_{\{w_i = w_j = c^U, c^I = c^U\}} = (P'(Q^*) \; q_i(w_i, \boldsymbol{w_{-i}}) \; (\frac{\partial Q_{-i}^*(c^U, c^U)}{\partial w_i})) < 0$ implying that the optimal wholesale prices have to be lower. As the wholesale prices cannot be below marginal costs, there will be a corner solution. We now show the existence of a $\hat{c}$ such that for all $c^I \leq \hat{c}$, there exists a corner solution where $w^* = c^U$. Using intermediate value theorem and the fact that $\frac{\partial \pi^U}{\partial w_i}$ is continuous on c^I, we can say that there exists a $c^I = \hat{c}$ such that $\frac{\partial \pi^U}{\partial w_i}|_{\{w_i = w_j = c^U, c^I = \hat{c}\}} = 0$. Hence, for all $c^I < \hat{c}$, wholesale prices are set at $w^* = c^U$. □

Proof of Proposition 5. For expositional purposes, let us assume that the 2 firms ($\{1, 2\}$) downstream take a symmetric partial ownership $\delta_i = \delta$ in the supplier. The profit of firm i is then given as

$$\pi_i - f_i = (P(q_1 + q_2) - w_i) \; q_i + \delta \sum_{j=1}^{2} [(w_j - c^U)q_j + f_j] - f_i \; \forall i \in 1, 2.$$

[27]This can be seen as $(\frac{\partial q_i^*}{\partial w_i} + \frac{\partial Q_{-i}^*}{\partial w_i}) < 0$ and $P'(Q^*) < 0$.

Rearranging yields

$$\pi_i - f_i = (P(Q) - c^U)\ q_i - (1-\delta)(w_i - c^U)\ q_i + \delta \sum_{j \neq i}^{2} [(w_j - c^U)\ q_j + f_j] - (1-\delta)\ f_i.$$

The first order conditions with respect to q_i yield $\frac{\partial \pi_i}{\partial q_i} = (P(Q) - w_i) + P'(Q)\ q_i + \delta(w_i - c^U) = 0$. Let us denote the equilibrium quantities as $(q_1^*(w_1,\ w_2),\ q_2^*(w_2,\ w_1))$ and the total quantity in the market as $Q^*(w_1,\ w_2) = q_1^* + q_2^*$. The inhouse profit of firm i with a partial ownership δ is given as

$$\Pi_i^{inhouse} = (P(Q^*(c^I, w_j)) - c^I)\ q_i^*(c^I, w_j) + \delta[(w_j - c^U)\ q_j^*(w_j, c^I)] + \delta f_j.$$

Moving on to the upstream contracting stage, where the supplier sets $(w_i,\ f_i)$ for $i \in 1, 2$. The supplier's profits are given as

$$\max_{(w_1, f_1), (w_2, f_2)} \pi^U = [(w_1 - c^U)\ q_1^* + (w_2 - c^U)\ q_2^* + f_1 + f_2] \quad s.\ t. \quad \pi_i - f_i \geq \Pi_i^{inhouse}\ \forall\ i \in 1, 2.$$

The fixed fees are set such that the participation constraints of the downstream firms are binding and hence are given as $f_i = \frac{\pi_i - \Pi_i^{inhouse}(c^I, w_j)}{1-\delta}$ $\forall i$.[28] The supplier's maximization problem then becomes

$$\max_{w_1, w_2} \pi^U = \frac{(P(Q^*) - c^U)\ Q^*(w_i, w_j) + \delta \sum_{i=1}^{2} (w_i - c^U)\ q_i^* - \sum_{i=1}^{2} \Pi_i^{inhouse}}{1-\delta}.$$

Taking the first derivative with respect to w_i gives the following first order conditions:

$$\frac{\partial \pi^U}{\partial w_i} = \frac{(P'(Q^*)Q^* + P(Q^*) - c^U)\ \frac{\partial Q^*}{\partial w_i} + \delta(q_i^* + \sum_{j=1}^{2}(w_i - c^U)\ \frac{\partial q_i^*}{\partial w_i}) - \frac{\partial \Pi_j^{inhouse}}{\partial w_i}}{1-\delta} = 0.$$

Rearranging and substituting from the first order condition of q_i, we get

$$\frac{\partial \pi^U}{\partial w_i} = \frac{(P'(Q^*)\ q_j^* + (1-\delta)(w_i - c^U))\ \frac{\partial Q^*}{\partial w_i} + \delta(q_i^* + \sum_{j=1}^{n}(w_i - c^U)\ \frac{\partial q_i^*}{\partial w_i}) - \frac{\partial \Pi_j^{inhouse}(w_j = c^I, w_i)}{\partial w_i}}{1-\delta} = 0.$$

The comparative statics of total quantity with a change in w_i as well as the change in q_1^* and q_2^* are given as

$$\begin{aligned}
\frac{\partial q_i}{\partial w_i} &= \frac{a}{(a-b)(a+b)}(1-\delta) < 0, \\
\frac{\partial q_i}{\partial w_j} &= \frac{-b}{(a-b)(a+b)}(1-\delta) > 0,
\end{aligned}$$

where $a := \frac{\partial^2 \pi_i}{\partial q_i^2} = 2P'(Q^*) + P''(Q^*)q_1$, $b := \frac{\partial^2 \pi_i}{\partial q_i \partial q_j} = P'(Q^*) + P''(Q)q_i$. It is easy to verify

[28] Note here that in the term $\pi_i - \pi_i^{Inhouse}(c^I, w_j)$, the fixed fees f_j cancel out.

that $(a + b) < 0$ and $a - b < 0$.

Due to symmetry, $\frac{\partial q_1}{\partial w_1} = \frac{\partial q_2}{\partial w_2}$ and $\frac{\partial q_1}{\partial w_2} = \frac{\partial q_2}{\partial w_1} \forall i \neq j \in 1, 2$. Moreover, we can then write the change in total quantity with a change in w_i as $\frac{\partial Q^*}{\partial w_1} = \frac{(1-\delta)}{(2(P'(Q^*)+P''(Q^*)q_1^*)+P'(Q^*))} < 0$ where $P'(Q^*) + P''(Q^*)q_1 < 0$.

When inhouse production is very inefficient such that it is not a credible supply substitution threat, i.e., c^I large enough such that $q_1^*(w_1 = c^I, w_2) \leq 0$, the inhouse profit is just the profit from the partial ownership. This inhouse profit is given as

$$\Pi_1^{inhouse} = \delta(w_2 - c^U)q_2^M,$$

where q_2^M is the quantity offered when only firm 2 is active downstream off equilibrium and firm 1 is absent from the downstream market. Hence, the derivative of the supply profit with respect to w_1 is given as

$$\frac{\partial \pi^U}{\partial w_1}|_{\{w_1=w_2=c^U\}} = \frac{(P'(Q^*)q_2^*)\ \frac{\partial Q^*}{\partial w_1} + \delta q_1^* - \frac{\partial \Pi_2^{inhouse}(w_2=c^I, w_1=c^U)}{\partial w_1}}{1-\delta}.$$

substituting the above expression with $\frac{\partial \Pi_2^{inhouse}(w_2=c^I, w_1=c^U)}{\partial w_1} = \delta q_1^M$ and rearranging we get

$$\frac{\partial \pi^U}{\partial w_1}|_{\{w_1=w_2=c^U\}} = q_1^*(P'(Q^*)\ \frac{\partial Q^*}{\partial w_1} + \delta) - \delta q_1^M > 0.$$

The above expression utilizes the fact that on equilibrium for symmetric wholesale prices the quantities demanded by each firm are equal and hence $q_1^* = q_2^*$. It is easy to see that the above derivative is positive. We then look at the sign of the above equation at $c^I = c^U$ where the inhouse production is as efficient as the incumbent supplier. This is the case where the downstream have the largest buyer power.

Suppose the inhouse production firm is as efficient as the incumbent supplier, $c^I = c^U$, and evaluating the above derivative at $w_1^* = w_2^* = c^U$ yields

$$\frac{\partial \pi^U}{\partial w_1}|_{\{w_1=w_2=c^U, c^I=c^U\}} = P'(Q^*)\ q_2^*\frac{\partial Q^*}{\partial w_1} + \delta q_1^* - (P'(Q^*)q_2^*\frac{\partial q_1(c^U, c^U)}{\partial w_1} - \delta q_1^*(c^U, c^U)).$$

Rearranging yields

$$P'(Q^*)q_2^*\frac{\partial Q^*}{\partial w_1} - P'(Q^*)q_2^*\frac{\partial q_1(c^U, c^U)}{\partial w_1} = P'(Q^*)q_2^*\frac{\partial q_2^*}{\partial w_1} < 0.$$

The intermediate value theorem and the fact that $\frac{\partial \pi^U}{\partial w_i}$ is continuous on c^I imply that there exists a $c^I = \hat{c}$ such that $w_i^* = w_j^* = c^U$.[29] By assumption, the wholesale prices cannot be below cost. Hence, for all $c^I < \hat{c}$, wholesale prices are set at $w^* = c^U$. Hence, we show the existence of marginal cost pricing in a public contract setting. This parameter range gives similar results as in the secret contracts case. □

[29] $\hat{c}$ is such that $\frac{\partial \pi^U}{\partial w_1} = (P'(Q^*)q_2 - \frac{\partial \pi_2^*(w_2=\hat{c}, w_1)}{\partial w_1} = 0$ and $w_1 = w_2 = c^U$ is optimal.

Annex B: Non-observable contract acceptance

We first study the case when there is no partial ownership and show that there is no incentive to foster upstream innovation. We then move on to the case that downstream firms have partial ownership and look at the innovation incentives.

The only difference to our previous case is the non-observability of contract acceptance. This implies that the profit of firm i off-equilibrium when i rejects the contract offer is given as

$$\Pi_i^{\text{inhouse}} = \max_{q_i} \left(p(q_i + Q_{-i}^*) - c^I \right) \; q_i.$$

One can see that due to non-observability of acceptance or rejection decision, the belief firm i has on the equilibrium quantity choice of its rivals does not change. As the outside option is constant in w_i and only a function of w_{-i}^* , the value of the choice variable w_i on equilibrium does not change and is equal to c^U. Only the fixed fee changes and is given by $f^* = \pi(c^U, c^U) - \Pi_i^{\text{inhouse}}$. Non-observability of contract acceptance only redistributes rents. As $\frac{\partial \Pi_i^{\text{inhouse}}}{\partial c^U} < 0$, the firm i has no incentive to share a cost reducing technology with the efficient supplier U and instead wants to share it with the inhouse production facility.

Similarly, we can obtain the equilibrium contracts for the case when a firm i has partial ownership δ_i in U. Using the idea that the inhouse production profits of a firm i is independent of w_i, we again obtain that the wholesale prices are equal to marginal costs c^U. Only the fixed fees are different. This redistribution of rents arises because the profits in case a contractual breakdown and inhouse production are different. Hence, the profit of a firm with partial ownership δ_i is given as

$$\pi_i - f_i = \tilde{\pi}(c^I, \; c^U) \left[1 - \delta_i \sum_{j \neq i} \frac{1}{1 - \delta_j} \right] + \pi(c^U, \; c^U) \left[\delta_i \sum_{j \neq i} \frac{1}{1 - \delta_j} \right],$$

where $\tilde{\pi}$ is the off-equilibrium flow profit of firm i which deviates and obtains $w_i = c^I$, while the other firms cannot observe that a firm i is not supplied by the efficient supplier. As the flow profits $\pi(c^U, \; c^U)$ increase when c^U decreases, for a sufficiently large weight δ_i, firm i has incentives to offer cost reducing technology to the efficient supplier.

PREVIOUS DISCUSSION PAPERS

281 Hunold, Matthias and Shekhar, Shiva, Supply Chain Innovations and Partial Ownership, February 2018.

280 Rickert, Dennis, Schain, Jan Philip and Stiebale, Joel, Local Market Structure and Consumer Prices: Evidence from a Retail Merger, January 2018.

279 Dertwinkel-Kalt, Markus and Wenzel, Tobias, Focusing and Framing of Risky Alternatives, December 2017.
Forthcoming in: Journal of Economic Behavior and Organization.

278 Hunold, Matthias, Kesler, Reinhold, Laitenberger, Ulrich and Schlütter, Frank, Evaluation of Best Price Clauses in Online Hotel Booking, December 2017 (First Version October 2016).

277 Haucap, Justus, Thomas, Tobias and Wohlrabe, Klaus, Publication Performance vs. Influence: On the Questionable Value of Quality Weighted Publication Rankings, December 2017.

276 Haucap, Justus, The Rule of Law and the Emergence of Market Exchange: A New Institutional Economic Perspective, December 2017.
Published in: von Alemann, U., D. Briesen & L. Q. Khanh (eds.), The State of Law: Comparative Perspectives on the Rule of Law, Düsseldorf University Press: Düsseldorf 2017, pp. 143-172.

275 Neyer, Ulrike and Sterzel, André, Capital Requirements for Government Bonds – Implications for Bank Behaviour and Financial Stability, December 2017.

274 Deckers, Thomas, Falk, Armin, Kosse, Fabian, Pinger, Pia and Schildberg-Hörisch, Hannah, Socio-Economic Status and Inequalities in Children's IQ and Economic Preferences, November 2017.

273 Defever, Fabrice, Fischer, Christian and Suedekum, Jens, Supplier Search and Re-matching in Global Sourcing – Theory and Evidence from China, November 2017.

272 Thomas, Tobias, Heß, Moritz and Wagner, Gert G., Reluctant to Reform? A Note on Risk-Loving Politicians and Bureaucrats, October 2017.
Published in: Review of Economics, 68 (2017), pp. 167-179.

271 Caprice, Stéphane and Shekhar, Shiva, Negative Consumer Value and Loss Leading, October 2017.

270 Emch, Eric, Jeitschko, Thomas D. and Zhou, Arthur, What Past U.S. Agency Actions Say About Complexity in Merger Remedies, With an Application to Generic Drug Divestitures, October 2017.

269 Goeddeke, Anna, Haucap, Justus, Herr, Annika and Wey, Christian, Flexibility in Wage Setting Under the Threat of Relocation, September 2017.
Forthcoming in: Labour: Review of Labour Economics and Industrial Relations.

268 Haucap, Justus, Merger Effects on Innovation: A Rationale for Stricter Merger Control?, September 2017.
Published in: Concurrences: Competition Law Review, 4 (2017), pp.16-21.

267 Brunner, Daniel, Heiss, Florian, Romahn, André and Weiser, Constantin, Reliable Estimation of Random Coefficient Logit Demand Models, September 2017.

266 Kosse, Fabian, Deckers, Thomas, Schildberg-Hörisch, Hannah and Falk, Armin, The Formation of Prosociality: Causal Evidence on the Role of Social Environment, July 2017.

265 Friehe, Tim and Schildberg-Hörisch, Hannah, Predicting Norm Enforcement: The Individual and Joint Predictive Power of Economic Preferences, Personality, and Self-Control, July 2017.
Published in: European Journal of Law and Economics, 45 (2018), pp. 127-146.

264 Friehe, Tim and Schildberg-Hörisch, Hannah, Self-Control and Crime Revisited: Disentangling the Effect of Self-Control on Risk Taking and Antisocial Behavior, July 2017.

263 Golsteyn, Bart and Schildberg-Hörisch, Hannah, Challenges in Research on Preferences and Personality Traits: Measurement, Stability, and Inference, July 2017.
Published in: Journal of Economic Psychology, 60 (2017), pp. 1-6.

262 Lange, Mirjam R.J., Tariff Diversity and Competition Policy – Drivers for Broadband Adoption in the European Union, July 2017.
Published in: Journal of Regulatory Economics, 52 (2017), pp. 285-312.

261 Reisinger, Markus and Thomes, Tim Paul, Manufacturer Collusion: Strategic Implications of the Channel Structure, July 2017.

260 Shekhar, Shiva and Wey, Christian, Uncertain Merger Synergies, Passive Partial Ownership, and Merger Control, July 2017.

259 Link, Thomas and Neyer, Ulrike, Friction-Induced Interbank Rate Volatility under Alternative Interest Corridor Systems, July 2017.

258 Diermeier, Matthias, Goecke, Henry, Niehues, Judith and Thomas, Tobias, Impact of Inequality-Related Media Coverage on the Concerns of the Citizens, July 2017.

257 Stiebale, Joel and Wößner, Nicole, M&As, Investment and Financing Constraints, July 2017.

256 Wellmann, Nicolas, OTT-Messaging and Mobile Telecommunication: A Joint Market? – An Empirical Approach, July 2017.

255 Ciani, Andrea and Imbruno, Michele, Microeconomic Mechanisms Behind Export Spillovers from FDI: Evidence from Bulgaria, June 2017.
Published in: Review of World Economics, 153 (2017), pp. 704-734.

254 Hunold, Matthias and Muthers, Johannes, Capacity Constraints, Price Discrimination, Inefficient Competition and Subcontracting, June 2017.

253 Dertwinkel-Kalt, Markus and Köster, Mats, Salient Compromises in the Newsvendor Game, June 2017.
Published in: Journal of Economic Behavior and Organization, 141 (2017), pp. 301-315.

252 Siekmann, Manuel, Characteristics, Causes, and Price Effects: Empirical Evidence of Intraday Edgeworth Cycles, May, 2017.

251 Benndorf, Volker, Moellers, Claudia and Normann, Hans-Theo, Experienced vs. Inexperienced Participants in the Lab: Do they Behave Differently?, May 2017.
Forthcoming in: Journal of the Economic Science Association.

250 Hunold, Matthias, Backward Ownership, Uniform Pricing and Entry Deterrence, May 2017.

249 Kreickemeier, Udo and Wrona, Jens, Industrialisation and the Big Push in a Global Economy, May 2017.

248 Dertwinkel-Kalt, Markus and Köster, Mats, Local Thinking and Skewness Preferences, April 2017.

247 Shekhar, Shiva, Homing Choice and Platform Pricing Strategy, March 2017.

246 Manasakis, Constantine, Mitrokostas, Evangelos and Petrakis, Emmanuel, Strategic Corporate Social Responsibility by a Multinational Firm, March 2017.

245 Ciani, Andrea, Income Inequality and the Quality of Imports, March 2017.

244 Bonnet, Céline and Schain, Jan Philip, An Empirical Analysis of Mergers: Efficiency Gains and Impact on Consumer Prices, February 2017.

243 Benndorf, Volker and Martinez-Martinez, Ismael, Perturbed Best Response Dynamics in a Hawk-Dove Game, January 2017.
Published in: Economics Letters, 153 (2017), pp. 61-64.

242 Dauth, Wolfgang, Findeisen, Sebastian and Suedekum, Jens, Trade and Manufacturing Jobs in Germany, January 2017.
Forthcoming in: American Economic Review, Papers & Proceedings.

241 Borrs, Linda and Knauth, Florian, The Impact of Trade and Technology on Wage Components, December 2016.

240 Haucap, Justus, Heimeshoff, Ulrich and Siekmann, Manuel, Selling Gasoline as a By-Product: The Impact of Market Structure on Local Prices, December 2016.

239 Herr, Annika and Normann, Hans-Theo, How Much Priority Bonus Should be Given to Registered Organ Donors? An Experimental Analysis, November 2016.

238 Steffen, Nico, Optimal Tariffs and Firm Technology Choice: An Environmental Approach, November 2016.

237 Behrens, Kristian, Mion, Giordano, Murata, Yasusada and Suedekum, Jens, Distorted Monopolistic Competition, November 2016.

236 Beckmann, Klaus, Dewenter, Ralf and Thomas, Tobias, Can News Draw Blood? The Impact of Media Coverage on the Number and Severity of Terror Attacks, November 2016.
Forthcoming in: Peace Economics, Peace Science and Public Policy.

235 Dewenter, Ralf, Dulleck, Uwe and Thomas, Tobias, Does the 4th Estate Deliver? Towars a More Direct Measure of Political Media Bias, November 2016.

234 Egger, Hartmut, Kreickemeier, Udo, Moser, Christoph and Wrona, Jens, Offshoring and Job Polarisation Between Firms, November 2016.

233 Moellers, Claudia, Stühmeier, Torben and Wenzel, Tobias, Search Costs in Concentrated Markets – An Experimental Analysis, October 2016.

232 Moellers, Claudia, Reputation and Foreclosure with Vertical Integration – Experimental Evidence, October 2016.

231 Alipranti, Maria, Mitrokostas, Evangelos and Petrakis, Emmanuel, Non-comparative and Comparative Advertising in Oligopolistic Markets, October 2016.
Forthcoming in: The Manchester School.

230 Jeitschko, Thomas D., Liu, Ting and Wang, Tao, Information Acquisition, Signaling and Learning in Duopoly, October 2016.

229 Stiebale, Joel and Vencappa, Dev, Acquisitions, Markups, Efficiency, and Product Quality: Evidence from India, October 2016.

228 Dewenter, Ralf and Heimeshoff, Ulrich, Predicting Advertising Volumes: A Structural Time Series Approach, October 2016.
Published in: Economics Bulletin, 37 (2017), Volume 3.

227 Wagner, Valentin, Seeking Risk or Answering Smart? Framing in Elementary Schools, October 2016.

226 Moellers, Claudia, Normann, Hans-Theo and Snyder, Christopher M., Communication in Vertical Markets: Experimental Evidence, July 2016.
Published in: International Journal of Industrial Organization, 50 (2017), pp. 214-258.

225 Argentesi, Elena, Buccirossi, Paolo, Cervone, Roberto, Duso, Tomaso and Marrazzo, Alessia, The Effect of Retail Mergers on Prices and Variety: An Ex-post Evaluation, June 2016.

224 Aghadadashli, Hamid, Dertwinkel-Kalt, Markus and Wey, Christian, The Nash Bargaining Solution in Vertical Relations With Linear Input Prices, June 2016.
Published in: Economics Letters, 145 (2016), pp. 291-294.

223 Fan, Ying, Kühn, Kai-Uwe and Lafontaine, Francine, Financial Constraints and Moral Hazard: The Case of Franchising, June 2016.
Forthcoming in: Journal of Political Economy.

222 Benndorf, Volker, Martinez-Martinez, Ismael and Normann, Hans-Theo, Equilibrium Selection with Coupled Populations in Hawk-Dove Games: Theory and Experiment in Continuous Time, June 2016.
Published in: Journal of Economic Theory, 165 (2016), pp. 472-486.

221 Lange, Mirjam R. J. and Saric, Amela, Substitution between Fixed, Mobile, and Voice over IP Telephony – Evidence from the European Union, May 2016.
Published in: Telecommunications Policy, 40 (2016), pp. 1007-1019.

220 Dewenter, Ralf, Heimeshoff, Ulrich and Lüth, Hendrik, The Impact of the Market Transparency Unit for Fuels on Gasoline Prices in Germany, May 2016.
Published in: Applied Economics Letters, 24 (2017), pp. 302-305.

219 Schain, Jan Philip and Stiebale, Joel, Innovation, Institutional Ownership, and Financial Constraints, April 2016.

218 Haucap, Justus and Stiebale, Joel, How Mergers Affect Innovation: Theory and Evidence from the Pharmaceutical Industry, April 2016.

217 Dertwinkel-Kalt, Markus and Wey, Christian, Evidence Production in Merger Control: The Role of Remedies, March 2016.

216 Dertwinkel-Kalt, Markus, Köhler, Katrin, Lange, Mirjam R. J. and Wenzel, Tobias, Demand Shifts Due to Salience Effects: Experimental Evidence, March 2016.
Published in: Journal of the European Economic Association, 15 (2017), pp. 626-653.

215 Dewenter, Ralf, Heimeshoff, Ulrich and Thomas, Tobias, Media Coverage and Car Manufacturers' Sales, March 2016.
Published in: Economics Bulletin, 36 (2016), pp. 976-982.

214 Dertwinkel-Kalt, Markus and Riener, Gerhard, A First Test of Focusing Theory, February 2016.

213 Heinz, Matthias, Normann, Hans-Theo and Rau, Holger A., How Competitiveness May Cause a Gender Wage Gap: Experimental Evidence, February 2016.
Forthcoming in: European Economic Review, 90 (2016), pp. 336-349.

212 Fudickar, Roman, Hottenrott, Hanna and Lawson, Cornelia, What's the Price of Consulting? Effects of Public and Private Sector Consulting on Academic Research, February 2016.

211 Stühmeier, Torben, Competition and Corporate Control in Partial Ownership Acquisitions, February 2016.
Published in: Journal of Industry, Competition and Trade, 16 (2016), pp. 297-308.

210 Muck, Johannes, Tariff-Mediated Network Effects with Incompletely Informed Consumers, January 2016.

209 Dertwinkel-Kalt, Markus and Wey, Christian, Structural Remedies as a Signalling Device, January 2016.
Published in: Information Economics and Policy, 35 (2016), pp. 1-6.

208 Herr, Annika and Hottenrott, Hanna, Higher Prices, Higher Quality? Evidence From German Nursing Homes, January 2016.
Published in: Health Policy, 120 (2016), pp. 179-189.

207 Gaudin, Germain and Mantzari, Despoina, Margin Squeeze: An Above-Cost Predatory Pricing Approach, January 2016.
Published in: Journal of Competition Law & Economics, 12 (2016), pp. 151-179.

206 Hottenrott, Hanna, Rexhäuser, Sascha and Veugelers, Reinhilde, Organisational Change and the Productivity Effects of Green Technology Adoption, January 2016.
Published in: Energy and Ressource Economics, 43 (2016), pp. 172–194.

205 Dauth, Wolfgang, Findeisen, Sebastian and Suedekum, Jens, Adjusting to Globalization – Evidence from Worker-Establishment Matches in Germany, January 2016.

Older discussion papers can be found online at:
http://ideas.repec.org/s/zbw/dicedp.html

Heinrich-Heine-University of Düsseldorf

**Düsseldorf Institute for
Competition Economics (DICE)**

Universitätsstraße 1 _ 40225 Düsseldorf
www.dice.hhu.de

ISSN 2190-9938 (online)
ISBN 978-3-86304-280-6