GOVERNANCE AND THE EFFICIENCY OF ECONOMIC SYSTEMS
GESY

Discussion Paper No. 455

The strategic value of partial vertical integration

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March 2014

Financial support from the Deutsche Forschungsgemeinschaft through SFB/TR 15 is gratefully acknowledged.

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March 9, 2014

Abstract

We investigate the incentive for partial vertical integration, namely, partial ownership agreements between manufacturers and retailers, when the retailers are privately informed about their production costs and engage in differentiated good price competition. Partial vertical integration entails an "information vertical effect": the partial misalignment of profit objectives within a partially integrated manufacturer-retailer hierarchy involves costs from asymmetric information that reduce the hierarchy's profitability. This translates into an opposite "competition horizontal effect": the partially integrated hierarchy commits to a higher retail price than under full integration, which strategically relaxes competition. The equilibrium degree of vertical integration trades off the benefits of softer competition against the informational costs.

Keywords: asymmetric information, partial vertical integration, product differentiation, vertical mergers, vertical restraints.

JEL Classification: D82, L13, L42.

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1. Introduction

Most of the practical and theoretical debate about the firms' organizational structure in vertically related markets has focused on two extreme alternatives, i.e., full vertical integration and separation. However, we often observe the presence of partial vertical integration, namely, partial ownership agreements in which a firm acquires less than 100% of shares in a vertically related firm (e.g., Allen and Phillips 2000; Fee et al. 2006; Reiffen 1998). Riordan (2008) reports that in 2003 News Corp., a major owner of cable programming networks in the US, acquired 34% of shares in Hughes Electronics, which operates via its wholly-owned subsidiary DirectTV in the downstream market of direct broadcast satellite services. Gilo and Spiegel (2011) provide empirical evidence that partial vertical integration is much more common than full integration in telecommunication and media markets in Israel. For instance, Bezeq operates in the broadband Internet infrastructure market and holds a share of 49.77% in DBS Satellite Services, which competes in the downstream multi-channel broadcast market.

Despite the empirical relevance of this phenomenon, little theoretical attention has been devoted to partial vertical ownership arrangements. In this paper, we investigate the incentive of an upstream firm (manufacturer) to acquire a partial ownership stake in a downstream firm (retailer). Our aim is to explore the scope for partial vertical integration and its competitive effects.

We address this question in a setting where two manufacturer-retailer hierarchies engage in differentiated good price competition and retailers are privately informed about their production costs. The economic literature has emphasized since Crocker's (1983) seminal contribution that a major problem within a supply hierarchy is that a firm can have access to privileged information about some relevant aspects of the market.

In our framework, a manufacturer exclusively deals with its retailer, which is reasonable in the presence of product specific investments that have to be sunk before production decisions take place.[1] Moreover, bilateral contracting within the supply hierarchy is secret. This reflects the natural idea that the trading rules specified in a given contractual relationship cannot be observed by competitors. Alternatively, these rules can be easily (secretly) renegotiated if both parties agree to do so.[2] In the benchmark case of full information within the supply hierarchy, the manufacturer which can use non-linear (secret) contracts is indifferent about the ownership

[1] For theoretical justifications of exclusive dealing in a context of asymmetric information, we refer to Gal-Or (1991b).

[2] We refer to Martimort (1996) and Martimort and Piccolo (2010) for a justification of this approach.

stake in its retailer. The manufacturer makes its retailer residual claimant for the hierarchy's profits and extracts these profits through a fixed fee. This restores the outcome of vertical integration irrespective of the ownership stake, and therefore vertical ownership arrangements are inconsequential.

This result does not hold any longer in the presence of asymmetric information about the retail costs. To begin with, consider a successive monopoly framework where a manufacturer-retailer pair operates in isolation. It is well established in the economic literature (e.g., Gal-Or 1991c) that asymmetric information within a supply hierarchy entails a higher retail price to reduce the (costly) informational rents to the retailer. This reduces the hierarchy's efficiency whose joint profits are lower than under full information, and the manufacturer is therefore induced to fully integrate with its retailer in order to internalize the negative externality within the hierarchy.

This strict preference for full vertical integration does not carry over in a setting with different manufacturer-retailer pairs engaging in differentiated good price competition. We show that in this setting partial vertical integration can emerge in equilibrium. In line with the successive monopoly case, a partial vertical ownership agreement entails an "information vertical effect": the partial misalignment between the profit objectives of the manufacturer and the retailer entails allocative costs incurred to reduce the (costly) informational rents to the retailer. For a given retail price charged by the competitor, the higher price from allocative inefficiency reduces the hierarchy's profitability relative to full integration.

This form of double marginalization from asymmetric information translates into an opposite "competition horizontal effect": the partially integrated hierarchy's commitment to a higher retail price than under full integration induces an accommodating behavior of the rival and strategically relaxes competition. The trade-off between the benefits of softer competition and the costs of asymmetric information drives the equilibrium degree of vertical integration.

These results are presented in a fairly general setting without making any particular assumption on functional forms. Our analysis recommends a careful antitrust investigation into the competitive effects of ownership agreements in vertically related markets.

2. Related literature

The private and social effects of partial ownership agreements in horizontally related markets have been well explored in the economic literature (e.g., Gilo et al. 2006). A seminal recent paper on this topic is Foros et al. (2011), which shows that a firm can prefer the acquisition of a partial ownership stake in a rival to full merger, if it obtains the corporate control over all price decisions.

Conversely, the literature on partial ownership in vertically related markets is still in its infancy. A relevant contribution is Dasgupta and Tao (2000), which demonstrates that partial vertical ownership may perform better than take-or-pay contracts if the upstream firms undertake investments which benefit downstream firms. However, Greenlee and Raskovich (2006) find that, under certain circumstances, partial vertical ownership interests do not have any effect on the price or output choices of downstream firms.[3] In this paper, we show that partial vertical integration constitutes a strategic devise to relax competition in the presence of asymmetric information about the retail costs.

Our analysis is also related to the literature about the strategic choice between vertical separation and integration when supply hierarchies compete. This issue has been investigated in a setting of complete information (e.g., Bonanno and Vickers 1988; Gal-Or 1991a; Jansen 2003) and, more relevantly for our purposes, in a context of asymmetric information. Caillaud and Rey (1994) provide an overview of the strategic use of vertical delegation. Gal-Or (1992) shows that, in the presence of asymmetric information about the retail costs, for intermediate costs of integration one firm finds it optimal to integrate while its rival remains vertically separated. Barros (1997) demonstrates that in an oligopolistic industry some firms may profit from a commitment to face asymmetric information about their agents' operations. Along these lines, Gal-Or (1999) derives the conditions under which vertically related firms follow different strategies about the integration or separation of their sale functions when asymmetric information concerns consumer demand. Differently from the aforementioned contributions, we consider the manufacturer's option of "fine-tuning" the degree of vertical integration by acquiring a (possibly) partial ownership stake in its retailer.

Our paper also belongs to the strand of literature dealing with vertical restraints under asymmetric information. In a successive monopoly framework with adverse selection, Gal-Or (1991c) compares quantity fixing and resale price maintenance contracts. Martimort (1996) investigates the choice of competing manufacturers between a common or exclusive retailer and

[3]In a setting with an upstream homogeneous product and downstream imperfect competition, Hunold et al. (2012) show that passive (non-controlling) ownership of downstream firms in upstream firms is more profitable than full merger. Gilo et al. (2013) find that partial ownership acquisitions can increase the risk of anticompetitive foreclosure relative to full integration.

shows that this choice depends on the degree of product differentiation and the extent of the adverse selection problem. In a model with adverse selection and moral hazard, Martimort and Piccolo (2007) qualify the results of Gal-Or (1991c) according to the retailers' technology for providing services. In a setting with competing manufacturer-retailer pairs, Martimort and Piccolo (2010) and Kastl et al. (2011) show that manufacturers may strategically prefer quantity fixing over resale price maintenance contracts and investigate the welfare consequences of these contractual relationships.

Our contribution also shares some relevant similarities with the literature on strategic delegation in a competitive environment. However, contrary to the early work (e.g., Fershtman and Judd 1987), we consider an asymmetric information setting with secret contracts (e.g., Martimort 1996), where the terms of trade cannot be used for strategic purposes.

The rest of the paper is structured as follows. Section 3 sets out the formal model. Section 4 considers the benchmark setting of a manufacturer informed about its retail costs, which is indifferent whether to integrate with its retailer or not. Section 5 investigates the case of asymmetric information and shows that the manufacturer can find it optimal to partially integrate with its privately informed retailer rather than fully integrate. In an illustrative example with explicit functions, Section 6 derives the equilibrium degree of partial vertical integration. Section 7 explores alternatives assumptions and the robustness of the results. Section 8 discusses some implications for the antitrust policy. Section 9 concludes. All formal proofs are provided in the Appendix.

3. The model

Setting We consider a vertically related market, where two upstream manufacturers, M_1 and M_2, provide symmetrically differentiated goods through two downstream retailers, R_1 and R_2, which engage in price competition. We assume that each manufacturer is in an exclusive relationship with one retailer. To make the analysis as sharp as possible for our aims, in the spirit of Martimort and Piccolo (2010) we consider a setting where manufacturer M_1 and retailer R_1 exclusively deal with each other, while manufacturer M_2 is fully integrated with retailer R_2.[4]

Let $q_i(p_i, p_{-i})$ denote the (direct) demand function for good $i = 1, 2$, which is decreasing and (weakly) concave in its own price p_i, i.e., $\frac{\partial q_i}{\partial p_i} < 0$ and $\frac{\partial^2 q_i}{\partial p_i^2} \leq 0$. Goods exhibit some

[4] As discussed in Section 7, our results carry over in a more symmetric setting where both supply hierarchies decide on the ownership stake in their retailers.

degree of substitutability, i.e., $\frac{\partial q_i}{\partial p_{-i}} > 0$ (the equality holds if and only if market demands are independent). We impose $\left|\frac{\partial q_i}{\partial p_i}\right| > \frac{\partial q_i}{\partial p_{-i}}$, which implies that own-price effects are larger than cross-price effects. We also assume $\frac{\partial^2 q_i}{\partial p_i \partial p_{-i}} \geq 0$, which ensures strategic complementarity in prices.[5] Manufacturing costs are normalized to zero.

Manufacturer M_1 offers retailer R_1 a contract which specifies a retail price p_1 for the good and a fixed franchise fee t_1 paid by the retailer to the manufacturer for the right to sell the good.[6] Retailer R_1's (interim expected) profits are

$$\pi_{R_1} = p_1 E\left(q_1\left(p_1, p_2\right) | \theta_1\right) - \theta_1 E\left(q_1\left(p_1, p_2\right) | \theta_1\right) - t_1, \tag{1}$$

where $\theta_1 \in \{\theta_l, \theta_h\}$ is the marginal retail cost, whose realization is private information of the retailer at the time the contract is signed. With probability $\nu \in (0, 1)$ costs are θ_l, while with probability $1 - \nu$ costs are θ_h, where $\Delta\theta \equiv \theta_h - \theta_l > 0$. Moreover, $E\left(q_1\left(p_1, p_2\right) | \theta_1\right)$ represents the expected quantity of R_1, which is conditional on its own retail costs θ_1. This is because R_1 is uncertain about the rival's retail costs when contracting with M_1 but it can update its information on the basis of its cost realization. Specifically, in line with the main literature (e.g., Gal-Or 1991b, 1999; Martimort 1996), we allow for (weakly) positive correlation between retail costs.[7] In the example provided in Section 6, we assume perfect cost correlation, i.e., $\theta_1 = \theta_2$.

Manufacturer M_1's (interim expected) profits are

$$\pi_{M_1} = t_1 + \rho\left[p_1 E\left(q_1\left(p_1, p_2\right) | \theta_1\right) - \theta_1 E\left(q_1\left(p_1, p_2\right) | \theta_1\right) - t_1\right], \tag{2}$$

which is a weighted sum of upstream profits from the franchise fee t_1 and downstream profits π_{R_1} in (1) from retail operations. When offering a contract to R_1, M_1 is concerned about the profits in (2). The parameter $\rho \in [0, 1]$ represents the ownership stake acquired by M_1 in R_1. In the words of O'Brien and Salop (2000), ρ captures the financial interest of the acquiring firm, which is entitled to receive a share of the profits of the acquired firm. If $\rho = 0$, the two firms

[5] This implies that the best response functions are positively sloped (Bulow et al. 1985). We refer to Vives (1999, Ch. 6) for a full characterization of standard regularity conditions which ensure that there exists a unique Nash equilibrium outcome.

[6] This contractual mode yields the manufacturer the highest profit. The practice of dictating the final price to a retailer is commonly known as resale price maintenance. As discussed in Section 7, our qualitative results are unaffected if we consider a two-part tariff contract.

[7] Positive correlation is reasonable in competitive markets, where costs are usually subject to common trends.

are perfectly separated. If $\rho \in (0,1)$, M_1 acquires an ownership share in R_1, which means that the two firms are partially integrated. If $\rho = 1$, M_1 wholly owns R_1, and full integration occurs.

We wish to derive the equilibrium degree of vertical integration between manufacturer M_1 and retailer R_1, namely, the ownership stake ρ that M_1 decides to acquire in R_1. Following the main literature on partial ownership (e.g., Foros et al. 2011; Greenlee and Raskovich 2006; Hunold et al. 2012), we assume that M_1 chooses the ownership stake ρ in R_1 that maximizes the (expected) joint profits of the two firms. This ensures that M_1 can design an offer to R_1 which makes the shareholders in both firms better off, so that they will find it mutually beneficial to sign such an agreement.[8] Note that, if M_1 chose ρ to maximize its profits in (2), it could offer R_1 a new vertical ownership agreement that maximizes joint profits together with a transfer which makes R_1 indifferent and it would be strictly better off. Therefore, a joint profit maximizing ownership agreement exhibits a higher commitment value. In Section 7, we qualify our results for the case where the manufacturer maximizes its own profits when deciding on ρ.

In order to focus on the strategic effects of acquisition, we abstract from any cost savings arising from the ownership arrangement.

The (interim expected) profits of the vertical structure $M_2 - R_2$ are

$$\pi_2 = p_2 E\left(q_2\left(p_1, p_2\right) | \theta_2\right) - \theta_2 E\left(q_2\left(p_1, p_2\right) | \theta_2\right), \tag{3}$$

where $E\left(q_2\left(p_1, p_2\right) | \theta_2\right)$ represents the expected quantity of $M_2 - R_2$, which is conditional on its own retail costs θ_2 whose realization is private information. The two competing supply hierarchies do not know the cost of each other but, as stressed before, costs are (weakly) positively correlated.[9]

Contracting In line with the main literature on competing supply hierarchies (e.g., Gal-Or 1999; Martimort 1996; Martimort and Piccolo 2010, Kastl et al. 2011), bilateral contracting within the hierarchy is secret. We invoke the revelation principle (e.g., Myerson 1982) in order

[8] In a similar vein, Farrell and Shapiro (1990) suggest the criterion of joint profits to derive the equilibrium ownership stake. This approach also reflects the practice of takeovers and acquisitions. For instance, in the US a bidder that makes an offer to purchase less than 100% of the shares of a firm must accept all shares tendered on a pro-rated basis. For additional details about the takeover process, we refer to Hunt (2009, p. 524).

[9] As it will become clear later, since $M_2 - R_2$ is vertically integrated, our results fully carry over even when the upstream manufacturer M_2 does not know the costs of its downstream division R_2. Moreover, even though we allow for (possibly) different probability distributions for θ_1 and θ_2, we adopt the same expectation operator $E(.)$ to simplify notation.

to characterize the set of incentive feasible allocations. In our setting, this means that, for any strategy choice of $M_2 - R_2$, there is no loss of generality in deriving the best response of M_1 within the class of direct incentive compatible mechanisms. Specifically, manufacturer M_1 offers its retailer R_1 a direct contract menu $\left\{t_1\left(\widehat{\theta}_1\right), p_1\left(\widehat{\theta}_1\right)\right\}_{\widehat{\theta}_1 \in \{\theta_l, \theta_h\}}$, which determines a fixed franchise fee $t_1(.)$ and a retail price $p_1(.)$ contingent on the retailer's report $\widehat{\theta}_1 \in \{\theta_l, \theta_h\}$ about its costs. This contract menu must be incentive compatible, namely, it must induce the retailer to report truthfully its costs, which implies $\widehat{\theta}_1 = \theta_1$ in equilibrium.[10]

It is worth noting that this contract mechanism is incomplete, since manufacturer M_1 cannot contract upon the retail price of the competitor $M_2 - R_2$.[11] This assumption, which is familiar in the literature (e.g., Gal-Or 1991a, 1991b, 1992, 1999; Martimort 1996; Martimort and Piccolo 2010; Kastl et al. 2011), can be justified on several grounds. For instance, a contract contingent on the retail price of the competitor may be condemned as collusive practice by antitrust authorities.[12]

Timing The sequence of events unfolds as follows.

(I) M_1 decides on what ownership stake $\rho \in [0, 1]$ to acquire in R_1.

(II) R_1 and $M_2 - R_2$ privately learn their respective retail costs $\theta_1 \in \{\theta_l, \theta_h\}$ and θ_2.

(III) M_1 secretly makes an offer $\left\{t_1\left(\widehat{\theta}_1\right), p_1\left(\widehat{\theta}_1\right)\right\}_{\widehat{\theta}_1 \in \{\theta_l, \theta_h\}}$ to R_1. The offer can be either rejected or accepted by R_1.[13] If the offer is rejected, each firm obtains its outside option (normalized to zero), while $M_2 - R_2$ acts as a monopolist. If the offer is accepted, R_1 picks one element within the contract menu by sending a report $\widehat{\theta}_1 \in \{\theta_l, \theta_h\}$ about the realized retail costs. Price competition with $M_2 - R_2$ takes place and payments are made.

The solution concept we adopt is Perfect Bayesian Equilibrium, with the additional "passive beliefs" refinement (e.g., Martimort 1996; Martimort and Piccolo 2010, Kastl et al. 2011). Whenever R_1 receives an unexpected offer from M_1, it does not change its beliefs about the

[10] Since the manufacturer can obtain (a part of) the retailer's profits, it might infer the value of the retail costs and design a penalty which extracts all profits of the retailer following from cost misreporting. However, this penalty is unfeasible under a range of reasonable circumstances. The profit realization may be affected by random shocks (occurring after firms' decisions take place) which prevent the detection of the true costs. In the presence of limited liability, it would be hard to implement a fine which deters cost misreporting. Furthermore, the fine implemented by the manufacturer would have the only effect of expropriating the profits of the other shareholders of the retailer. This would be interpreted as a violation of their rights and condemned by antitrust authorities.

[11] Similarly, the contract cannot be made contingent on any report from $M_2 - R_2$ about its retail costs.

[12] Alternatively, the retail price charged by the rival can be hard to observe or verify because of the lack of the proper auditing rights. We refer to Martimort (1996) for a discussion of this assumption.

[13] This is justified in the literature by assuming that a retailer is selected from a very large population of (equally ex ante efficient) potential firms, so that the manufacturer can dictate the terms of trade in the contract.

equilibrium strategy of $M_2 - R_2$.

Proceeding backward, we first compute the retail prices in the competition stage for a given ownership stake. Afterwards, we derive the equilibrium ownership stake.

4. Benchmark: manufacturer fully informed about its retail costs

To better appreciate how the strategic value of partial ownership arrangements follows from the presence of asymmetric information, we first consider the benchmark case where manufacturer M_1 is fully informed about its retail costs.

We formalize the main results in the following lemma.

Lemma 1 *If manufacturer M_1 is fully informed about the costs θ_1 of its retailer R_1, the equilibrium retail price p_i^{fi}, $i = 1, 2$, satisfies*

$$E\left(q_i\left(p_i^{fi}, p_{-i}^{fi}\right)|\theta_i\right) + \left(p_i^{fi} - \theta_i\right)\frac{\partial E\left(q_i\left(p_i^{fi}, p_{-i}^{fi}\right)|\theta_i\right)}{\partial p_i} = 0. \tag{4}$$

The equilibrium ownership stake that M_1 holds in R_1 is any $\rho \in [0, 1]$.

The retail price of each supply hierarchy is set above marginal costs in order to equate (expected) marginal revenues with (expected) marginal costs from retailing.

The problem of manufacturer M_1 reduces to the problem of the vertical structure $M_2 - R_2$. Since contracting is secret and cannot be used for strategic purposes, a fully informed manufacturer using non-linear contracts finds it optimal to fully remove the double marginalization problem by making its retailer residual claimant for the hierarchy's total profits, which are extracted through a fixed fee. As a result, the manufacturer achieves the outcome of full integration irrespective of the ownership stake ρ, and the choice about the degree of vertical integration is inconsequential.

This conclusion does not hold any longer in the presence of asymmetric information.

5. The case of asymmetric information

We now consider the setting where retailer R_1 privately knows its costs. As discussed in Section 3, manufacturer M_1 can restrict attention to a direct incentive compatible contract menu $\left\{t_1\left(\widehat{\theta}_1\right), p_1\left(\widehat{\theta}_1\right)\right\}_{\widehat{\theta}_1 \in \{\theta_l, \theta_h\}}$ which induces retailer R_1 to truthfully reveal its costs, i.e., $\widehat{\theta}_1 = \theta_1$.

This contract menu can be written as $\{(t_{1l}, p_{1l}), (t_{1h}, p_{1h})\}$, where (t_{1l}, p_{1l}) and (t_{1h}, p_{1h}) represent the contracts designed for the efficient and inefficient retailer, with costs θ_l and θ_h respectively.

5.1. The competition stage

We first derive the retail prices for a given ownership stake. In addition to the participation constraints $\pi_{R_{1l}} \geq 0$ and $\pi_{R_{1h}} \geq 0$ for the efficient and inefficient retailer respectively, the contract offered by manufacturer M_1 to retailer R_1 must satisfy the following incentive compatibility constraints

$$\begin{aligned}
\pi_{R_{1l}} &= p_{1l} E\left(q_1\left(p_{1l}, p_2\right) | \theta_l\right) - \theta_l E\left(q_1\left(p_{1l}, p_2\right) | \theta_l\right) - t_{1l} \\
&\geq p_{1h} E\left(q_1\left(p_{1h}, p_2\right) | \theta_l\right) - \theta_l E\left(q_1\left(p_{1h}, p_2\right) | \theta_l\right) - t_{1h} \\
&= \pi_{R_{1h}} + p_{1h}\left[E\left(q_1\left(p_{1h}, p_2\right) | \theta_l\right) - E\left(q_1\left(p_{1h}, p_2\right) | \theta_h\right)\right] \\
&+ \theta_h E\left(q_1\left(p_{1h}, p_2\right) | \theta_h\right) - \theta_l E\left(q_1\left(p_{1h}, p_2\right) | \theta_l\right) \\
&= \pi_{R_{1h}} + \Delta\theta E\left(q_1\left(p_{1h}, p_2\right) | \theta_h\right) - \left(p_{1h} - \theta_l\right)\left[E\left(q_1\left(p_{1h}, p_2\right) | \theta_h\right) - E\left(q_1\left(p_{1h}, p_2\right) | \theta_l\right)\right]
\end{aligned} \tag{5}$$

$$\begin{aligned}
\pi_{R_{1h}} &= p_{1h} E\left(q_1\left(p_{1h}, p_2\right) | \theta_h\right) - \theta_h E\left(q_1\left(p_{1h}, p_2\right) | \theta_h\right) - t_{1h} \\
&\geq p_{1l} E\left(q_1\left(p_{1l}, p_2\right) | \theta_h\right) - \theta_h E\left(q_1\left(p_{1l}, p_2\right) | \theta_h\right) - t_{1l} \\
&= \pi_{R_{1l}} + p_{1l}\left[E\left(q_1\left(p_{1l}, p_2\right) | \theta_h\right) - E\left(q_1\left(p_{1l}, p_2\right) | \theta_l\right)\right] \\
&+ \theta_l E\left(q_1\left(p_{1l}, p_2\right) | \theta_l\right) - \theta_h E\left(q_1\left(p_{1l}, p_2\right) | \theta_h\right) \\
&= \pi_{R_{1l}} - \Delta\theta E\left(q_1\left(p_{1l}, p_2\right) | \theta_l\right) + \left(p_{1l} - \theta_h\right)\left[E\left(q_1\left(p_{1l}, p_2\right) | \theta_h\right) - E\left(q_1\left(p_{1l}, p_2\right) | \theta_l\right)\right].
\end{aligned} \tag{6}$$

Conditions (5) and (6) ensure that retailer R_1 does not benefit from misreporting its costs.

The participation constraint $\pi_{R_{1h}} \geq 0$ for the inefficient retailer and the incentive constraint (5) for the efficient retailer are binding at the optimal contract.[14] Substituting these binding constraints, M_1's problem of maximizing its (expected) profits in (2) can be formulated in the

[14] Otherwise, manufacturer M_1 could increase the franchise fee and be better off. We check in the proof of Proposition 1 in the Appendix that the two remaining constraints are satisfied in equilibrium.

following way

$$\begin{aligned}
&\max_{p_{1l},p_{1h}} \nu \{p_{1l}E\left(q_1\left(p_{1l},p_2\right)|\theta_l\right) - \theta_l E\left(q_1\left(p_{1l},p_2\right)|\theta_l\right) - (1-\rho) \\
&\times [\Delta\theta E\left(q_1\left(p_{1h},p_2\right)|\theta_h\right) - \left(p_{1h}-\theta_l\right)\left(E\left(q_1\left(p_{1h},p_2\right)|\theta_h\right) - E\left(q_1\left(p_{1h},p_2\right)|\theta_l\right)\right)]\} \\
&+ (1-\nu)\{p_{1h}E\left(q_1\left(p_{1h},p_2\right)|\theta_h\right) - \theta_h E\left(q_1\left(p_{1h},p_2\right)|\theta_h\right)\}, \qquad (7)
\end{aligned}$$

where the two expressions in curly brackets are the manufacturer's profits generated with the efficient and inefficient retailer, respectively.

Using (3), the problem of the vertical structure $M_2 - R_2$ is

$$\max_{p_2} p_2 E\left(q_2\left(p_1,p_2\right)|\theta_2\right) - \theta_2 E\left(q_2\left(p_1,p_2\right)|\theta_2\right). \qquad (8)$$

We now derive the retail prices for a given ownership stake ρ.

Proposition 1 *If retailer R_1 is privately informed about its costs $\theta_1 \in \{\theta_l, \theta_h\}$, the retail price charged by R_1 is $p_1^{ai} \in \left\{p_{1l}^{ai}, p_{1h}^{ai}\right\}$, where p_{1l}^{ai} and p_{1h}^{ai} satisfy respectively*

$$E\left(q_1\left(p_{1l}^{ai},p_2^{ai}\right)|\theta_l\right) + \left(p_{1l}^{ai}-\theta_l\right)\frac{\partial E\left(q_1\left(p_{1l}^{ai},p_2^{ai}\right)|\theta_l\right)}{\partial p_1} = 0 \qquad (9)$$

$$\begin{aligned}
&E\left(q_1\left(p_{1h}^{ai},p_2^{ai}\right)|\theta_h\right) + \left(p_{1h}^{ai}-\theta_h\right)\frac{\partial E\left(q_1\left(p_{1h}^{ai},p_2^{ai}\right)|\theta_h\right)}{\partial p_1} - \phi(\nu)(1-\rho) \\
&\times \left[\Delta\theta \frac{\partial E\left(q_1\left(p_{1h}^{ai},p_2^{ai}\right)|\theta_h\right)}{\partial p_1} - E\left(q_1\left(p_{1h}^{ai},p_2^{ai}\right)|\theta_h\right) + E\left(q_1\left(p_{1h}^{ai},p_2^{ai}\right)|\theta_l\right)\right. \\
&\left. - \left(p_{1h}^{ai}-\theta_l\right)\left(\frac{\partial E\left(q_1\left(p_{1h}^{ai},p_2^{ai}\right)|\theta_h\right)}{\partial p_1} - \frac{\partial E\left(q_1\left(p_{1h}^{ai},p_2^{ai}\right)|\theta_l\right)}{\partial p_1}\right)\right] = 0, \qquad (10)
\end{aligned}$$

with $\phi(\nu) \equiv \frac{\nu}{1-\nu}$. Furthermore, the retail price p_2^{ai} charged by the supply hierarchy $M_2 - R_2$ satisfies

$$E\left(q_2\left(p_1^{ai},p_2^{ai}\right)|\theta_2\right) + \left(p_2^{ai}-\theta_2\right)\frac{\partial E\left(q_2\left(p_1^{ai},p_2^{ai}\right)|\theta_2\right)}{\partial p_2} = 0. \qquad (11)$$

This yields the following lemma.

Lemma 2 *It holds that (i) $\frac{\partial p_{1l}^{ai}}{\partial \rho} < 0$, (ii) $\frac{\partial p_{1h}^{ai}}{\partial \rho} < 0$, (iii) $\frac{\partial p_2^{ai}}{\partial \rho} < 0$.*

Under asymmetric information, the efficient retailer commands some informational rents in (5) which, as (7)) reveals, are costly for manufacturer M_1 when it does not full internalize the retailer's profits, i.e., $\rho < 1$. To reduce these rents, the price in (10) of the inefficient retailer is distorted above the full information level, which generates allocative costs within the supply hierarchy.[15] The magnitude of this form of double marginalization from asymmetric information depends on the ownership stake ρ that determines M_1's degree of internalization of R_1's profits. As Lemma 2 indicates, higher values for ρ translate into a lower price of the inefficient retailer, since M_1 internalizes to a larger extent R_1's profits. In particular, with a full acquisition of R_1 ($\rho = 1$), M_1 maximizes joint profits in (7) and R_1's rents are not costly any longer. This fully removes the informational costs and the retail price reflects its full information level in (4).

The best response function of the efficient retailer coincides with that under full information. This is because the informational rents in (5) are independent of the price of the efficient retailer and therefore manufacturer M_1 does not find it profitable to implement any distortion. However, the price in (9) charged by the efficient retailer generally differs from the price in (4) under full information if $\rho < 1$. To understand the rationale for this result, consider the price in (11) charged by $M_2 - R_2$.[16] Given strategic complementarity in prices, a lower value for ρ, which entails an increase in the price charged by the inefficient retailer, induces $M_2 - R_2$ to set a higher price, as shown in Lemma 2. The efficient retailer also increases its price in response to the higher price charged by the competitor.

It is worth noting that this result depends on the fact that $M_2 - R_2$ cannot distinguish between the efficient and inefficient retailer and therefore it determines its price on the basis of the (conditional) expectation about the rival's retail costs. As we will see in Section 5, when costs are perfectly correlated, $M_2 - R_2$ certainly knows the rival's costs, and therefore it does not distort its price when the retailer is efficient. As a consequence, in this case both the price of $M_2 - R_2$ and the price of the efficient retailer reflect their full information values.

5.2. The equilibrium ownership stake

Having derived the retail prices for a given ownership stake of manufacturer M_1 in its retailer R_1, we can go back to the first stage of the game and determine the equilibrium ownership

[15] The expression in square brackets in (10) is negative. This result is reminiscent of the rent extraction-efficiency trade-off in optimal regulation (e.g., Baron and Myerson 1982).

[16] The best response function of $M_2 - R_2$ is also the same as under full information. This result would apply even under asymmetric information within the vertical structure, since manufacturer M_2, which maximizes joint profits, would not find it profitable to distort the price of its privately informed division R_2.

stake. Since M_1 chooses how much of R_1 to acquire in order to maximize joint profits, the equilibrium ownership stake is the solution to the following maximization program

$$\max_{\rho\in[0,1]} \nu \left[p_{1l}^{ai}(\rho) E\left(q_1\left(p_{1l}^{ai}(\rho), p_2^{ai}(\rho)\right)|\theta_l\right) - \theta_l E\left(q_1\left(p_{1l}^{ai}(\rho), p_2^{ai}(\rho)\right)|\theta_l\right)\right]$$
$$+(1-\nu)\left[p_{1h}^{ai}(\rho) E\left(q_1\left(p_{1h}^{ai}(\rho), p_2^{ai}(\rho)\right)|\theta_h\right) - \theta_h E\left(q_1\left(p_{1h}^{ai}(\rho), p_2^{ai}(\rho)\right)|\theta_h\right)\right]. \tag{12}$$

We are now in a position to show our main results.

Proposition 2 *If retailer R_1 is privately informed about its costs $\theta_1 \in \{\theta_l, \theta_h\}$, the equilibrium ownership stake that manufacturer M_1 holds in its retailer R_1 is $\rho^{ai} < 1$ whenever market demands are interdependent ($\frac{\partial q_i}{\partial p_{-i}} > 0$). Equivalently, partial vertical integration is more profitable than full vertical integration. Full vertical integration, i.e., $\rho^{ai} = 1$, emerges in equilibrium if and only if market demands are independent ($\frac{\partial q_i}{\partial p_{-i}} = 0$).*

Proposition 2 indicates that, in the presence of asymmetric information, M_1 is no longer indifferent about its ownership stake in R_1. Specifically, when facing competition in the retail market, M_1 finds it desirable to acquire an ownership interest in R_1 which is strictly lower than full ownership, i.e., $\rho^{ai} < 1$. We know from the discussion following Proposition 1 that a partial misalignment between profit objectives within the partially integrated hierarchy induces a higher retail price of the inefficient retailer to reduce the (costly) informational rents to the efficient retailer. For a given price charged by the competitor $M_2 - R_2$, this form of double marginalization from asymmetric information reduces the efficiency of the supply hierarchy $M_1 - R_1$. These informational costs constitute what we call *information vertical effect.*

In the presence of price competition, this effect translates into an opposite *competition horizontal effect.* The partially integrated hierarchy $M_1 - R_1$ commits to a higher retail price than under full integration, which induces the competitor $M_2 - R_2$ to raise its price as well. Consequently, partial vertical integration acts as a strategic device to relax competition.

The equilibrium degree of integration trades off the benefits of softer competition against the informational costs. Only if markets are independent and therefore there is no benefit of softer competition, a pattern of full vertical integration that completely removes informational costs is clearly preferable. In the sequel, using explicit functions, we derive the equilibrium degree of vertical integration.

6. An illustrative example

For the sake of concreteness, we now consider a setting with explicit functions. Specifically, the consumer demand takes the following linear form

$$q_{R_i} = \alpha - \beta p_{R_i} + \gamma p_{R_{-i}}, \tag{13}$$

where α and β are positive parameters, and $\gamma \in [0, \beta)$ denotes the degree of substitutability between goods.[17] The profits of retailer R_1, manufacturer M_1, and the vertical structure $M_2 - R_2$ are respectively given by (1), (2), and (3), with retail costs being now perfectly correlated, i.e., $\theta_1 = \theta_2 \in \{\theta_l, \theta_h\}$.

The following lemma collects the main results with a fully informed manufacturer.

Lemma 3 *If manufacturer M_1 is fully informed about the costs θ_1 of its retailer R_1, the equilibrium retail price p_i^{fi}, $i = 1, 2$, is*

$$p_i^{fi} = \frac{\alpha + \beta\theta_i}{2\beta - \gamma}. \tag{14}$$

The equilibrium ownership stake that M_1 holds in R_1 is any $\rho \in [0, 1]$.

We know from Lemma 1 that, in the absence of asymmetric information, retail prices are set efficiently. As costs are perfectly correlated, the equilibrium prices in (14) charged by the two supply hierarchies coincide.

We now turn to the problem under asymmetric information. Substituting (13) into (5) and (6), the incentive compatibility constraints can be written as

$$\begin{aligned}
\pi_{R_{1l}} &= p_{1l} (\alpha - \beta p_{1l} + \gamma p_{2l}) - \theta_l (\alpha - \beta p_{1l} + \gamma p_{2l}) - t_{1l} \\
&\geq p_{1h} (\alpha - \beta p_{1h} + \gamma p_{2l}) - \theta_l (\alpha - \beta p_{1h} + \gamma p_{2l}) - t_{1h} \\
&= \pi_{R_{1h}} + \gamma p_{1h} (p_{2l} - p_{2h}) + \theta_h (\alpha - \beta p_{1h} + \gamma p_{2h}) - \theta_l (\alpha - \beta p_{1h} + \gamma p_{2l}) \\
&= \pi_{R_{1h}} + \Delta\theta (\alpha - \beta p_{1h} + \gamma p_{2h}) - \gamma (p_{2h} - p_{2l}) (p_{1h} - \theta_l)
\end{aligned} \tag{15}$$

[17] The system of demands in (13) follows from the optimization problem of a unit mass of identical consumers with a quasi-linear utility function $y + U(q_1, q_2)$, where y is the Hicksian composite commodity and $U(q_1, q_2) = a(q_1 + q_2) - \frac{1}{2}\left(bq_1^2 + bq_2^2 + 2gq_1q_2\right)$, with $a > 0$, $b > g \geq 0$, and $\alpha \equiv \frac{a(b-g)}{b^2-g^2}$, $\beta \equiv \frac{b}{b^2-g^2}$, $\gamma \equiv \frac{g}{b^2-g^2}$ (e.g., Vives 1999, Ch. 6).

$$
\begin{aligned}
\pi_{R_{1h}} &= p_{1h}\left(\alpha - \beta p_{1h} + \gamma p_{2h}\right) - \theta_h\left(\alpha - \beta p_{1h} + \gamma p_{2h}\right) - t_{1h} \\
&\geq p_{1l}\left(\alpha - \beta p_{1l} + \gamma p_{2h}\right) - \theta_h\left(\alpha - \beta p_{1l} + \gamma p_{2h}\right) - t_{1l} \\
&= \pi_{R_{1l}} + \gamma p_{1l}\left(p_{2h} - p_{2l}\right) - \theta_h\left(\alpha - \beta p_{1l} + \gamma p_{2h}\right) + \theta_l\left(\alpha - \beta p_{1l} + \gamma p_{2l}\right) \\
&= \pi_{R_{1l}} - \Delta\theta\left(\alpha - \beta p_{1l} + \gamma p_{2l}\right) + \gamma\left(p_{2h} - p_{2l}\right)\left(p_{1l} - \theta_h\right), \qquad (16)
\end{aligned}
$$

where p_{1l} and p_{1h} are the retail prices charged by R_1, while p_{2l} and p_{2h} are the prices charged by $M_2 - R_2$, with costs θ_l and θ_h respectively. Under perfect cost correlation, R_1 and $M_2 - R_2$ certainly know the costs of each other.

As in Section 5, we first derive the retail prices for a given ownership stake ρ.

Proposition 3 *If retailer R_1 is privately informed about its costs $\theta_1 \in \{\theta_l, \theta_h\}$, the retail price charged by R_1 is $p_1^{ai} \in \left\{p_{1l}^{ai}, p_{1h}^{ai}\right\}$, where*

$$
p_{1l}^{ai} = \frac{\alpha + \beta\theta_l}{2\beta - \gamma} \qquad (17)
$$

$$
p_{1h}^{ai} = \frac{\left(\alpha + \beta\theta_h\right)\left(4\beta^2 - \gamma^2\right) + \phi\left(\nu\right)\left(1 - \rho\right)\left[4\beta^3\Delta\theta - \gamma^2\left(\alpha + \beta\theta_h\right)\right]}{\left(2\beta - \gamma\right)\left[4\beta^2 - \gamma^2\left(1 + \phi\left(\nu\right)\left(1 - \rho\right)\right)\right]}, \qquad (18)
$$

with $\phi\left(\nu\right) \equiv \frac{\nu}{1-\nu}$. Furthermore, the retail price charged by the supply hierarchy $M_2 - R_2$ is $p_2^{ai} \in \left\{p_{2l}^{ai}, p_{2h}^{ai}\right\}$, where

$$
p_{2l}^{ai} = \frac{\alpha + \beta\theta_l}{2\beta - \gamma} \qquad (19)
$$

$$
p_{2h}^{ai} = \frac{\left(\alpha + \beta\theta_h\right)\left(4\beta^2 - \gamma^2\right) + \gamma\phi\left(\nu\right)\left(1 - \rho\right)\left[2\beta^2\Delta\theta - \gamma\left(\alpha + \beta\theta_h\right)\right]}{\left(2\beta - \gamma\right)\left[4\beta^2 - \gamma^2\left(1 + \phi\left(\nu\right)\left(1 - \rho\right)\right)\right]}. \qquad (20)
$$

Proposition 3 illustrates with explicit results the main insights gleaned from Proposition 1. We know that the best response functions of the efficient retailer R_1 and of the vertical structure $M_2 - R_2$ coincide with those under full information. Note that the prices in (17) and (19) reflect their full information values in (4). With perfectly correlated costs, $M_2 - R_2$ certainly knows whether it faces the efficient retailer, whose price is not distorted for rent reduction purposes. Therefore, their prices are the same as under full information.

Conversely, the price in (18) charged by the inefficient retailer can be inflated above the full information level to reduce the informational rents to the efficient retailer. The price difference between (18) and (14) amounts to $\frac{4\beta^3\Delta\theta\phi(\nu)(1-\rho)}{(2\beta-\gamma)[4\beta^2-\gamma^2(1+\phi(1-\rho))]} \geq 0$, which vanishes if and only if $\rho = 1$. This measures the impact of the ownership stake on retail pricing. Differentiating (18) yields

$$\frac{\partial p_{1h}^{ai}}{\partial \rho} = -\frac{4\beta^3\left(2\beta-\gamma\right)\Delta\theta\phi\left(\nu\right)}{\left[4\beta^2-\gamma^2\left(1+\phi\left(\nu\right)\left(1-\rho\right)\right)\right]^2} < 0, \tag{21}$$

namely, a lower ownership stake ρ exacerbates the price upward distortion. This is because M_1 internalizes to a lesser extent the profits in (15) of the efficient retailer and therefore is more inclined to curb these profits via a price increase. For a given price charged by the competitor $M_2 - R_2$, the supply hierarchy $M_1 - R_1$ becomes more inefficient, since it obtains lower joint profits. However, in the presence of price competition, the rival $M_2 - R_2$ responds to a price change by adjusting its price in the same direction. In particular, differentiating (20) yields

$$\frac{\partial p_{2h}^{ai}}{\partial \rho} = -\gamma\frac{4\beta^2\left(2\beta-\gamma\right)\Delta\theta\phi\left(\nu\right)}{\left[4\beta^2-\gamma^2\left(1+\phi\left(\nu\right)\left(1-\rho\right)\right)\right]^2} < 0 \tag{22}$$

for $\gamma > 0$. A lower ownership stake of M_1 in R_1 translates into higher retail prices for both supply hierarchies. Note from (21) and (22) that the price response of $M_2 - R_2$ to a change in ρ is smoother than the price response of $M_1 - R_1$. Hence, even though the two supply hierarchies share the same retail costs, $M_1 - R_1$ is weaker vis-à-vis its rival, since the price in (18) is higher than the price in (20) for $\rho < 1$.

The following proposition illustrates the result of the trade-off between the benefits of softer competition and the informational costs.

Proposition 4 *If retailer R_1 is privately informed about its costs $\theta_1 \in \{\theta_l, \theta_h\}$, the equilibrium ownership stake that manufacturer M_1 holds in its retailer R_1 is*

$$\rho^{ai} = 1 - \frac{\gamma^2\left(4\beta^2-\gamma^2\right)\left(\alpha-\left(\beta-\gamma\right)\theta_h\right)}{\phi\left(\nu\right)\left[8\beta^3\Delta\theta\left(2\beta^2-\gamma^2\right)+\gamma^4\left(\alpha-\left(\beta-\gamma\right)\theta_h\right)\right]}. \tag{23}$$

It holds $\rho^{ai} < 1$ whenever market demands are interdependent ($\gamma \neq 0$). In particular, we have

(i) partial vertical integration, i.e., $\rho^{ai} \in (0,1)$, if $\phi\left(\nu\right) > \frac{\gamma^2\left(4\beta^2-\gamma^2\right)\left(\alpha-\left(\beta-\gamma\right)\theta_h\right)}{8\beta^3\Delta\theta\left(2\beta^2-\gamma^2\right)+\gamma^4\left(\alpha-\left(\beta-\gamma\right)\theta_h\right)}$;

(ii) full vertical separation, i.e., $\rho^{ai} = 0$, otherwise.

Full vertical integration, i.e., $\rho^{ai} = 1$, is preferable if and only if market demands are independent ($\gamma = 0$).

Proposition 4 indicates that, when market demands are interdependent, M_1 finds it optimal to partially integrate with R_1 if the retailer is relatively likely to be efficient ($\phi(\nu)$ increases with ν). A higher probability ν of the efficient retailer translates into larger expected (costly) informational rents and therefore higher informational costs within the hierarchy. If ν is high enough, M_1 is induced to acquire a partial financial interest in R_1, which mitigates the informational distortions. For lower values of ν, the informational costs within the hierarchy are relatively small. In this case, M_1 fully separates from R_1 and benefits from softer competition by committing to the highest possible prices. Conversely, a pattern of full integration, which completely removes the informational costs, is optimal if and only if the hierarchy acts as a monopolist, since there is no benefit of relaxing competition.

Note from (23) that an increase in the spread of retail cost distribution $\Delta\theta$ results in a higher ρ^{ai}. When the asymmetric information problem is more severe, the higher informational costs associated with R_1's rents induce M_1 to mitigate these costs through a larger degree of vertical integration.

The result in Proposition 4 that the ownership stake of M_1 in R_1 is lower than 100% holds whenever market demands are interdependent ($\gamma \neq 0$). Hence, partial vertical integration can emerge in the presence of complementary goods ($\gamma < 0$), which entail strategic substitutability in prices in a linear demand setting. As (21) and (22) indicate, a higher price of the inefficient retailer R_1 arising from a lower ownership stake than under full integration translates now into a lower price for the complementary good provided by $M_2 - R_2$. This stimulates the output of $M_1 - R_1$, which is therefore better off.

7. Robustness

We now discuss some assumptions of the model to gain insights into the robustness of the results.

7.1. Derivation of the equilibrium value for the ownership stake

Following the main literature on partial ownership, we have derived the equilibrium ownership stake of M_1 in R_1 from the joint profit maximization problem. As discussed in Section 3, this ensures that M_1 can design an offer to R_1 which makes the shareholders in both firms better off, so that they will find it mutually profitable to accept this offer. We now examine the case in which M_1, instead of caring about joint profits, chooses ρ in order to maximize the profits in (2) it expects from the relationship with R_1. Using (2) and the binding condition for R_1's profits in (5), the equilibrium value for ρ is solution to the following maximization problem

$$\begin{aligned}
&\max_{\rho\in[0,1]} \nu \left\{p_{1l}^{ai}(\rho) E\left(q_1\left(p_{1l}^{ai}(\rho), p_2^{ai}(\rho)\right)|\theta_l\right) - \theta_l E\left(q_1\left(p_{1l}^{ai}(\rho), p_2^{ai}(\rho)\right)|\theta_l\right)\right. \\
&- (1-\rho)\left[\Delta\theta E\left(q_1\left(p_{1h}^{ai}(\rho), p_2^{ai}(\rho)\right)|\theta_h\right)\right. \\
&\left.\left.- \left(p_{1h}^{ai}(\rho) - \theta_l\right)\left[E\left(q_1\left(p_{1h}^{ai}(\rho), p_2^{ai}(\rho)\right)|\theta_h\right) - E\left(q_1\left(p_{1h}^{ai}(\rho), p_2^{ai}(\rho)\right)|\theta_l\right)\right]\right\}\right. \\
&+ (1-\nu)\left[p_{1h}^{ai}(\rho) E\left(q_1\left(p_{1h}^{ai}(\rho), p_2^{ai}(\rho)\right)|\theta_h\right) - \theta_h E\left(q_1\left(p_{1h}^{ai}(\rho), p_2^{ai}(\rho)\right)|\theta_h\right)\right]. \qquad (24)
\end{aligned}$$

This yields the following result.

Proposition 5 *Suppose that manufacturer M_1 chooses the ownership stake ρ in its retailer R_1 to maximize the profits in (2) rather than joint profits. If the probability of the efficient retailer ν is relatively low and market demands are interdependent ($\frac{\partial q_i}{\partial p_{-i}} > 0$), then the equilibrium ownership stake is $\rho^{ai} < 1$.*

Proposition 5 shows that, under certain circumstances, partial integration is more profitable than full integration even though it is not the result of joint profit maximization. Specifically, M_1 does not acquire full ownership in R_1 when the efficient retailer is relatively unlikely and therefore its (expected) informational rents are not too costly. A manufacturer which only cares about its own profits when deciding on the ownership stake overestimates the informational costs relative to a joint profit maximizer, since it takes also into consideration the fact that it is not able to fully extract the profits of its retailer. As a result, a full integration pattern which mitigates the informational costs may be preferred if the probability of the efficient retailer is relatively high.

7.2. Fully integrated competitor

Another assumption that deserves further discussion is that M_1 faces the fully integrated competitor $M_2 - R_2$ when deciding on the ownership stake in R_1. Note that this modeling choice allows the investigation of the unilateral incentive to partially integrate in a setting which is biased in favor of the decision of full integration. The vertical structure $M_2 - R_2$ does not have any negative externality from asymmetric information and can only benefit from M_1's higher price. This clearly mitigates M_1's incentive to incur informational costs to commit to a higher price.

A more symmetric framework where both supply hierarchies are allowed to choose the ownership stake in their retailers would facilitate a commitment to higher prices via partial ownership agreements, which strengthens the outcome of partial vertical integration.

7.3. Resale price maintenance

The contract that manufacturer M_1 offers to the retailer R_1 directly specifies the retail price, which is known as resale price maintenance. Even though this type of vertical arrangements is sometimes viewed with skepticism by the antitrust authorities, some countries (e.g., New Zealand) traditionally allow this practice if the beneficial effects can be shown to outweigh the anticompetitive harm. In the 2007 case "Leegin Creative Leather Products, Inc., vs. PSKS, Inc." the US Supreme Court held that resale price maintenance agreements are not per se unlawful, but must be judged under a "rule of reason", which allows a firm to produce evidence that an individual resale price maintenance agreement is justified.[18]

Remarkably, our qualitative results do not depend on the use of resale price maintenance agreements. For instance, consider a contract which stipulates a two-part tariff with a unit input price and a fixed fee the retailer pays to the manufacturer. In the presence of asymmetric information, the manufacturer is inclined to distort upward the unit input price in order to reduce the informational rents to the efficient retailer, according to the ownership stake acquired by the manufacturer in the retailer. This results in a higher retail price, which yields the trade-off investigated in the paper.

8. Antitrust policy implications

Our analysis emphasizes the strategic use of partial ownership arrangements to relax competition. Despite the huge empirical literature on vertical integration (exhaustively surveyed by Lafontaine and Slade 2007), more research is warranted on the impact of the firms' organizational structure on competition. Using appropriate econometric techniques, the predictions of our model lend themselves for an empirically testable validation.

Our results recommend careful investigations into partial ownership agreements that can

[18] There is also some empirical evidence about the presence of resale price maintenance arrangements in Europe (see Bonnet and Bubois (2010) for the French water industry).

facilitate a dampening of competition. Furthermore, takeover regulations could facilitate full acquisitions relative to partial equity holdings. Antitrust authorities should allow partial ownership agreements when efficiency benefits (for instance, in terms of cost savings) are expected to offset the anticompetitive effects of firms' strategic behavior.

Partial ownership agreements for strategic purposes will typically emerge in markets characterized by price competition. Therefore, we do not generally expect any strategic partial ownership when severe capacity constraints induce Cournot competition. This is because the partially integrated hierarchy's output reduction to curb informational rents entails a more aggressive behavior of the rival.

9. Concluding remarks

In this paper we have investigated the scope for partial ownership agreements in vertically related markets where two manufacturer-retailer pairs engage in differentiated good price competition and retailers are privately informed about their production costs.

A partial ownership stake of a manufacturer in its retailer, which introduces a misalignment between profit objectives of the two firms, entails an upward price distortion for the inefficient retailer to reduce the (costly) informational rents to the efficient retailer. This form of double marginalization from asymmetric information reduces the supply hierarchy's efficiency for a given price of the competitor.

This information vertical effect translates into an opposite competition horizontal effect. The hierarchy's commitment to a higher price induces the rival to increase its price, which relaxes competition. The equilibrium degree of vertical integration trades off the benefits of softer competition against the informational costs.

Our analysis explores the strategic incentive for partial vertical ownership and gives recommendations to the antitrust authorities when investigating mergers and acquisitions in vertically related markets.

Appendix

This appendix collects the proofs.

Proof of Lemma 1. Substituting t_1 with π_{R_1} from (1), M_1's problem of maximizing (2) can be written as

$$\max_{p_1,\pi_{R_1}} p_1 E\left(q_1\left(p_1,p_2\right)|\theta_1\right) - \theta_1 E\left(q_1\left(p_1,p_2\right)|\theta_1\right) - (1-\rho)\,\pi_{R_1}$$

$$s.t. \quad \pi_{R_1} \geq 0,$$

where the constraint ensures the participation of R_1 in the contractual relationship with M_1. Since the maximand decreases with π_{R_1} for any $\rho \in [0,1]$, we have $\pi_{R_1} = 0$ in equilibrium. Taking the first-order condition for p_1 yields $E\left(q_1\left(p_1,p_2\right)|\theta_1\right) + \left(p_1-\theta_1\right)\frac{\partial E\left(q_1\left(p_1,p_2\right)|\theta_1\right)}{\partial p_1} = 0$.

Using (3), the problem of $M_2 - R_2$ is

$$\max_{p_2} p_2 E\left(q_2\left(p_1,p_2\right)|\theta_2\right) - \theta_2 E\left(q_2\left(p_1,p_2\right)|\theta_2\right),$$

which entails $E\left(q_2\left(p_1,p_2\right)|\theta_2\right) + \left(p_2-\theta_2\right)\frac{\partial E\left(q_2\left(p_1,p_2\right)|\theta_2\right)}{\partial p_2} = 0$. The system of the first-order conditions for M_1 and $M_2 - R_2$ yields the expression in (4). ■

Proof of Proposition 1 . The results in the proposition immediately follow from the first-order conditions for p_{1l} and p_{1h} in the maximization problem in (2), and from the first-order condition for p_2 in the maximization problem in (8). We now show that the incentive constraint (6) is satisfied in equilibrium. Substituting the binding incentive constraint (5) into (6), we obtain

$$\begin{aligned}0 \geq\ & \Delta\theta\left[E\left(q_1\left(p_{1h}^{ai},p_2^{ai}\right)|\theta_h\right) - E\left(q_1\left(p_{1l}^{ai},p_2^{ai}\right)|\theta_l\right)\right] - \left(p_{1h}^{ai}-\theta_l\right)\left[E\left(q_1\left(p_{1h}^{ai},p_2^{ai}\right)|\theta_h\right)\right.\\ &\left.-E\left(q_1\left(p_{1h}^{ai},p_2^{ai}\right)|\theta_l\right)\right] + \left(p_{1l}^{ai}-\theta_h\right)\left[E\left(q_1\left(p_{1l}^{ai},p_2^{ai}\right)|\theta_h\right) - E\left(q_1\left(p_{1l}^{ai},p_2^{ai}\right)|\theta_l\right)\right].\end{aligned}$$

Since we have $E\left(q_1\left(p_{1h}^{ai},p_2^{ai}\right)|\theta_k\right) \approx E\left(q_1\left(p_{1l}^{ai},p_2^{ai}\right)|\theta_k\right) + \frac{\partial E\left(q_1\left(p_{1l}^{ai},p_2^{ai}\right)|\theta_k\right)}{\partial p_1}\left(p_{1h}^{ai}-p_{1l}^{ai}\right)$, $k = l,h$ from Taylor's expansion, this expression can be rewritten after some manipulation in the following way

$$\begin{aligned}0 \geq\ & -E\left(q_1\left(p_{1l}^{ai},p_2^{ai}\right)|\theta_h\right)\left(p_{1h}^{ai}-p_{1l}^{ai}\right) - \frac{\partial E\left(q_1\left(p_{1l}^{ai},p_2^{ai}\right)|\theta_h\right)}{\partial p_1}\left(p_{1h}^{ai}-\theta_h\right)\left(p_{1h}^{ai}-p_{1l}^{ai}\right)\\ &+ E\left(q_1\left(p_{1l}^{ai},p_2^{ai}\right)|\theta_l\right)\left(p_{1h}^{ai}-p_{1l}^{ai}\right) + \frac{\partial E\left(q_1\left(p_{1l}^{ai},p_2^{ai}\right)|\theta_l\right)}{\partial p_1}\left(p_{1h}^{ai}-\theta_l\right)\left(p_{1h}^{ai}-p_{1l}^{ai}\right)\\ &= -\left(p_{1h}^{ai}-p_{1l}^{ai}\right)\left[E\left(q_1\left(p_{1l}^{ai},p_2^{ai}\right)|\theta_h\right) - E\left(q_1\left(p_{1l}^{ai},p_2^{ai}\right)|\theta_l\right)\right.\\ &\left.+\frac{\partial E\left(q_1\left(p_{1l}^{ai},p_2^{ai}\right)|\theta_h\right)}{\partial p_1}\left(p_{1h}^{ai}-\theta_h\right) - \frac{\partial E\left(q_1\left(p_{1l}^{ai},p_2^{ai}\right)|\theta_l\right)}{\partial p_1}\left(p_{1h}^{ai}-\theta_l\right)\right].\end{aligned}$$

The expression in square brackets is (strictly) positive, since $\frac{\partial q_1}{\partial p_2} > 0$, $\frac{\partial^2 q_1}{\partial p_1 \partial p_2} \geq 0$ and costs are (weakly) positively correlated. As $p_{1h}^{ai} - p_{1l}^{ai} > 0$, the constraint (6) is satisfied in equilibrium. Finally, we check that the participation constraint $\pi_{R_{1l}} \geq 0$ is also satisfied in equilibrium. Note from the binding incentive constraint (5) that sufficient (but not necessary) condition for this to be the case is that either the degree of cost correlation or the level substitutability is not too high. ■

Proof of Lemma 2. Denoting by z the left-hand side of (10), the implicit function theorem yields $\frac{\partial p_{1l}^{ai}}{\partial \rho} = -\frac{\partial z\left(p_{1l}^{ai},\rho\right)/\partial \rho}{\partial z\left(p_{1l}^{ai},\rho\right)/\partial p_{1l}}$. Standard computations entail

$$\frac{\partial z\left(p_{1l}^{ai},\rho\right)}{\partial \rho} = E\left(\frac{\partial q_1\left(p_{1l}^{ai},p_2^{ai}\right)}{\partial p_2}\frac{\partial p_2^{ai}}{\partial \rho}|\theta_l\right) + \left(p_{1l}^{ai} - \theta_l\right)E\left(\frac{\partial^2 q_1\left(p_{1l}^{ai},p_2^{ai}\right)}{\partial p_1 \partial p_2}\frac{\partial p_2^{ai}}{\partial \rho}|\theta_l\right) < 0,$$

where the inequality follows from the assumptions on the parameters of the model, $p_{1l}^{ai} - \theta_l > 0$, and $\frac{\partial p_2^{ai}}{\partial \rho} < 0$ (see below). Since $\frac{\partial z\left(p_{1l}^{ai},\rho\right)}{\partial p_{1l}} < 0$ (second-order condition for p_{1l}), it follows that $\frac{\partial p_{1l}^{ai}}{\partial \rho} < 0$.

Denoting by f the left-hand side of (10) yields $\frac{\partial p_{1h}^{ai}}{\partial \rho} = -\frac{\partial f\left(p_{1h}^{ai},\rho\right)/\partial \rho}{\partial f\left(p_{1h}^{ai},\rho\right)/\partial p_{1h}} < 0$, where the inequality follows from $\frac{\partial f\left(p_{1h}^{ai},\rho\right)}{\partial \rho} < 0$ (the term in square brackets in (10) is negative) and $\frac{\partial f\left(p_{1h}^{ai},\rho\right)}{\partial p_{1h}} < 0$ (second-order condition for p_{1h}).

Denoting by g the left-hand side of (11) yields $\frac{\partial p_2^{ai}}{\partial \rho} = -\frac{\partial g\left(p_2^{ai},\rho\right)/\partial \rho}{\partial g\left(p_2^{ai},\rho\right)/\partial p_2}$. We have

$$\frac{\partial g\left(p_2^{ai},\rho\right)}{\partial \rho} = E\left(\frac{\partial q_2\left(p_1^{ai},p_2^{ai}\right)}{\partial p_1}\frac{\partial p_1^{ai}}{\partial \rho}|\theta_2\right) + \left(p_2^{ai} - \theta_2\right)E\left(\frac{\partial^2 q_2\left(p_1^{ai},p_2^{ai}\right)}{\partial p_1 \partial p_2}\frac{\partial p_1^{ai}}{\partial \rho}|\theta_2\right) < 0,$$

where the inequality follows from the assumptions of the model, $p_2^{ai} - \theta_2 > 0$, and $\frac{\partial p_{1l}^{ai}}{\partial \rho} = 0$, $\frac{\partial p_{1h}^{ai}}{\partial \rho} < 0$ for a given p_2. Since $\frac{\partial g\left(p_2^{ai},\rho\right)}{\partial p_2} < 0$ (second-order condition for p_2), it follows that $\frac{\partial p_2^{ai}}{\partial \rho} < 0$. ■

Proof of Proposition 2. Differentiating the objective function (12) with respect to the ownership stake ρ yields

$$\nu\left[\frac{\partial p_{1l}^{ai}}{\partial \rho}E\left(q_1\left(p_{1l}^{ai}\left(\rho\right),p_2^{ai}\left(\rho\right)\right)|\theta_l\right) + \left(p_{1l}^{ai}\left(\rho\right) - \theta_l\right)\frac{\partial E\left(q_1\left(p_{1l}^{ai}\left(\rho\right),p_2^{ai}\left(\rho\right)\right)|\theta_l\right)}{\partial \rho}\right] + (1-\nu)$$
$$\times\left[\frac{\partial p_{1h}^{ai}}{\partial \rho}E\left(q_1\left(p_{1h}^{ai}\left(\rho\right),p_2^{ai}\left(\rho\right)\right)|\theta_h\right) + \left(p_{1h}^{ai}\left(\rho\right) - \theta_h\right)\frac{\partial E\left(q_1\left(p_{1h}^{ai}\left(\rho\right),p_2^{ai}\left(\rho\right)\right)|\theta_h\right)}{\partial \rho}\right].$$

Applying the chain rule yields

$$\frac{\partial E\left(q_1\left(p_{1k}^{ai}(\rho), p_2^{ai}(\rho)\right)|\theta_k\right)}{\partial\rho} = \frac{\partial p_{1k}^{ai}}{\partial\rho}\frac{\partial E\left(q_1\left(p_{1k}^{ai}(\rho), p_2^{ai}(\rho)\right)|\theta_k\right)}{\partial p_1} + E\left[\frac{\partial q_1\left(p_{1k}^{ai}(\rho), p_2^{ai}(\rho)\right)}{\partial p_2}\frac{\partial p_2^{ai}}{\partial\rho}|\theta_k\right], \ k = l, h. \tag{25}$$

Using (25), we find after some manipulation

$$\begin{aligned}
&\nu\left\{\frac{\partial p_{1l}^{ai}}{\partial\rho}\left[E\left(q_1\left(p_{1l}^{ai}(\rho), p_2^{ai}(\rho)\right)|\theta_l\right) + \left(p_{1l}^{ai}(\rho) - \theta_l\right)\frac{\partial E\left(q_1\left(p_{1l}^{ai}(\rho), p_2^{ai}(\rho)\right)|\theta_l\right)}{\partial p_1}\right]\right.\\
&\left.+\left(p_{1l}^{ai}(\rho) - \theta_l\right)E\left[\frac{\partial q_1\left(p_{1l}^{ai}(\rho), p_2^{ai}(\rho)\right)}{\partial p_2}\frac{\partial p_2^{ai}}{\partial\rho}|\theta_l\right]\right\} + (1-\nu)\\
&\times\left\{\frac{\partial p_{1h}^{ai}}{\partial\rho}\left[E\left(q_1\left(p_{1h}^{ai}(\rho), p_2^{ai}(\rho)\right)|\theta_h\right) + \left(p_{1h}^{ai}(\rho) - \theta_h\right)\frac{\partial E\left(q_1\left(p_{1h}^{ai}(\rho), p_2^{ai}(\rho)\right)|\theta_h\right)}{\partial p_1}\right]\right.\\
&\left.+\left(p_{1h}^{ai}(\rho) - \theta_h\right)E\left[\frac{\partial q_1\left(p_{1h}^{ai}(\rho), p_2^{ai}(\rho)\right)}{\partial p_2}\frac{\partial p_2^{ai}}{\partial\rho}|\theta_h\right]\right\}.
\end{aligned} \tag{26}$$

Note from (9) that the expression in the first line of (26) is zero, while the expressions in the second and fourth line are negative as $p_{1l}^{ai} - \theta_l > 0$, $p_{1h}^{ai} - \theta_h > 0$, $\frac{\partial q_1}{\partial p_2} > 0$, and $\frac{\partial p_2^{ai}}{\partial\rho} < 0$ (see the proof of Lemma 2). We find from (10) that the expression in square brackets in the third line is zero at $\rho = 1$, which implies that $\rho < 1$ is optimal. If $\frac{\partial q_1}{\partial p_2} = 0$ (independent demands), the first-order condition (26) is zero for $\rho = 1$, which is optimal (given that the second-order conditions are satisfied). ■

Proof of Lemma 3. Using (1), M_1's problem of maximizing (2) can be written as

$$\begin{aligned}
&\max_{p_{1k},\pi_{R_{1k}}} p_{1k}(\alpha - \beta p_{1k} + \gamma p_{2k}) - \theta_k(\alpha - \beta p_{1k} + \gamma p_{2k}) - (1-\rho)\pi_{R_{1k}}\\
&s.t. \quad \pi_{R_{1k}} \geq 0, \quad k = l, h,
\end{aligned}$$

where the constraint ensures the participation of R_1 (with costs θ_l or θ_h) in the contractual relationship with M_1. Since the maximand is decreasing in $\pi_{R_{1k}}$ for any $\rho \in [0,1]$, we have $\pi_{R_{1k}} = 0$ in equilibrium. After taking the first-order condition for p_{1k} we find $\alpha - 2\beta p_{1k} + \gamma p_{2k} + \beta\theta_k = 0$.

Using (3), the problem of $M_2 - R_2$ is

$$\max_{p_{2k}} p_{2k}(\alpha - \beta p_{2k} + \gamma p_{1k}) - \theta_k(\alpha - \beta p_{2k} + \gamma p_{1k}), \quad k = l, h,$$

which yields $\alpha - 2\beta p_{2k} + \gamma p_{1k} + \beta\theta_k = 0$. The system of the first-order conditions for M_1 and $M_2 - R_2$ yields the expression in (14). ■

Proof of Proposition 3. The participation constraint $\pi_{R_{1h}} \geq 0$ for the inefficient retailer and the incentive constraint (5) for the efficient retailer are binding at the optimal contract. Substituting them and using (13), M_1's problem of maximizing its profits in (2) is

$$\max_{p_{1l},p_{1h}} \nu \{p_{1l}(\alpha - \beta p_{1l} + \gamma p_{2l}) - \theta_l(\alpha - \beta p_{1l} + \gamma p_{2l}) - (1-\rho)[\Delta\theta(\alpha - \beta p_{1h} + \gamma p_{2h})$$
$$-\gamma(p_{2h} - p_{2l})(p_{1h} - \theta_l)]\} + (1-\nu)\{p_{1h}(\alpha - \beta p_{1h} + \gamma p_{2h}) - \theta_h(\alpha - \beta p_{1h} + \gamma p_{2h})\}.$$

The first-order conditions for p_{1l} and p_{1h} are respectively given by $\alpha - 2\beta p_{1l} + \gamma p_{2l} + \beta\theta_l = 0$ and $\alpha - 2\beta p_{1h} + \gamma p_{2h} + \beta\theta_h + \phi(\nu)(1-\rho)[\beta\Delta\theta + \gamma(p_{2h} - p_{2l})] = 0$.

After substituting (13) into (3), we can write the maximization problem of $M_2 - R_2$ as follows

$$\max_{p_{2k}} p_{2k}(\alpha - \beta p_{2k} + \gamma p_{1k}) - \theta_k(\alpha - \beta p_{2k} + \gamma p_{1k}), \quad k = l, h,$$

which yields $\alpha - 2\beta p_{2k} + \gamma p_{1k} + \beta\theta_k = 0$. The first-order conditions for the maximization problems of M_1 and $M_2 - R_2$ yield the results in the proposition.

We now check that the two omitted constraints in M_1's problem are satisfied in equilibrium. Substituting the binding constraint (15) into (16) yields after some manipulation $0 \geq -\left(p_{1h}^{ai} - p_{1l}^{ai}\right)\left[\beta\Delta\theta + \gamma\left(p_{2h}^{ai} - p_{2l}^{ai}\right)\right]$, which is fulfilled since $p_{1h}^{ai} - p_{1l}^{ai} > 0$ and $p_{2h}^{ai} - p_{2l}^{ai} > 0$. Moreover, the binding constraint (15) implies that sufficient (but not necessary) condition for the participation constraint $\pi_{R_{1l}} \geq 0$ to be satisfied is that γ is not too high. ■

Proof of Proposition 4. The maximization problem of M_1 is

$$\max_{\rho\in[0,1]} \nu\left[p_{1l}^{ai}\left(\alpha - \beta p_{1l}^{ai} + \gamma p_{2l}^{ai}\right) - \theta_l\left(\alpha - \beta p_{1l}^{ai} + \gamma p_{2l}^{ai}\right)\right]$$
$$+(1-\nu)\left[p_{1h}^{ai}\left(\alpha - \beta p_{1h}^{ai} + \gamma p_{2h}^{ai}\right) - \theta_h\left(\alpha - \beta p_{1h}^{ai} + \gamma p_{2h}^{ai}\right)\right].$$

Using the results in Proposition 3, the first-order condition for ρ can be written as

$$\left\{\frac{-\phi(\nu)\left[4\beta^3\Delta\theta - \gamma^2(\alpha + \beta\theta_h)\right]\left[4\beta^2 - \gamma^2(1 + \phi(\nu)(1-\rho))\right]}{(2\beta - \gamma)\left[4\beta^2 - \gamma^2(1 + \phi(\nu)(1-\rho))\right]^2}\right.$$

$$-\gamma^2\phi(\nu)\frac{(\alpha+\beta\theta_h)\left(4\beta^2-\gamma^2\right)+\phi(\nu)(1-\rho)\left[4\beta^3\Delta\theta-\gamma^2(\alpha+\beta\theta_h)\right]}{(2\beta-\gamma)\left[4\beta^2-\gamma^2(1+\phi(\nu)(1-\rho))\right]^2}\Bigg\}$$

$$+\left\{\alpha-\frac{(\beta-\gamma)\left(4\beta^2-\gamma^2\right)(\alpha+\beta\theta_h)}{(2\beta-\gamma)\left[4\beta^2-\gamma^2(1+\phi(\nu)(1-\rho))\right]}-\phi(\nu)(1-\rho)\right.$$

$$\left.\times\frac{2\beta^2\left(2\beta^2-\gamma^2\right)\Delta\theta-\gamma^2(\alpha+\beta\theta_h)(\beta-\gamma)}{(2\beta-\gamma)\left[4\beta^2-\gamma^2(1+\phi(\nu)(1-\rho))\right]}\right\}$$

$$+\left\{\frac{(\alpha+\beta\theta_h)\left(4\beta^2-\gamma^2\right)+\phi(\nu)(1-\rho)\left[4\beta^3\Delta\theta-\gamma^2(\alpha+\beta\theta_h)\right]}{(2\beta-\gamma)\left[4\beta^2-\gamma^2(1+\phi(\nu)(1-\rho))\right]}-\theta_h\right\}$$

$$\times\left\{\phi(\nu)\frac{2\beta^2\left(2\beta^2-\gamma^2\right)\Delta\theta-\gamma^2(\alpha+\beta\theta_h)(\beta-\gamma)\left[4\beta^2-\gamma^2(1+\phi(\nu)(1-\rho))\right]}{(2\beta-\gamma)\left[4\beta^2-\gamma^2(1+\phi(\nu)(1-\rho))\right]^2}\right.$$

$$+\gamma^2\phi(\nu)\left[\frac{(\beta-\gamma)\left(4\beta^2-\gamma^2\right)(\alpha+\beta\theta_h)}{(2\beta-\gamma)\left[4\beta^2-\gamma^2(1+\phi(\nu)(1-\rho))\right]^2}+\phi(\nu)(1-\rho)\right.$$

$$\left.\left.\times\frac{2\beta^2\left(2\beta^2-\gamma^2\right)\Delta\theta-\gamma^2(\alpha+\beta\theta_h)(\beta-\gamma)}{(2\beta-\gamma)\left[4\beta^2-\gamma^2(1+\phi(\nu)(1-\rho))\right]^2}\right]\right\}=0.$$

Combining terms yields after some manipulation

$$\phi(\nu)(1-\rho)\left(4\beta^2-\gamma^2\right)\left\{4\alpha\beta^3\gamma^2(2\beta-\gamma)\Delta\theta+\left[2\beta^2\left(2\beta^2-\gamma^2\right)\Delta\theta-\gamma^2(\alpha+\beta\theta_h)(\beta-\gamma)\right]\right.$$

$$\times\left[4\beta^3\Delta\theta-\gamma^2(\alpha+\beta\theta_h)\right]+\gamma^2\left[2\beta^2\left(2\beta^2-\gamma^2\right)\Delta\theta-\gamma^2(\alpha+\beta\theta_h)(\beta-\gamma)\right](\alpha+\beta\theta_h)$$

$$\left.+2\beta^2\left(2\beta^2-\gamma^2\right)\left[4\beta^3\Delta\theta-\gamma^2(\alpha+\beta\theta_h)\right]\Delta\theta+2\beta^2\gamma^2(2\beta-\gamma)\left(2\beta^2-\gamma^2\right)\Delta\theta\theta_h\right\}$$

$$+\left(4\beta^2-\gamma^2\right)^2\left[-4\alpha\beta^3(2\beta-\gamma)\Delta\theta+4\beta^3(\beta-\gamma)(\alpha+\beta\theta_h)\Delta\theta\right.$$

$$\left.+2\beta^2\left(2\beta^2-\gamma^2\right)(\alpha+\beta\theta_h)\Delta\theta-2\beta^2(2\beta-\gamma)\left(2\beta^2-\gamma^2\right)\Delta\theta\theta_h\right]=0.$$

Further simplifications imply

$$\phi(\nu)(1-\rho)\left\{8\beta^3\left(2\beta^2-\gamma^2\right)\Delta\theta+\gamma^4\left[\alpha-(\beta-\gamma)\theta_h\right]\right\}-\gamma^2\left(4\beta^2-\gamma^2\right)\left[\alpha-(\beta-\gamma)\theta_h\right]=0,$$

which yields the equilibrium ownership stake in (23). Points (i) and (ii) of the proposition follow from straightforward computations. ■

Proof of Proposition 5. Differentiating (24) with respect to ρ yields

$$\nu\left\{\frac{\partial p_{1l}^{ai}}{\partial\rho}\left[E\left(q_1\left(p_{1l}^{ai}(\rho),p_2^{ai}(\rho)\right)|\theta_l\right)+\left(p_{1l}^{ai}(\rho)-\theta_l\right)\frac{\partial E\left(q_1\left(p_{1l}^{ai}(\rho),p_2^{ai}(\rho)\right)|\theta_l\right)}{\partial p_1}\right]\right.$$

$$\left.+\left(p_{1l}^{ai}(\rho)-\theta_l\right)E\left[\frac{\partial q_1\left(p_{1l}^{ai}(\rho),p_2^{ai}(\rho)\right)}{\partial p_2}\frac{\partial p_2^{ai}}{\partial\rho}|\theta_l\right]\right\}+(1-\nu)$$

$$\times \left\{ \frac{\partial p_{1h}^{ai}}{\partial \rho} \left[E\left(q_1\left(p_{1h}^{ai}(\rho), p_2^{ai}(\rho)\right)|\theta_h\right) + \left(p_{1h}^{ai}(\rho) - \theta_h\right) \frac{\partial E\left(q_1\left(p_{1h}^{ai}(\rho), p_2^{ai}(\rho)\right)|\theta_h\right)}{\partial p_1} \right] \right.$$
$$\left. + \left(p_{1h}^{ai}(\rho) - \theta_h\right) E\left[\frac{\partial q_1\left(p_{1h}^{ai}(\rho), p_2^{ai}(\rho)\right)}{\partial p_2} \frac{\partial p_2^{ai}}{\partial \rho} |\theta_h \right] \right\} + \nu \pi_{R_{1l}}^{ai} - \nu(1-\rho) \frac{\partial \pi_{R_{1l}}^{ai}}{\partial \rho},$$

where $\pi_{R_{1l}}^{ai}$ is defined by the binding constraint (15). Since for $\rho = 1$ the expressions in the two curly brackets are negative (see the proof of Proposition 2), while the last term in the fourth line vanishes, sufficient (but not necessary) condition for the entire expression to be negative and therefore $\rho < 1$ be optimal is that the probability ν is low enough. ■

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