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Marie-Laure Allain, Claire Chambolle, Patrick Rey

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MARIE-LAURE ALLAIN
Ecole Polytechnique and CREST
CLAIRE CHAMBOLLE
INRA (UR1303 ALISS)
and
PATRICK REY
Toulouse School of Economics (Gremaq and IDEI)

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While vertical integration is traditionally seen as a *solution* to the hold-up problem, this article highlights instead that it can *generate* hold-up problems—for rivals. We consider a successive duopoly where downstream firms invest and then secure support from an upstream supplier. We first show that vertical integration generates *ex ante* incentives to create hold-up problems: an integrated supplier is willing to pre-commit itself to appropriating or dissipating part of its customer's profits, to expose the independent rival to being held-up by the other supplier, and discourage in this way the rival's investment. We then show that, even in the absence of any pre-commitment, vertical integration also creates hold-up problems *ex post* when degrading the quality of the support provided to one downstream firm benefits its rival. We also provide illustrations in terms of standard industrial organization models and of antitrust cases, and discuss the robustness of the insights.

Key words: Vertical Integration, Hold-up, Incomplete contracts, Vertical foreclosure

JEL Codes: L13, L41, L42

1. INTRODUCTION

While the literature on incomplete contracts emphasizes the role of vertical integration as a *solution* to hold-up problems, in practice antitrust authorities voice instead concerns that vertical integration may *generate* hold-up problems ... for rivals.[1] To explore this issue, we introduce a classic hold-up concern in an oligopolistic setup, in which two downstream competitors must invest before contracting with one of the two upstream suppliers. Despite the lack of *ex ante* contracting, under vertical separation, competition among suppliers eliminates any risk of hold-up, and firms obtain *ex post* the full return on their investments. In contrast, vertical integration provides both *ex ante* and *ex post* incentives to degrade the conditions offered to the downstream rival. *Ex ante*, doing so discourages the rival from investing, by exposing it to being held-up by

1. Section 3.3 discusses several illustrative cases.

the other supplier. *Ex post*, degrading the input provided to the rival benefits the downstream subsidiary. Hence, vertical integration does not solve here any hold-up problem for the integrated subsidiary (as no such concern arises under separation), but does create hold-up concerns for the downstream rival.

To discuss *ex ante* incentives, we first allow suppliers, if they wish so, to pre-commit themselves, before investment decisions, to being "greedy" when negotiating with customers. We show that, while independent suppliers never consider this option, an integrated supplier uses it instead to create hold-up problems for the downstream rival. We then show that similar insights apply when suppliers can pre-commit themselves to offering a degraded quality, so as to dissipate, rather than appropriate, part of the return on investment.

To discuss *ex post* incentives, we consider the case where input quality is unverifiable. An integrated supplier would then degrade the input provided to its rival, so as to confer a competitive advantage to its own downstream subsidiary. Vertical integration thus creates hold-up problems for the downstream rival, even in the absence of any pre-commitment: simply put, vertical integration makes the integrated supplier less reliable, which suffices to place the downstream rival in the hands of the remaining supplier.

Our article builds on the literature on hold-up and vertical integration.[2] Hold-up concerns arise when part of the return on an investment can be appropriated *ex post* by a trading partner. This is the case when (1) the trading partner enjoys bargaining power (stemming from market power, or because the investment is relationship-specific); and (2) contracting either cannot take place *ex ante*, before investments are sunk, or complete contracts are too costly to write or to enforce—see, for example, Williamson (1975) and Hart and Moore (1988) for extensive discussions of these assumptions, and Grout (1984) and Tirole (1986) for a first formal analysis of this hold-up problem. As already noted, vertical integration has been viewed as a solution to such hold-up problems—see for instance Williamson (1975, 1985), Klein *et al.* (1978), and Grossman and Hart (1986). These first papers however focus on bilateral monopolies. In case of competition among investors, vertical integration can still provide a solution to foster the integrated firm's investment, as shown by Bolton and Whinston (1993) in a context of supply insurance and downstream competition.[3] However, competition among trading partners may also contribute to eliminate hold-up concerns (both when negotiating *ex post*, and possibly by encouraging partners to enhance *ex ante* contracting), in which case vertical integration need not affect the subsidiary's investment incentives. We contribute to this literature by emphasizing that vertical integration can *exacerbate* hold-up concerns for rivals, and reduce in this way their own investment incentives.[4]

Our article also relates to the literature on foreclosure,[5] and in particular to the seminal papers by Ordover, Saloner and Salop (1990, henceforth OSS) and Salinger (1988). They argue that a vertical merger can be profitable because it enables the integrated firm to raise rivals' costs, by limiting their access to its own supply and increasing in this way the market power of alternative suppliers.[6] We revisit this literature by focussing on hold-up and investment incentives, rather than on product market competition. Furthermore, as stressed by Hart and Tirole (1990), the

2. For a detailed discussion of this literature, see Hart (1995).

3. See also McLaren (2000).

4. As in Bolton and Whinston (1993), because of strategic substitution, vertical integration induces both higher investment by the integrated firm, and less investment by its rivals. However, in the case of an upstream monopoly considered by Boston and Whinston, this is achieved by fostering the investment incentives of the integrated firm; in the case of upstream competition considered here, this is instead achieved by impeding rivals' investment incentives. In practice, both effects can complement each other, further exacerbating the asymmetry among firms' investments.

5. See Rey and Tirole (2007) for an overview of this literature.

6. Hart and Tirole (1990), O'Brien and Shaffer (1992) and McAfee and Schwartz (1994) offer a different rationale, based on the risk of opportunism. Spiegel (2013) shows that vertical integration can also result into higher input prices

"raising rivals' costs" argument relies on inefficient pricing (namely, linear tariffs), even *ex post*; otherwise suppliers' market power would affect the division of profits, but marginal input prices would still reflect (marginal) costs, as independent suppliers have no incentives to make their customers less competitive. In contrast, here hold-up problems alter rivals' investment incentives despite efficient *ex post* contracting. In addition, as pointed out by Hart and Tirole (1990) and Reiffen (1992), the analysis of OSS also relies on the assumption that the integrated firm can somehow commit itself to limiting its supplies to downstream rivals—otherwise, it would have an incentive to keep competing with the alternative suppliers.[7] We thus also contribute to this literature by showing that such commitment is not required when input quality is non-verifiable. Our analysis therefore responds to the two main criticisms addressed to the original analysis by OSS, and shows that vertical integration can lead to foreclosure even with *ex post* efficient contracting and in the absence of any *ex ante* pre-commitment.

The article is organized as follows. Section 2 shows that vertical integration triggers *ex ante* incentives to create hold-up problems for independent rivals. Section 3 shows that, even in the absence of any pre-commitment, vertical integration can also create hold-up problems *ex post*, when degrading the quality provided to one firm benefits its rival. It also provides several illustrations in terms of standard industrial organization models and antitrust cases. Section 4 discusses the robustness of these insights as well as several extensions. Section 5 concludes.

2. VERTICAL INTEGRATION AND HOLD-UP: AN *EX ANTE* PERSPECTIVE

We consider a successive duopoly framework with two upstream firms U_A and U_B, and two downstream firms D_1 and D_2. Each D_i first decides whether to invest at cost c_i ($I_i = 1$), or not ($I_i = 0$). Exploiting the investment moreover requires an indivisible input, which either U_A or U_B can supply, at no cost. This input can for instance be a patent, an infrastructure, or a database; henceforth we will simply refer to this input as "support". Without investment or support, D_i generates no return; with the support, D_i's investment generates a return $r_i(I_j)$, which decreases with the rival's investment I_j, but always covers the cost:

$$\text{(A1)} \qquad c_i < r_i(1) < r_i(0).$$

Keeping in line with the hold-up literature, contracts are incomplete: For simplicity, we assume away the possibility of contracting *ex ante*, before investment decisions are made. Suppliers can therefore appropriate *ex post* part of the benefits if they enjoy market power, a concern however mitigated here by upstream competition.

To show how vertical integration creates incentives to generate hold-up concerns, we assume here that suppliers can pre-commit themselves to being "greedy". In practice, this commitment can for example be achieved by delegating decision powers to appropriate third parties. For instance, in information and communications technology industries, some firms have delegated the monetization of (part of) their patent portfolios to so-called Patent Assertion Entities (PAEs).[8] These entities, who specialize in the enforcement of patent rights and the litigation against potential infringers, have built a reputation of being particularly aggressive and engaging in economic rent-seeking, at the expense of patent users—earning them the nickname "patent

when downstream firms have some bargaining power in their negotiation with an upstream monopolist—see the discussion in subsection 4.4.

7. This assumption can be re-interpreted as a commitment over input design. For example, in Choi and Yi (2000) an integrated supplier may tailor its input to the needs of its downstream unit; in Church and Gandal (2000) an integrated firm may make its software incompatible with a rival's hardware.

8. We thank Tim Simcoe for prompting this discussion.

trolls".[9] A case in point is provided by Microsoft, which, following its acquisition of Nokia's handset business, handed over to Mosaid (now Conversant) the management of a portfolio of patents reading on devices, prompting claims of patent trolling by rival device maker Huawei.[10]

To capture such possibility we allow here suppliers, if they wish so, to commit themselves *ex ante*, before investment decisions, to a given sharing rule $\hat{s}$, which does not allow downstream firms to cover the cost of their investments:

(A2) $\quad \hat{s} < \min\{\frac{c_1}{r_1(0)}, \frac{c_2}{r_2(0)}\}$.

We thus consider the following game:

- Stage 0 (*ex ante*): each supplier can publicly commit itself to leaving (no more than) a share $\hat{s} < 1$ of profit to its partners.[11] To rule out trivial outcomes, we assume that doing so involves an arbitrarily small cost ε.
- Stage 1 (*investment*): downstream firms make their investment decisions; these decisions are publicly observed.
- Stage 2 (*ex post*): each U_h offers each D_i a profit-sharing rule $s_{hi} \in [0,1]$ (where $s_{hi} = \hat{s}$ in case of pre-commitment in stage 1); each D_i then chooses its supplier.[12]

To analyse the impact of vertical integration on hold-up, we compare the subgame perfect Nash-equilibria of this game in two scenarios. In the first scenario, all firms are *independent*; in the second scenario, one supplier, say U_A, is *vertically integrated*, say with D_1.

We first note that, in equilibrium, an independent supplier never adopts the sharing rule $\hat{s}$ in stage 0: pre-committing itself to the rule $\hat{s}$ costs ε and would moreover limit the supplier's ability to compete in the final stage. Hence, if both suppliers are independent, none of them pre-commits itself in stage 0. Therefore, if D_i invests in stage 1, then in stage 2 Bertrand-like competition leads suppliers to offer support "at cost", thus enabling D_i to obtain the full return on its investment, $r_i(I_j)$. Anticipating this, both downstream firms invest in stage 1.

Suppose now that U_A is vertically integrated with D_1. This does not affect D_1's behaviour, which can secure support internally at cost; it thus obtains the full return on its investment, $r_1(I_2)$, and still chooses to invest. In contrast, D_2's investment behaviour depends on U_A's decision in stage 0. If U_A does not pre-commit itself to the sharing rule $\hat{s}$ in that stage, then in stage 2 Bertrand upstream competition again enables D_2 to obtain the full return on its investment; anticipating this, D_2 invests in stage 1. In contrast, if U_A adopts the rule $\hat{s}$ in stage 0 then, in stage 2, U_B wins the competition for the supply of D_2 by offering an only slightly better sharing rule; it follows that D_2's return on investment is reduced to $\hat{s}r_2(I_1)$. In other words, committing itself *ex ante*

9. Distributing a portfolio of complementary patents among several PAEs would moreover create double marginalization problems and lead to even higher royalty rates. A recent dispute between Cisco and Ericsson may provide a case in point: In this dispute, Cisco accuses Ericsson, with which it competes on network equipment products, of having split the management of patents reading on these products between two patent trolls, Rockstar and Spherix, so as to raise total licensing fees. See *Spherix Incorporated and NNPT, LLC versus Cisco Systems*, in the US District Court for the District of Delaware, C.A. No. 14-393, Cisco Systems, Inc's Answer and Amended Counterclaims.

10. This led the Chinese merger agency MOFCOM to impose behavioural remedies, including licensing under FRAND ("fair, reasonable and non-discriminatory") terms, and not seeking injunctions or "grant-back provisions" (provisions requiring the licensee to transfer back to the licensor the property rights on any improvement made to the licensed technology); see Freshfields (2014).

11. Whether the sharing rule $\hat{s}$ then applies to all downstream partners, or can target selected ones, does not affect the analysis. See Appendix A for a discussion.

12. For the sake of exposition, we suppose that this competition occurs for both downstream firms, regardless of whether they invested or not; the analysis is unchanged if instead stage 2 only occurs for those downstream firms that invested in stage 1. Also, whether the offers and acceptance decisions are public or private is of no consequence.

to the rule $\hat{s}$ enables the integrated firm $U_A - D_1$ to expose D_2 to being held-up *ex post* by U_B. Intuitively, this is a profitable strategy for the integrated firm, as D_1 benefits from discouraging D_2's investment. Indeed, we have:

Proposition 1. *Under Assumptions* (*A*1) *and* (*A*2)*:*

(i) Independent suppliers never commit themselves to the sharing rule $\hat{s}$; as a result, absent vertical integration, upstream competition eliminates any risk of hold-up and both firms invest.

(ii) In contrast, an integrated supplier commits itself to the sharing rule $\hat{s}$, so as to create hold-up problems for the downstream rival; as a result, only the integrated firm invests.

Proof See Appendix A. ‖

Under vertical separation, upstream competition disciplines suppliers, and thus there is no risk of hold-up. It follows that, in contrast to the literature emphasizing vertical integration as a solution to hold-up problems, here vertical integration has only adverse effects: it has no impact on the integrated subsidiary, but generates hold-up problems for the independent rival.

We conclude this section with several remarks.

2.1. *Upstream market power*

To be sure, if upstream competition were more limited, then hold-up concerns could arise as well under vertical separation; vertical integration would then alleviate these concerns for the integrated subsidiary,[13] but would still contribute to exacerbate them for downstream rivals.

Consider for instance a variant of the above setting with an upstream monopoly; that is, there is a single supplier, U, who thus has all the bargaining power in *ex post* bilateral negotiations. If U does not commit *ex ante* to the sharing rule $\hat{s}$, then *ex post* it appropriates all investment benefits, thereby discouraging downstream firms from undertaking any investment. In the absence of vertical integration, the supplier will therefore choose to commit itself to the sharing rule $\hat{s}$, in order to *limit* hold-up concerns and encourage investment, and then share the benefits: in stage 1, each D_i then bases its investment decision on its share of the return, $\hat{s}r_i\left(I_j\right)$, and some investment occurs as long as $\hat{s} > c_i/r_i(0)$ for at least one D_i.[14] If instead U is vertically integrated with D_1, say, then in stage 1 D_1 takes into account the full return on its investment, $r_1(I_2)$; that is, vertical integration *eliminates* any hold-up concern for D_1. But U may now choose not to commit *ex ante* to $\hat{s}$, so as to *exacerbate* again *ex post* hold-up concerns for the downstream rival, D_2, and discourage in this way its investment—U will do so when the downstream benefits to its subsidiary, D_1, more than compensate the upstream loss of profit from not supplying D_2.[15]

2.2. *Hold-up through profit dissipation*

The above insights carry over when suppliers can threaten to dissipate, rather than appropriate, part of their customers' investment benefits. In practice, suppliers could achieve this in various

13. Bolton and Whinston (1993) stress that this may however result in excessive investment incentives, compared with what is socially desirable.

14. That is, the sharing rule $\hat{s}$ should not be too greedy—in particular, (*A*2) should not hold.

15. In the case of upstream competition considered above, *ex post* competition among suppliers dissipates their profits. Hence, a vertically integrated firm does not face the trade-off just mentioned between upstream and downstream profits; as a result it *always* commits *ex ante* to $\hat{s}$, so as create hold-up concerns and discourage the downstream rival's investment.

ways, for example, by limiting access to some input, granting low-priority access to premium resources,[16] exploiting commercially sensitive information, and so forth.

Suppose for instance that degrading the quality $s_i \in [0,1]$ of the support supplied to D_i reduces its return on investment, which becomes $s_i r(I_j)$—degrading the support ($s_i < 1$) is here akin to pure *sabotage***:** It reduces D_i's profit but has no direct impact on the rival's profit.[17] Suppose further that *ex post*, that is, once investments have been made, suppliers compete by choosing a quality level and a lump-sum tariff.[18] As before, although *ex post* negotiations introduce a risk of hold-up, this risk is mitigated by upstream competition: once investment decisions have been made, suppliers offer *ex post* the best quality at cost.

Suppose now that, at some cost ε, suppliers can choose *ex ante* to limit the quality of the support offered to their partners[19] to $\hat{s} < 1$, in which case *ex post* they only compete in tariffs. In practice, such commitment could for instance be achieved through technological tying.[20] The analysis then confirms the previous insights (see Appendix B for a formal derivation). It is clearly unprofitable for independent suppliers to pre-commit themselves to offering a degraded quality, which would cost ε and only put them at a disadvantage in the *ex post* competition; as a result, absent vertical integration, upstream competition still leads suppliers to provide the best support at cost, and downstream firms obtain the full return on their investments. In contrast, a vertically integrated U_A benefits from committing itself to offering a degraded quality to the independent D_2, so as to create hold-up concerns: *ex post*, U_A cannot do better than offering the degraded quality $\hat{s}$ at cost, thereby allowing U_B to supply D_2, with the best quality but a higher tariff; D_2 must therefore share the benefits from its investment with U_B, which in turn discourages D_2's investment.

2.3. *Vertical integration and foreclosure*

The above analysis revisits the link between vertical integration and hold-up, but it also contributes to the literature on vertical foreclosure. As in OSS, we highlight a foreclosure mechanism that relies on a commitment to reducing the downstream rival's profit—by raising its cost in OSS, and by exposing it to hold-up here. However, in contrast to OSS, our foreclosure mechanism affects *ex ante* competition in investment (*e.g.* in R&D or in capacity) rather than *ex post* product market competition in prices or quantities.

16. See Bolton and Whinston (1993) for a study of the impact of vertical integration on access to a scarce input controlled by an upstream monopoly.

17. Such sabotage has been a concern in markets such as the telecom industry, where regulating access prices may prompt a dominant firm to degrade rivals' non-price access conditions; see, for example, Weisman (1995), Economides (1998), and Beard *et al.* (2001).

18. We rule out contracting on exit (*e.g.* an integrated supplier cannot offer a "reverse payment" to keep a downstream competitor out of the market). Such reverse payments (or "pay-for-delay" contracts, for generic drugs) are likely to be deemed illegal, as exemplified by the recent US Supreme Court decision *FTC versus Actavis*, 570 US (2013), available at: http://www.supremecourt.gov/opinions/12pdf/12-416_m5n0.pdf, last accessed August 8, 2015. In the same vein, we rule out exclusive dealing contracts which, as shown by Chen and Riordan (2007), could be used to achieve the same outcome. Such provisions involve an "horizontal" dimension (as they restrict trade with rival partners) and are also under antitrust scrutiny; focusing instead on purely "vertical" contracts allows us to single out a potential anticompetitive effect of vertical integration alone.

19. We assume that the integrated firm provides good support to its own subsidiary—degrading this support could only have a negative impact on its profit and discourage its investment.

20. For example, a firm could make its software incompatible with rival hardware technologies or systems; see Church and Gandal (2000) for a discussion. Likewise, in the telecommunications industry, a firm could limit the compatibility between its infrastructure and third-parties' equipment; see, for example, Mandy and Sappington (2007) and Gilbert and Riordan (2007).

Reiffen (1992) argues that the foreclosure equilibrium in OSS also relies on their restriction to linear tariff contracts. In fact, if the integrated firm stops supplying the downstream rival, a raising rival's costs effect still arises with non-linear (*e.g.* two-part) tariffs, provided that they are public: as in the literature on strategic delegation,[21] an independent supplier would have an incentive to raise its wholesale price over marginal cost, in order to *dampen* downstream competition.[22] However, this mechanism collapses with secret contracts, where marginal cost pricing then prevails. In addition, both the "competition dampening" and the "raising rival's cost" effects rely on strategic increases in marginal wholesale tariffs. These effects thus do not arise in the case of lump-sum wholesale tariffs (stemming from discrete supply decisions) considered in our framework. In contrast, the hold-up effect highlighted here arises even with *ex post* efficient lump-sum tariffs, and whether these tariffs are publicly observed or not.

2.4. *Commitment*

In order to discuss *ex ante* incentives to raise hold-up concerns, the above model supposes that suppliers can pre-commit themselves to being "greedy". As mentioned above, delegating the management of a patent portfolio to a "patent troll" can for instance constitute such a commitment. More generally, a supplier may influence the *ex post* bargaining power in various ways, for example, by posting bonds, exchanging (economic) "hostages", limiting its freedom of actions, and so forth.[23] For example, imposing a monetary penalty on the partner if trade is delayed can be a way of increasing one's bargaining power in the negotiation.[24] Alternatively, at the beginning of the relationship, the partner could be required to pay some amount (a financial "hostage"), to be given back, without interest, when trade takes place.

The next section assumes away any such commitment, and shows that vertical integration can also exacerbate hold-up concerns from a purely *ex post* perspective.

3. VERTICAL INTEGRATION AND HOLD-UP: AN *EX POST* PERSPECTIVE

We now show that, *even in the absence of any pre-commitment*, vertical integration can raise hold-up concerns when the quality of the support is not verifiable: vertical integration alone then suffices in general to alter a supplier's *ex post* incentive to degrade the support provided to a downstream rival. We show in Section 3.1 that this creates hold-up problems for the independent rival when degrading its support, while benefitting the downstream subsidiary, reduces total industry profit. Section 3.2 provides a discussion on this condition and shows that it is verified in a variety of classic industrial organization models. Section 3.3 provides some illustrations.

3.1. *Unverifiable quality*

We now exclude any pre-commitment possibility, and suppose instead that suppliers freely choose *ex post* the quality of their support, which is unverifiable and thus cannot be contracted upon.

21. See Bonanno and Vickers (1988) and Rey and Stiglitz (1988,1995); Caillaud and Rey (1995) provide a survey of this literature on strategic delegation.

22. This could however arise as well absent vertical integration if suppliers can offer exclusive contracts; see, for example, Shaffer (1991). Schutz however stresses inexistence issues in such situations.

23. See, for example, Aghion *et al.* (1994) for a discussion of *ex ante* measures that can influence *ex post* bargaining positions with negotiating partners, and their role in alleviating hold-up concerns.

24. This would for instance be the case in the context of a standard Rubinstein–Stahl bargaining model with alternating offers.

For the sake of exposition, we suppose that the quality of the support can take two values, $\overline{s}$ and $\underline{s} < \overline{s}$, but allow it to affect the rival's profit as well. Formally, letting s_i and s_j denote the quality of the support provided to D_i and D_j, D_i's return on investment is now given by

$$r_i(I_j; s_i, s_j) \geq 0,$$

which increases in s_i, but decreases in both I_j and s_j; more precisely:

$$r_i\left(0; s_i, s_j\right) > r_i\left(1; s_i, s_j\right),\ r_i\left(1; \underline{s}, s_i\right) < r_i\left(1; \overline{s}, s_i\right) \text{ and } r_i\left(1; s_i, \underline{s}\right) > r_i\left(1; s_i, \overline{s}\right).$$

The fear of *ex post* quality degradation was for instance at the core of the discussions surrounding the 2008 merger between TomTom, the leading manufacturer of portable navigation devices (or "PNDs"), and Tele Atlas, one of the two main providers of digital map databases in Europe and North America. In its decision,[25] the European Commission noted that "PND manufacturers were concerned that the merged entity would [...] provide them with map databases of lower quality or delay the availability of new features and updates, thereby preventing them from effectively competing with TomTom in the PND market". Quality degradation could also involve the abuse of commercially sensitive information:[26] third parties expressed the concern that "certain categories of information [...] could, after the merger, be shared with TomTom [which] would allow the merged firm to preempt any of their actions aimed at winning more customers (through better prices, innovative features, new business concepts, increased coverage of map databases)".

We now show that an integrated supplier has indeed an incentive to degrade *ex post* the quality provided to the downstream rival, which in turn can create hold-up concerns for the rival. To see this, consider the following game:

- Stage 1: each D_i chooses $I_i \in \{0, 1\}$; these decisions are observed by all parties.
- Stage 2: each U_h sets the tariff T_{hi} at which it is willing to supply D_i.
- Stage 3: each D_i selects a supplier, who then chooses the quality of the support provided to D_i, $s_i \in \{\underline{s}, \overline{s}\}$.[27]

To break indifference, we assume that a supplier incurs an arbitrarily small cost ε when providing a degraded support $\underline{s}$.[28] For the sake of exposition, we will omit this cost in most of the analysis, and account for it only when needed for the formal proofs.

In equilibrium, in stage 3 an independent supplier always provides high-quality support: degrading *ex post* the quality brings no direct benefit, and only exposes the supplier to pay the cost ε. Anticipating this, when both suppliers are independent, in stage 2 Bertrand competition leads suppliers to offer this high-quality support at cost.

Consider now the case where U_A is vertically integrated with D_1, and D_2 invested in stage 2. In stage 3, the integrated U_A does not have any incentive to degrade the quality of the support

25. See the EC Decision of 14/05/2008 in Case No. COMP/M.4854 - TOMTOM/TELE ATLAS, at § 190.

26. The Commission noted that the exchange of such information was indeed important: "Tele Atlas's customers have to share information on their future competitive actions with their map supplier. [...] In a number of examples provided [...] by third parties, companies voluntarily passed information about their estimated future sales, product roadmaps and new features included in the latest version of their devices."

27. Whether offers and acceptance decisions are publicly observable or not is of no consequence.

28. As shown below, this cost can be interpreted as a proxy for the penalties to which the supplier may be exposed, with small probability, when supplying poor support.

provided to its subsidiary D_1, but has an incentive to degrade the quality supplied to the rival D_2, as by doing so it generates a benefit for D_1, equal to:

$$B \equiv r_1\left(1;\overline{s},\underline{s}\right) - r_1\left(1;\overline{s},\overline{s}\right)(>0).$$

Thus in stage 2, D_2 anticipates that it would obtain a degraded support from the integrated U_A,[29] and a high-quality support from the independent U_B. However, the integrated firm is willing to subsidize its support in order to "bribe" D_2 into accepting a degraded quality. As a result, which supplier wins the competition depends on the net effect of degrading D_2's support on the profits of the two downstream firms.

More precisely, U_B's best offer still consists in offering high-quality at cost, thus giving D_2 a profit equal to $r_2(1;\overline{s},\overline{s})$, whereas U_A's best offer gives D_2 a net profit of $r_2(1;\underline{s},\overline{s})+B$. Comparing these best offers yields the following:

• When degrading the quality increases total industry profit, that is, when $\Delta\Pi > 0$, where

$$\Delta\Pi \equiv r_1(1;\overline{s},\underline{s}) + r_2(1;\underline{s},\overline{s}) - r_1(1;\overline{s},\overline{s}) - r_2(1;\overline{s},\overline{s}), \tag{3.1}$$

the integrated firm successfully bribes D_2 into accepting a degraded quality: U_A offers a *degraded* support, but *wins* the competition for D_2 by offering a subsidy matching U_B's best offer.[30] As a result, *ex post* industry profits are increased, and D_2 obtains the same profit as with high-quality support supplied at cost—it follows that D_2's investment incentives are not distorted in that case, as D_2 obtains the full return on its investment.

• When instead $\Delta\Pi < 0$, degrading the quality supplied to D_2 hurts D_2 more than it benefits D_1, and thus the integrated firm is unwilling to offer a subsidy large enough to compensate for the poor quality of its support. As a result, U_B not only wins the competition, but is able to hold D_2 up and charge a supra-competitive tariff. Formally, we have:

Proposition 2. *Independent suppliers do not have an incentive to degrade ex post the quality of the support they provide; in contrast:*

(i) When it invests, an integrated firm does have an incentive to degrade the quality supplied to the independent rival, in order to increase the profit of its downstream subsidiary.

(ii) If $\Delta\Pi < 0$, that is, if degrading the quality of the support provided to D_2 reduces total industry profit, then vertical integration between U_A and D_1 creates hold-up problems for D_2.

Proof See Appendix C. ‖

Hence, when degrading the quality of the support provided to D_2 reduces total industry profit (*i.e.* $\Delta\Pi < 0$), vertical integration does not affect *ex post* industry profit (as D_2 still obtains good-quality support from U_B); it however generates hold-up concerns, which distort D_2's investment incentives:

Corollary 3. *We have:*

(i) If, for $i = 1, 2$,

$$c_i < r_i(1;\overline{s},\overline{s})\,(< r_i(0;\overline{s},\overline{s})), \tag{3.2}$$

then both firms invest in case of vertical separation, and an integrated firm invests as well.

29. U_A has indeed an incentive to degrade the quality supplied to D_2, even if the benefit B to D_1 is small, as long as it exceeds the cost ε.

30. This corresponds to the case analysed by Chen and Riordan (2007), where a vertically integrated firm convinces a downstream rival to enter into an exclusive deal with a high input price, making the rival a less effective competitor.

(ii) If in addition $c_2 > r_2(1;\bar{s},\bar{s}) + \Delta\Pi$*, where* $\Delta\Pi$ *is given by (3.1), then vertical integration between* U_A *and* D_1 *deters* D_2 *from investing.*

Proof See Appendix D. ‖

This insight is in line with concerns raised by the TomTom - Tele Atlas merger mentioned above, in which downstream competitors expressed their fear that the integrated firm would benefit from degrading their support, and that "this would strengthen the market power of NAVTEQ, the only alternative map supplier, with regards to these PND operators and could lead to increased prices or less innovation".[31]

We conclude this section with a couple of remarks.

3.1.1. Vertical integration and foreclosure. The above analysis shows that—in sharp contrast to OSS—vertical integration can lead to vertical foreclosure not only with *ex post* efficient contracts, but also in the absence of any commitment. As the quality of the support is endogenous, vertical integration makes the supplier less reliable for the downstream rival. When $\Delta\Pi < 0$, this puts the rival in the hands of the remaining supplier, which in turn discourages the rival's investment.

As in Hart and Tirole (1990) and Spiegel (2013), we assume that contracts are freely negotiated *ex post*. However, in the case of a monopolistic supplier they consider, raising the input price makes vertical integration profitable from an *ex post* standpoint (*i.e.* for given investment levels), and only indirectly affects investment decisions. In contrast, in our framework (when $\Delta\Pi < 0$) vertical integration is profitable only because it discourages the rival's investment: for any given investment decision by the rival, vertical integration does not increase the profit achieved *ex post* by the merging firms; by the same token, it does not affect either their investment behaviour (*i.e.* their best response remains unchanged).

3.1.2. Scope for hold-up. Interestingly, the scope for hold-up and investment foreclosure is larger, the *less* the integrated firm gains from degrading the quality of the support provided to its rival.[32] For instance, Proposition 2 shows that hold-up concerns arise precisely when the benefit to the integrated subsidiary does not compensate for the reduction in the rival's profit (*i.e.* when $\Delta\Pi < 0$). And when this is the case, the rival is more likely to stop investing (*i.e.* the condition $c_2 > r_2(1;\bar{s},\bar{s}) + \Delta\Pi$ is more likely to hold) when the benefit to the integrated subsidiary is small. Thus, it is precisely when the integrated firm has little to gain, *ex post*, from degrading the quality of the support provided to its rival, that the risk of hold-up, and its adverse impact on *ex ante* investment incentives, are the greatest.

3.1.3. Partial contractibility. So far we have assumed that quality was not verifiable, and thus could not be contracted upon; our results still apply, however, when quality is "partially contractible". Suppose for instance that, *ex post*, input quality provided can be verified with some probability (*e.g.* through an audit, litigation in court, and so forth). To protect its customers, the supplier can then offer to compensate them if it is established that the provided support

31. See the EC Decision in TOMTOM/TELE ATLAS, at § 253. Interestingly, shortly after the first merger announcement, Nokia (then the leading manufacturer of smartphones, which were starting to offer GPS features) acquired NAVTEQ, raising similar concerns for the remaining downstream competitors (see COMP/M.4942 - NOKIA/NAVTEQ, 02/07/2008).

32. We thank an anonymous referee for highlighting this.

was indeed of poor quality. The effectiveness of such compensation schemes however depends not only on the accuracy of *ex post* investigations but also on the legal environment, which often limits the compensation that can be offered. For instance, the "expected damage rule" (see, *e.g.* Che and Chung (1999), or Shavell (1984)) limits the compensation to the actual profit loss resulting from the degraded service. Even stricter, the "reliance damages rule" enables only compensations for reliance expenditures, that is expenses that the customer incurred in anticipation of contract performance. Because of these limitations, vertical integration may affect the extent to which a supplier can credibly guarantee the quality of its support.

To see this, suppose that poor quality is detected with probability p, in which case the supplier can offer a compensation that cannot exceed a cap (dictated by the legal environment) Φ. Hence in stage 2, each D_i offers a contract of the form (T_{hi}, ϕ_{hi}), where $\phi_{hi} \leq \Phi$; and in stage 3, if U_h supplies a degraded quality, then it is found guilty with probability p, in which case it pays D_i the compensation ϕ_{hi}.

In equilibrium, an independent supplier will offer such a compensation scheme (*e.g.* $\phi_{hi} = \Phi$); in effect, this enables the supplier to commit itself to delivering good quality, as degrading the quality would not bring any profit and would cost $\varepsilon = p\Phi$. Likewise, an integrated supplier does not have any incentive to degrade the quality of the support provided to its own subsidiary. In contrast, it will degrade the quality of the service offered to the independent rival, even if it offers a compensation, whenever the direct benefit for its subsidiary exceeds the maximal expected compensation it will have to pay, that is, whenever:[33]

$$p\Phi < B.$$

Hence, under this condition, an integrated U_A will be unable to credibly commit itself to delivering good quality, whereas an independent U_B could do so. The above analysis then readily applies—in particular, U_A's best offer still consists of (providing poor quality and) offering a global subsidy of B (through the expected compensation as well as a reduction in tariff),[34] whereas U_B's best offer still consists of supplying good quality (by offering a compensation Φ if a default were detected) at cost; hence, as before, vertical integration creates hold-up problems for the downstream rival whenever degrading the quality of its support reduces total industry profit.

3.2. *On the impact of quality degradation on industry profit*

Proposition 2 shows that hold-up concerns arise when degrading the support provided to one firm reduces total industry profit (*i.e.* $\Delta\Pi < 0$). We consider here several classic models of competition, and show that this condition holds when downstream competition is sufficiently imperfect.

3.2.1. Cournot competition. Consider for instance a simple linear Cournot duopoly, in which D_i faces a demand

$$P_i(q_i, q_j) = 1 - q_i - \sigma q_j,$$

where q_i and q_j denote the outputs of the two firms, and $\sigma \in [0,1]$ measures their degree of substitution. In Appendix E.1, we consider the case where degrading the quality of D_i's support increases its production cost or reduces the quality of its product; we show that this reduces industry profit as long as D_i is able to maintain a substantial market share, which is for instance the

33. If the maximum amount of compensation Φ follows the expected damage rule, the condition simply boils down to $p < \frac{r_1(1;\overline{s},\underline{s}) - r_1(1;\overline{s},\overline{s})}{r_2(1;\overline{s},\overline{s}) - r_2(1;\underline{s},\overline{s})}$.

34. More precisely, U_A's best offer is $T_{A2} = -B + p\Phi$, which gives D_2 an expected profit of $r_2(1;\underline{s},\overline{s}) + B$.

case when the resulting handicap is not too large, when the two firms are sufficiently differentiated, or when they have captive customer bases.

3.2.2. Bertrand competition. The same applies to *price competition* settings: altering one firm's offerings is likely to harm industry profit when firms cater to different types of customers. In Appendix E.2, we consider a duopoly with horizontal product differentiation à la Hotelling, and show that degrading the quality of the support offered to D_i reduces total industry profit when this makes for instance D_i's advertising campaigns less effective and limits in this way customers' awareness of D_i's products.

3.2.3. Patent race. Consider now the following standard patent race model:

- If it invests, D_i innovates with probability ρ_i.
- If only one firm innovates, it obtains a competitive edge generating an added value $V>0$; if instead both firms innovate, each firm obtains $v<V$.

Assume further that implementing the innovation requires close cooperation with the support provider, involving the exchange of key information about the innovation; the quality s_i of the support obtained by D_i can be interpreted as the extent to which D_i's information is protected from leakage leading to imitation: For the sake of exposition, suppose that the innovation is imitated with probability $1-s_i$.

If both firms invest, then the industry expected profit is equal to

$$\left[1-(1-\rho_i)\left(1-\rho_j\right)\right]2v+\left[\rho_i s_i\left(1-\rho_j\right)+\rho_j s_j(1-\rho_i)\right](V-2v).$$

It follows that degrading the quality of D_i's support reduces expected industry profit whenever imitation dissipates the rent of innovation, that is, whenever $V>2v$.

3.2.4. Spillovers. Suppose now that D_i' profit is determined by both downstream firms' "effective capacities", which depend on the quality of the support they receive as well as on their investments. Namely, D_i's effective capacity is $(1+e_jI_j)I_i$: degrading the support s_j provided to D_j generates positive spillovers $e_j=1-s_j$ for D_i if D_j invests. D_i's return on investment is then given by:

$$r_i\left(I_j;e_i,e_j\right)=R\left((1+e_i)I_j\right)\left(1+e_jI_j\right).$$

If for instance $R(K)=a-bK$, then degrading the quality of D_i's support reduces the industry profit whenever $a<2b(2-\bar{s})$.

3.3. *Illustrations*

We provide here several examples of *ex post* quality degradation by vertically integrated suppliers.

3.3.1. Imitation. As we have seen, concerns of *ex post* quality degradation involving the misuse of commercially sensitive information were raised by the 2008 merger between TomTom and Tele Atlas. To illustrate these concerns, consider the above-mentioned patent race model, in which the quality of support affects the probability of imitation. For simplicity, suppose further that firms are symmetric (each firm can innovate with probability ρ by investing at cost c) and

that the quality of support takes values in $\{0,1\}$: D_j's innovation is never imitated when $s_j=1$, and is imitated for sure when $s_j=0$. D_i's return on investment is then $\rho[1+(1-\rho)(1-s_j)]v+\rho(1-\rho)s_i(V-v)$, where the first term indicates the profit obtained by D_i whenever at least one firm innovates, while the second term captures the additional profit of being the only innovator. The quality of the support reflects here the degree of protection against information leakage and possible imitation granted by the supplier to the innovator: degrading the quality of the support provided to D_2 enables the integrated firm to "steal" part of D_2's return on investment, at the cost however of dissipating total profits: $\Delta\Pi<0$ whenever imitation dissipates industry profit, that is when $V>2v$.

Corollary 3 shows that, whenever $c<\overline{c}\equiv\rho(1-\rho)V+\rho^2 v$, both firms invest in case of vertical separation, and an integrated firm invests as well. In contrast, when U_A is vertically integrated with D_1, the fear of imitation by the integrated firm generates hold-up for the independent innovator D_2, and discourages its investment whenever $c>\underline{c}\equiv\rho(2-\rho)v$.[35]

3.3.2. Protection of private information. The sale in 2003 of the Israeli supermarket chain Blue Square provides another example of *ex post* quality degradation through information leakage.[36] Two downstream firms, the Alon-Dor group and Paz, were competing for the acquisition of the Blue Square supermarket chain. Leumi, one of the two main banks, was holding a 20% share of Paz and was therefore partly vertically integrated with one of the potential buyers. In a conference,[37] Alon-Dor's CEO complained that information concerns prevented his company from seeking financial support from Leumi, leaving it in the hands of the other main bank. In particular, the Alon-Dor group was fearing that information about its offer for the supermarket chain would be passed on to its rival, thereby reducing its own chances of obtaining the deal.[38]

3.3.3. Spillovers. In the US, in 2010 the Federal Trade Commission (FTC) put conditions on the vertical merger between PepsiCo and its two largest bottlers and distributors, who were also servicing its rival Dr. Pepper Snapple (DPSG). The FTC expressed the concern that "PepsiCo will have access to DPSG's commercially sensitive confidential marketing and brand plans. Without adequate safeguards, PepsiCo could misuse that information, leading to anti-competitive conduct that would make DPSG a less effective competitor".[39] Likewise, in a case involving the acquisition by The Coca-Cola Company (TCCC) of its main US bottler, the FTC was concerned that "TCCC's access to this information could enable it to use the information in ways that could impair DPSG's ability to compete and ultimately injure competition by weakening a competitor".[40]

These concerns can be illustrated by the above-mentioned model of spillovers. For instance, if a firm plans to launch an advertising campaign for a new product, then information about the characteristics of the product and/or the date of the campaign may enable a rival to free-ride on the promotional activities and steer consumers towards its own products. Degrading the quality of the support offered to a rival by allowing for information leakage enables here the integrated firm to "boost" the return on its own advertising campaign, at the cost again of dissipating total profits.

35. Note that $\underline{c}<\overline{c}$, whenever $2v<V$.

36. We thank Yossi Spiegel for bringing this example to our attention.

37. See http://www.presidentconf.org.il/en/indexNew.asp.

38. Asker and Ljungqvist (2010) study a related issue and show empirically that competitors have incentives to choose different banks so as to avoid the leakage of sensitive information.

39. According to the FTC, this included information on "research, development, production, marketing, advertising, promotion, pricing, distribution, sales, or after-sales support". See "In the Matter of PepsiCo Inc.", FTC-file 091-0133 of 02/26/2010.

40. See "In the Matter of The Coca-Cola Company", FTC-file 101-0107 of 09/27/2010.

Applying Corollary 3 to the above model, with for instance $\overline{s}=1$ and $\underline{s}=1-\hat{e}$, where $0<\hat{e}<1$, shows that vertical integration creates hold-up problems and discourages the downstream rival's investment whenever

$$R(1+\hat{e})+\hat{e}R(1)<c<R(1)(<R(0)).$$

3.3.4. Implications for competition policy. Whenever the quality of support is not verifiable, additional instruments could be adopted *ex ante* to provide (long-term) guarantees against *ex post* degradation of the support. Even when such guarantees are in place pre-merger,[41] they should still be imposed as a remedy to the merger, because, as shown in Section 3.1, the parties would no longer have an incentive to offer them post-merger. This is in line with the decisions of the FTC, which ordered PepsiCo and TCCC to set-up firewalls in order to protect commercially sensitive information.

4. ROBUSTNESS AND EXTENSIONS

The previous section shows that vertical integration can exacerbate hold-up problems for the independent downstream rival, by increasing the market power of the alternative supplier. This insight is robust in many respects. First, the analysis remains valid when downstream firms have more bargaining power in their bilateral procurement negotiations, as long as suppliers obtain a positive share of the specific gains generated by the relationship. Second, the analysis also readily extends to downstream oligopolies: Vertical integration enhances the market power of the alternative supplier over all independent downstream rivals, thus discouraging their investments to the benefit of the integrated firm.

We first derive in Section 4.1 the welfare implications of our results. We then extend our insights to the case of imperfect upstream competition (Section 4.2) and to customer foreclosure (Section 4.3). We also enrich our analysis by considering partial vertical integration (Section 4.4) and counter-fighting strategies by the independent rivals (Section 4.5).

4.1. *Welfare implications*

By creating hold-up concerns for rivals, vertical integration does not only discourage their investments but also affects consumers and thus total welfare. Intuitively, rivals become less effective competitors, which reduces their profits but is also likely to harm consumers. To see this, consider for instance the (symmetric) patent race illustration presented in section 3.3, where degrading the quality of the support exposes an innovator to imitation. That is, each D_i can innovate with probability ρ by investing c, and there is no risk of imitation if the support is of good quality ($s_i=1$), whereas the innovation is imitated with certainty if the support is degraded ($s_i=0$); and D_i obtains a profit of V when it is the only innovator, whereas each downstream firm obtains $v<V/2$ when they both innovate, or one imitates the other. For the sake of exposition, suppose further that consumers obtain an additional surplus $S(1)$ when one firm innovates, and $S(2)>S(1)$ when both firms innovate. It is natural to assume that *ex post* total welfare (*i.e.* the

41. In the TomTom–TeleAtlas merger case, firewalls were indeed offered before the merger. As mentioned by the EC: "Pre-merger, independent map makers such as Tele Atlas have a strong incentive to ensure that information passed by customers remain confidential and is not shared with competing customers. Firewalls and non-disclosure agreements are used by Tele Atlas to protect sensitive business information of its customers. The reputation of being an impartial supplier in the navigation markets is crucial."

sum of the industry profit – gross of investment costs – and consumer surplus) is also higher when both firms innovate, that is:

$$W(1) \equiv V + S(1) \leq W(2) \equiv 2v + S(2).$$

Under vertical separation, the two downstream firms invest and obtain a good support; the (expected) consumer surplus and total welfare are thus respectively equal to:

$$S^{VS} \equiv \rho^2 S(2) + 2\rho(1-\rho)S(1), W^{VS} \equiv \rho^2 W(2) + 2\rho(1-\rho)W(1) - c_1 - c_2.$$

When U_A is vertically integrated with D_1, under corollary 3 only the integrated firm invests and obtains good quality support in equilibrium. The (expected) consumer surplus and total welfare are then respectively equal to:

$$S^{VI} \equiv \rho S(1), W^{VI} \equiv \rho W(1) - c_1.$$

It follows that:

- By discouraging D_2's investment, vertical integration always harms consumers:

$$S^{VS} - S^{VI} = \rho\{\rho[S(2) - S(1)] + (1-\rho)S(1)\} > 0.$$

- Vertical integration also reduces total welfare whenever D_2's investment is socially valuable, that is, whenever:

$$c_2 < \rho\{\rho[W(2) - W(1)] + (1-\rho)W(1)\}.$$

This last condition holds for example when the two firms are close substitutes. Suppose for instance that they produce similar products, for which consumer demand is $D(p)$, and that the innovation lowers the unit cost of production from γ to $\gamma - \delta < \gamma$. A downstream firm then obtains $v \simeq 0$ when either no firm innovates or both of them innovate,[42] and obtains instead $V = \delta D(\gamma)$ when it is the only innovator; in contrast, consumers benefit from the innovation only when both firms innovate: $S(1) = 0$ and

$$S(2) = \int_{\gamma-\delta}^{\gamma} D(p)dp \geq V.$$

In that case,

$$W^{VS} - W^{VI} = \rho\{\rho[S(2) - V] + (1-\rho)V\} - c_2,$$

which is positive whenever D_2 finds it optimal to invest under separation (which amounts to $c_2 < \rho(1-\rho)V$). More generally, D_2's investment will be socially valuable whenever it exerts a positive externality on the other parties.[43]

42. An integrated supplier would still have an incentive to degrade the quality provided to the rival as long as v remains positive, even if arbitrarily small.

43. Allain *et al.* (2011) consider a setup with variable investment levels, and find that, even with an inelastic demand (implying $W(2) = W(1) = V$), vertical integration lowers total welfare when for instance investment costs are quadratic with respect to the probability of innovation.

4.2. *Imperfect upstream competition*

The analysis extends to upstream oligopolies, as long as degrading the perceived quality of the integrated supplier increases the market power of the other suppliers. This however supposes imperfect competition upstream, which triggers additional issues as now an integrated firm may have to strike a balance between upstream and downstream sources of profit.

To see this, suppose that U_A enjoys a comparative advantage over U_B when competing for D_2's needs: namely, D_2's return on investment is as before $r_2(I_1; s_2, s_1)$ when dealing with U_B, and $r_2(I_1; s_2, s_1)+\eta$ when dealing with U_A, for some $\eta > 0$. Absent vertical integration, standard (asymmetric) Bertrand competition ensures that U_A wins the competition for D_2 and moreover appropriates the additional surplus η. Hence, for D_2 the situation is the same as in the benchmark case $\eta = 0$, but U_A now has a profitable business in the upstream market. As a result, from an *ex ante* perspective it may no longer be profitable for an integrated $U_A - D_1$ to create hold-up concerns: while D_1 still benefits from distorting D_2's investment incentives, U_A would lose this profitable business.[44] Yet, *ex post* it would still be in the interest of an integrated U_A to degrade the support offered to D_2. Hence, if the quality of the support is not verifiable, vertical integration will trigger hold-up concerns even if this is not profitable from an *ex ante* perspective. The balance of the conflicting effects of hold-up on upstream and downstream profits may in that case lead to favour vertical separation.

This issue has for instance been mentioned in 1999 by General Motors (GM) as a motivation for spinning-off its auto parts subsidiary Delphi, so as to enable it to deal with other car makers, which were reluctant to rely on Delphi as long as it was part of GM.[45] A similar concern may have motivated AT&T's 1995 voluntary divestiture of its manufacturing arm, AT&T Technology (now Lucent), when the coming Telecommunication Act (1996) was about to allow the Regional Bell Operating Companies (RBOCs) to compete with AT&T on the long distance market.[46]

In the same spirit, Loertscher and Riordan (2013) study a downstream monopolist's incentives to divest its upstream division when alternative suppliers can invest in stochastic cost reductions. Being integrated enables the firm to source internally at cost, but reduces alternative suppliers' profits and thus discourages their investments. As a result, it is optimal for the integrated firm to divest its upstream division when there is a large dispersion of realized costs, as the downstream firm then relies quite often on the other suppliers.

4.3. *Customer foreclosure*

The analysis also applies ("upside-down") when the upstream firms are the ones that are subject to hold-up. For example, the development of private labels by large retail chains (a particular form of vertical integration) may expose national brand manufacturers to exacerbated hold-up, thereby discouraging their investments. For instance, in 1996 the EC blocked the merger between two Finnish retail groups, Kesko and Tuko, which would have created a dominant position on the retail market. One concern mentioned by the EC was that the development of private labels "enables retailers, who are inevitably privy to commercially sensitive details regarding the branded goods producers' product launches and promotional strategies, to act as competitors as well as key

44. The hold-up problem is however somewhat mitigated here, as U_B must compensate D_2 for the loss of the surplus η: as before, if it is anticipated that U_A will provide a degraded quality, U_B wins the competition for D_2 by matching U_A's best offer, but this best offer now provides a higher return, $r_2\left(1; \underline{s}, \overline{s}\right)+\eta$.

45. http://money.cnn.com/1999/05/31/companies/gm/

46. See for example Hausman and Kohlberg (1989) at p. 214: "The BOCs will not want to be in a position of technological dependence on a competitor, nor will they want to discuss further service plans with the manufacturing affiliate of a competitor."

customers of the producers. This privileged position increases the leverage enjoyed by retailers over branded goods producers".[47] In the same vein, a recent market study reports that new national brand products are imitated more quickly by private labels than by other national brands.[48]

To illustrate these concerns, consider the following framework, mirroring the previous one. Two manufacturers M_A and M_B invest to develop a new product, to be sold on an exclusive basis through one of two retailers (*i.e.* there is no intrabrand competition). As in Section 3.1, the resulting profit depends on the quality of the distribution: when M_h invests, its product generates a profit $r_h(I_k; s_h, s_k)$ (for $h \neq k \in \{A, B\}$), which increases in the quality of its distribution, s_h, and decreases in both the rival's investment, I_k, and the rival's quality of distribution service, s_k.[49]

The same reasoning as in Section 3.1 shows that independent retailers have no incentive to degrade *ex post* the quality of their distribution services, as this would only put them at a disadvantage when competing for the distribution of the brands. It follows that, under separation, if M_h invests, then Bertrand competition among the two retailers ensures that M_h obtains the full profit generated by its product; that is, retailers are willing to pay $T_{h1} = T_{h2} = r_h(I_k, \overline{s}, \overline{s})$. Likewise, an integrated retailer will provide good services for the distribution of its own brand. In contrast, it does have an incentive to degrade the distribution of the rival brand, in order to enhance the profit of its own brand. This, in turn, creates hold-up problems for the rival manufacturer whenever doing so reduces total industry profit.

4.4. *Partial vertical integration*

The analysis also applies to partial vertical integration, when one firm acquires a stake in a trading partner. To see this, let us return to the framework of Section 3.1, in which suppliers choose *ex post* whether to provide a degraded quality, and consider first the case of *forward* integration, in which U_A acquires a fraction $\alpha < 1$ of D_1's shares.[50] As before, in equilibrium U_B has no incentive to degrade the quality of its support, and U_A provides good support to D_1, which invests.

Consider now the provision of support to D_2. In stage 3, degrading the support provided to D_2 brings U_A a benefit αB. As long as αB exceeds ε, U_A is thus willing to degrade D_2's support: that is, Proposition 2(*i*) still holds with partial forward integration. Hence, in stage 2, U_A is willing to offer a subsidy of up to αB, whereas U_B's best offer consists in supplying good support at cost. It follows that U_B wins the competition when $\Delta\Pi_\alpha < 0$, where

$$\Delta\Pi_\alpha \equiv r_2(1; \underline{s}, \overline{s}) - r_2(1; \overline{s}, \overline{s}) + \alpha B.$$

As $\alpha < 1$, the condition $\Delta\Pi_\alpha < 0$ is less binding than under full integration, and thus hold-up concerns are *more* likely to arise: that is, Proposition 2(*ii*) holds in a wider range of situations under partial forward integration than under full integration. Furthermore, hold-up problems are also larger when they arise, because U_B now charges a higher tariff than under full integration: As a result, partial forward integration deters D_2 from investing (*i.e.* Corollary 3(*ii*) applies) in a wider range of situations.

Consider next the case of *backward* integration, in which D_1 acquires a fraction $\alpha < 1$ of U_A's shares. If this share grants D_1 the control of U_A, the analysis mimics that of full integration: U_A is

47. See §152 of the "Commission Decision of 20/11/1996 declaring a concentration to be incompatible with the common market", Case No IV/M.784 - Kesko/Tuko.

48. See DIW (2010); similar observations apply for packaging imitation.

49. For the sake of exposition, we assume here that the profit generated by each product is the same, whether the two products are sold by different retailers, or by the same retailer.

50. Whether U_A obtains or not the control of D_1 is of no consequence here, as tariffs are decided by the upstream firms.

willing to offer D_2 a subsidy of up to B, and hold-up concerns arise when $\Delta\Pi < 0$. In contrast, hold-up concerns do not arise if D_1 does not control U_A, as U_A then behaves as an independent supplier.[51]

Partial forward integration thus leads here to more hold-up concerns than full integration, whereas partial backward integration at most replicates the same concerns (if the downstream firm has control over upstream decisions). Interestingly, the opposite obtains in the framework considered by Spiegel (2013), in which downstream firms have bargaining power in their negotiations with a monopolistic supplier, and quality is not an issue: in the case of integration, the independent D_2 must then offer a higher input price to the upstream monopolist, in order to compensate it for the negative externality exerted on D_1's investment. This mechanism is even stronger when D_1 only holds a fraction $\alpha < 1$ of the supplier (as it is this fraction of the input price that must then compensate for D_1's losses), while the opposite is true when the supplier receives only a fraction α of D_1's profit (as the input price must only compensate for that share of the negative externality on D_1).

4.5. *Counter-fighting strategies*

We focused so far on the incentives to integrate vertically in an environment where all firms are initially independent. However, a first vertical merger may induce the remaining independent firms to merge as well, which in turn may affect the profitability of the first merger.

To explore this, consider first our successive duopoly framework, and for the sake of exposition let us assume that: (1) absent integration, both downstream firms invest (and obtain good support at cost); and (2) when instead U_A and D_1 are vertically integrated (and the other firms remain independent), D_1 invests (and obtains good support internally at cost) whereas D_2 does not (anticipating that it would be held-up by U_B). In this context, U_B and D_2, who obtain no profit if they remain independent, have indeed an incentive to integrate as well: this enables D_2 to obtain good support internally at cost, and thus replicates the outcome of vertical separation. Hence, in this successive duopoly framework, a first merger would trigger a second one, which in turn would annul the effect of the first one.

Note however that the second merger is likely to be less profitable than the first one. Indeed, the benefit generated by the first merger is given by $B_1 \equiv r_1(0;\overline{s},\overline{s}) - r_1(1;\overline{s},\overline{s})$, whereas the benefit from the second merger is given by $B_2 \equiv r_2(1;\overline{s},\overline{s})$. Therefore, $B_1 > B_2$ whenever discouraging D_2's investment increases total industry profit. Accounting for the cost of implementing a merger may then affect the analysis: if for instance vertical integration involves a fixed cost $K \in (B_1, B_2)$, then D_1 will find it profitable to merge, anticipating that this will not trigger a counter-merger by D_2.[52]

Furthermore, when there are more downstream firms than suppliers, a first merger can be profitable even if it triggers a merger wave. To see this, suppose now that there are $n > 2$ downstream firms $D_1, D_2, D_3, ..., D_n$, and let us study a simple "sequential merger game" in which each D_i bids in turn to buy one the suppliers, U_A or U_B (horizontal mergers are ruled out; hence each D_i can buy at most one supplier, and once acquired a supplier is no longer available for the remaining bidders). Consider first the last stage of this bidding game. If no supplier has been acquired yet, then D_n buys one of the suppliers (offering an arbitrarily small price suffices),

51. This corresponds to the "legal unbundling" scenario considered by Höffler and Kranz (2011), where a downstream firm owns an upstream monopolist, but the upstream firm is legally independent and maximizes its own profit. They find that such legal unbundling does not give the supplier any incentive to engage in sabotage, and yet may encourage the downstream firm to expand output.

52. See Allain *et al.* (2011) for a more detailed discussion.

so as to create hold-up problems for the downstream rivals. If instead one supplier has already been acquired, then D_n buys the other one, so as to protect itself from hold-up. Anticipating this, in the previous stages of the bidding game every D_i seeks to acquire a supplier whenever it has a chance. Hence, the equilibrium exhibits a "merger wave" in which D_1 buys one supplier and D_2 buys the other one. In this equilibrium, D_1 and D_2 obtain good support internally at cost, whereas every other D_i obtains a degraded quality (and is not even partially compensated by any subsidy, as each supplier anticipates that D_i would obtain a degraded quality anyway if it were to turn to the other supplier).[53]

Hence, while further integration may constitute an effective counter-fighting strategy in response to a vertical merger, such a merger remains profitable when trading partners are scarce—namely, when there are more investors than sources of support. This is consistent with the above-mentioned merger wave observed in the GPS industry, where *TomTom* and *Nokia* acquired the two suppliers of navigable digital databases, *Tele Atlas* and *Navteq*, which led other downstream competitors such as *Garmin* to complain about the risk of being left stranded.

5. CONCLUSION

In contrast with the established literature, which mainly views vertical integration as a solution to the hold-up problem, our analysis emphasizes that vertical integration may create hold-up problems for rivals. We first discuss *ex ante* incentives, in a framework where competing suppliers can choose to pre-commit themselves to being greedy. Independent suppliers never use this option; as a result, under vertical separation upstream competition eliminates hold-up concerns. In contrast, an integrated supplier takes advantage of this option, in order to create hold-up concerns for downstream rivals, and discourage in this way their investments. Similar insights apply when suppliers can threaten to dissipate (rather than appropriate) their customers' profits.

We then discuss *ex post* incentives, in a framework where suppliers' quality is unverifiable. We first note that a vertically integrated supplier would have an incentive to degrade the quality provided to downstream rivals, so as to confer a comparative advantage to its own downstream subsidiary. As a result, vertical integration alone makes the supplier less reliable. Building on this insight, we show that vertical integration exposes downstream rivals to being held up by the other supplier, even in the absence of any pre-commitment, as long as degrading access reduces total industry profits. We further show that this last condition holds in a variety of standard Industrial Organization models, and discuss several antitrust cases in which vertical mergers indeed triggered hold-up concerns.

Our analysis also contributes to the literature on vertical foreclosure, which has highlighted the impact of vertical integration on product market competition through "raising rivals' costs" effects; we emphasize instead the adverse impact of vertical integration on rivals' innovation and investment incentives, through exacerbated hold-up concerns. We further show that vertical foreclosure can arise even when contracts are *ex post* efficient, and in the absence of any pre-commitment to denying or degrading access.

The above insight have implications for merger policy, as by discouraging rivals' investments, thus making them less effective competitors, vertical integration may also harm consumers and reduce total welfare. In particular, when instruments can be used to provide quality guarantees,

53. Building on Bourreau *et al.* (2011), Hombert *et al.* (2014) find that, when there are more firms downstream than upstream, a merger wave can arise even in the absence of quality issues. In their framework, Bertrand-like competition drives input prices down to costs as long as there remains an independent supplier; in contrast, partial foreclosure arises when all suppliers are vertically integrated. As a result, in equilibrium, every upstream firm integrates with a downstream firm, and the remaining unintegrated downstream firms obtain the input at a high price.

merger control authorities may wish to impose these instruments when hold-up concerns arise—even if these instruments are already in place pre-merger, as vertical integration may alter the incentives to maintain them.

Finally, we discuss the robustness of the analysis and consider a number of extensions: upstream and downstream oligopolies, customer foreclosure, partial integration, and counter-fighting strategies. When upstream competition is imperfect, the benefit of foreclosure for the downstream subsidiary must be balanced against the foregone upstream profit. As a result, vertical integration may no longer be profitable. We also note that, while a downstream rival may respond to a merger by integrating as well, this second merger is likely to be less profitable than the first. It follows that a first merger need not trigger a counter-merger when implementing a merger is costly. In addition, even if a merger wave occurs, vertical integration still creates hold-up problems for the remaining independent rivals when there are more downstream firms than suppliers.

To be sure, we have emphasized here the "dark side" of vertical integration on *rivals*' investment incentives; in practice, the "bright side" emphasized by the existing literature, namely, the elimination of hold-up concerns for the *integrated firm*, can contribute to foster investment incentives. Our aim is certainly not to deny this benefit, but rather, to contribute to the analytical framework that can be used to evaluate the overall impact of vertical integration on investment and innovation, so as to provide guidance for policy makers and particularly for merger control. Furthermore, by increasing the upstream rival's profit, vertical integration may also foster upstream investment incentives—and possibly entry. We leave the analysis of these developments to future research.

APPENDIX

A. PROOF OF PROPOSITION 1

For the sake of exposition, we will first assume that, in case of commitment in stage 0, the sharing rule $\hat{s}$ applies to all (independent) downstream partners.[54]

Suppose that an independent supplier, say U_h, commits itself *ex ante* to the sharing rule $\hat{s}$. Note that U_h can obtain a positive revenue only if, *ex post*, it wins the competition for a downstream firm that invested in stage 1.[55] However:

- If the rival supplier, U_k, does not commit itself *ex ante* to the sharing rule $\hat{s}$, then it can outbid $\hat{s}$ *ex post*; as a result, the rival U_k wins the competition in stage 2 for any D_i that invested in stage 1.
- If instead U_k also commits *ex ante* itself to $\hat{s}$, then:
  - U_h cannot make a profit with independent downstream firms, as they do not invest in this case—indeed, under $(A1)-(A2)$ an independent downstream firm never invests in stage 1 (regardless of whether its rival invests or not) when it anticipates keeping only a share $\hat{s}$ of the return on investment.[56]
  - but U_h cannot make a profit with an integrated downstream firm either, as the latter can secure support at cost internally.

Hence, in all cases U_h obtains no revenue. Anticipating this, in stage 0, U_h does not commit itself to $\hat{s}$, so as to save the cost ε (note that U_h can guarantee itself at least zero profit in the continuation game if does not commit itself in stage 0).

54. Whether it applies to an integrated subsidiary is irrelevant, as internal transfers do not affect the integrated firm's investment decision.

55. If D_i does not invest in stage 1, then D_i and its supplier obtain zero profit.

56. Assumption $(A2)$ implies that the unique continuation equilibrium of the investment subgame is such that no firm invests. Under a weaker assumption such as $\hat{s} < \min_{i=1,2}\{c_i/r_i(1)\}$, there could exist multiple continuation equilibria (in which for instance one or the other downstream firm would invest), which could be used to punish deviations from an equilibrium in which both suppliers pre-commit themselves in stage 0.

It follows that, in the absence of vertical integration, if D_i invests in stage 1 then, *ex post*, Bertrand competition yields $s_{Ai}=s_{Bi}=1$ in stage 2. Anticipating this, under $(A1)$ both firms invest in stage 1 and each D_i obtains $r_i(c_i)-c_i$.

Suppose now that U_A is vertically integrated with D_1, which implies $s_1=1$ (as the integrated firm maximizes its joint profit) and thus, under $(A1)$, $I_1=1$. Consider now D_2's investment decision. If D_2 does not invest, then it obtains zero profit for sure. If instead it invests, then its profit depends on U_A's decision in stage 0:

- If *ex ante* U_A does not pre-commit itself to $\hat{s}$, then *ex post* Bertrand competition for supplying D_2 yields again $s_{A2}=s_{B2}=1$ in stage 2; anticipating this, under $(A1)$ D_2 still invests in stage 1, and the integrated firm thus obtains $r_1(1)-c_1$.
- If instead U_A commits itself *ex ante* to $\hat{s}$, then *ex post,* U_B wins the competition for D_2 by matching U_A's offer.[57] Anticipating this, under $(A1)-(A2)$, D_2 does not invest in stage 1, and the integrated firm thus obtains (gross of the commitment cost ε) $r_1(0)-c_1$.

Under $(A1)$, as long as the cost of commitment ε is not too large (namely if $\varepsilon<r_1(0)-r_1(1)$), and thus U_A chooses to commit itself to $\hat{s}$ in stage 0.

The same logic applies when in stage 0 suppliers can also choose to apply the sharing rule $\hat{s}$ selectively, so as to target a specific downstream firm. For the same reasons as above, independent suppliers will never pre-commit themselves vis-à-vis any downstream firm. In contrast, an integrated U_A does have an incentive to commit itself and target the independent rival, D_2.

B. HOLD-UP THROUGH PROFIT DISSIPATION

Consider the following variant of the framework introduced in Section 2, in which suppliers compete in the quality of their support as well as in (lump-sum) tariffs:

- Stage 0 (*ex ante*): each supplier can publicly commit itself, at cost ε, to offering a degraded quality $\hat{s}<1$ to its partners.
- Stage 1 (*investment*): downstream firms make their investment decisions; these decisions are publicly observed.
- Stage 2 (*ex post*): each U_h offers each independent D_i a contract, specifying a support quality $s_{hi}\in[0,1]$ (where $s_{hi}=\hat{s}$ in case of commitment in stage 0) and a lump-sum tariff T_{hi};[58] independent downstream firms then choose their suppliers.

Suppose further that $\hat{s}$ satisfies $(A1)$ and a weaker variant of $(A2)$, namely:

$$(A2') \qquad \hat{s}<\min\left\{\frac{c_1}{r_1(1)},\frac{c_2}{r_2(1)}\right\}.$$

Again, independent suppliers never commit themselves *ex ante* to offering a degraded support, as doing so would be costly and could only put them at a competitive disadvantage when competing for independent customers. To see this, it suffices to note that, as before, an independent U_h obtains no revenue if it commits itself *ex ante* to offering a degraded quality $\hat{s}$:

- If the rival supplier, U_k, does not commit itself *ex ante* to offering a degraded quality, then U_k wins the competition in stage 2 (with the best quality $s_{ki}=1$, and a tariff matching U_h's best offer—see below) for any D_i that invested in stage 1.
- If instead U_k also commits *ex ante* itself to $\hat{s}$, then *ex post* Bertrand competition leads the two suppliers to offering this degraded quality at cost (that is, $T_{A2}=T_{B2}=0$), whatever the investment decisions made in stage 1.[59]

Anticipating this, in stage 0, U_h does not commit itself to $\hat{s}$, so as to save the cost ε.

57. Technically, if D_2 invests in stage 1, then in stage 2 the only continuation equilibrium is indeed that U_B offers exactly $s_{B2}=\hat{s}$ and D_2 picks U_B as supplier.

58. An integrated downstream firm obtains internally high-quality support ($s=1$) at cost ($T=0$).

59. This is where the analysis differs from that of Appendix A, and allows us to rely on the weaker assumption $(A2')$; see footnote 56.

It follows that, absent vertical integration, *ex post* Bertrand-like competition among suppliers enables downstream firms to obtain the best support ($s=1$) at cost ($T=0$). Anticipating this, under Assumption ($A1$) both firms invest in stage 1, and thus D_i's profit is equal to $r_i(1)-c_i$ (and suppliers get zero profit).

Suppose now that U_A is integrated with D_1; as D_1 can internally obtain high-quality support at cost, under Assumption ($A1$) it invests in stage 1. Furthermore, if U_A does not commit itself *ex ante* to offering D_2 a degraded quality $\hat{s}$ then, *ex post*, Bertrand competition leads again the suppliers to offer the best quality at cost (that is, $s_{A2}=s_{B2}=1, T_{A2}=T_{B2}=0$). Anticipating this, D_2 invests in stage 1, and the integrated firm thus obtains a profit equal to $r_1(1)-c_1$.

In contrast, by committing itself *ex ante* to offering D_2 a degraded support $\hat{s}$, U_A exposes D_2 to being held-up *ex post* by U_B: indeed, if D_2 invests in stage 1 then, in stage 2, U_B wins the competition by offering high-quality support ($s_{B2}=1$), but with a positive tariff designed to match U_A's best offer, which consists in a degraded support $\left(s_{A2}=\hat{s}\right)$ supplied at cost ($T_{A2}=0$); that is, $T_{B2}=(1-\hat{s})r_2(1)$, leaving D_2 with a profit equal to $\hat{s}r_2(1)$. Anticipating this, under $\left(A2'\right)$ D_2 does not invest in stage 1, and the integrated firm thus obtains a profit (gross of the commitment cost ε) $r_1(0)-c_1$.

As it benefits from reducing the investment of its downstream rival D_2, and as long as ε is not too large, an integrated U_A prefers committing itself *ex ante* to offering a degraded support to D_2, in order to put it *ex post* at the mercy of the other supplier, U_B, and discourage in this way D_2's investment.

C. PROOF OF PROPOSITION 2

As noted in the text, in stage 3 it is optimal for an independent supplier to provide *ex post* high-quality support. Suppose now that U_A is vertically integrated with D_1. Obviously, it is then optimal for U_A to provide high-quality to D_1 and a degraded quality to D_2, so as to increase D_1's profit from $r_1(1;\bar{s},\bar{s})$ to $r_1\left(1;\bar{s},\underline{s}\right)$. In stage 2, D_1 obtains high-quality support at cost (which it can secure from U_A). U_B's best offer to D_2 consists in providing (high-quality) support at cost: $\hat{T}_{B2}=0$. In contrast, to induce D_2 to accept a degraded quality, U_A is willing to offer a subsidy and lower its tariff down to $\hat{T}_{A2}=-B+\varepsilon$, which is negative when ε is small enough. Therefore, U_A's best offer would give D_2 a net profit of

$$\hat{\pi}_2^A=r_2\left(1;\underline{s},\bar{s}\right)-\hat{T}_{A2}=r_2\left(1;\underline{s},\bar{s}\right)+r_1\left(1;\bar{s},\underline{s}\right)-r_1(1;\bar{s},\bar{s})-\varepsilon,$$

whereas U_B's best offer would give D_2 a profit of

$$\hat{\pi}_2^B=r_2(1;\bar{s},\bar{s})-\hat{T}_{B2}=r_2(1;\bar{s},\bar{s}).$$

U_B wins the competition when $\hat{\pi}_2^B>\hat{\pi}_2^A$, which amounts to

$$\begin{aligned}0 &> \hat{\pi}_2^A-\hat{\pi}_2^B\\ &= \left[r_2\left(1;\underline{s},\bar{s}\right)+r_1\left(1;\bar{s},\underline{s}\right)-r_1(1;\bar{s},\bar{s})-\varepsilon\right]-r_2(1;\bar{s},\bar{s})\\ &= \Delta\Pi-\varepsilon.\end{aligned}$$

As a result, when degrading the quality of D_2's support reduces total industry profit ($\Delta\Pi<0$), U_B wins the competition and in that case U_B is moreover able to charge a positive tariff: in equilibrium, U_B charges a tariff T_{B2} that leaves D_1 indifferent between accepting the offer or opting for U_A's best offer; that is, this tariff is such that $r_2(I_2;\bar{s},\bar{s})-T_{B2}=\hat{\pi}_2^A$, or:

$$T_{B2}=r_2(I_2;\bar{s},\bar{s})-\hat{\pi}_2^A=\hat{\pi}_2^B-\hat{\pi}_2^A=\varepsilon-\Delta\Pi>0.$$

D. PROOF OF COROLLARY 3

In the case of vertical separation, in stage 2 Bertrand-like competition enables downstream firms to obtain high-quality support at cost, and thus to earn the full return on their investments. Hence, if $c_i<r_i(1;\bar{s},\bar{s})\,(<r_i(0;\bar{s},\bar{s}))$, an independent D_i invests in stage 1: $I_i=1$, regardless of what the rival does. Suppose now that D_1 is vertically integrated with U_A. As D_1 still obtains high-quality support at cost, it keeps investing: $I_1=1$. In contrast, if $c_2>r_2(1;\bar{s},\bar{s})+\Delta\Pi-\varepsilon$ (which implies $\Delta\Pi<\varepsilon$), then the rival D_2 is better-off not investing, as it would only obtain $\hat{\pi}_2^B-T_{B2}=r_2(1;\bar{s},\bar{s})+\Delta\Pi-\varepsilon<c_2$.

E. $\Delta\Pi<0$: EXAMPLES

E.1. *Linear differentiated Cournot duopoly*

Consider a Cournot duopoly in which D_i faces a demand $P_i\left(q_i,q_j\right)=1-q_i-\sigma q_j$ and a linear cost $C_i(q_i)=c_iq_i$. The equilibrium quantities and profits are of the form $\pi_i^C\left(c_i,c_j\right)=\left[q_i^C\left(c_i,c_j\right)\right]^2$, where

$$q_i^C\left(c_i,c_j\right)=\frac{2-\sigma-2c_i+\sigma c_j}{4-\sigma^2}$$

as long as $c_i < (2-\sigma+\sigma c_j)/2$, and $q_i^C(c_i, c_j) = 0$ otherwise. Suppose now that degrading D_i's support increases its cost from $c_i = 0$ to $c_i = c$. Degrading D_2's support then eliminates D_2 when $c \geq \bar{c} \equiv 1-\sigma/2$, in which case D_1 monopolizes the industry and obtains $\Pi_1^m = 1/4$; when instead $c < \bar{c}$, total industry profit is equal to:

$$\Pi^C(c) = \frac{(2-\sigma)^2 2(1-c) + (4+\sigma^2)c^2}{(4-\sigma^2)^2}.$$

Note that

$$\frac{d\Pi^C(c)}{dc} = \frac{-2(2-\sigma)^2 + 2c(4+\sigma^2)}{(4-\sigma^2)^2}.$$

Therefore $\Pi^C(c)$ decreases in c for $c \in [0, \hat{c}]$, where $\hat{c} \equiv \frac{4-4\sigma+\sigma^2}{4+\sigma^2} \leq \bar{c}$ (with a strict inequality for $\sigma > 0$), whereas it increases for $c \in [\hat{c}, \bar{c}]$ (and remains equal to $\Pi_1^m = 1/4$ afterwards). In this framework, we thus have $\Delta\Pi < 0$ for any $c \in [0, \hat{c}]$, while the sign of $\Delta\Pi\left(= \Pi^C(c) - \Pi^C(0)\right)$ may be ambiguous for larger values of c. The overall impact of any discrete handicap is however more likely to be negative as firms become more differentiated: the comparison between "complete foreclosure" ($c = \bar{c} = 1-\sigma/2$) and "full access" ($c = 0$) yields:

$$\Delta\bar{\Pi}(\bar{c}) = \Pi(\bar{c}) - \Pi(0) = \frac{\sigma^2 + 4\sigma - 4}{4(2+\sigma)^2},$$

which increases with σ. It is moreover negative whenever $\sigma < \hat{\sigma} = 2\sqrt{2} - 2 \simeq 0.83$, in which case degrading D_2's support reduces total industry profit for *any* cost handicap (*i.e.* for any $c > 0$).

Clearly, the same analysis obtains when degrading D_i's support alters the quality of its offering. Suppose for instance that D_i's demand is now given by

$$P_i(q_i, q_j) = 1 + s_i - q_i - \sigma q_j,$$

where s_i denotes D_i's product quality. This is formally equivalent to the previous model, as decreasing s_i amounts to increase the net "quality-adjusted" cost $c_i - s_i$.

Finally, we show that a similar insight applies when firms have captive customer bases. To see this, suppose that firms supply two customer segments:

- In the *competitive* segment, they face a mass of consumers $1-\beta$ with inverse demand $P(Q) = 1-Q$, and thus obtain $(1-\beta)(1-2c_i+c_j)^2/9$.
- In addition, each firm supplies a *captive base* of mass β, in which it freely exploits the same demand and thus obtains a profit $\beta(1-c_i)^2/4$.

Interpreting again a degradation of the support as increasing the cost from $c_i = 0$ to $c_i = c$, degrading D_2's support yields an industry profit equal to:

$$\Pi^C(c) = (1-\beta)\frac{2-2c+5c^2}{9} + \beta\frac{2-2c+c^2}{4}.$$

Note that

$$\frac{d\Pi^C(c)}{dc} = -\frac{4+5\beta-(20-11\beta)c}{18}.$$

Therefore $\Pi^C(c)$ decreases in c for $c \in [0, \hat{c}_\beta]$, where $\hat{c}_\beta \equiv \frac{4+5\beta}{20-11\beta}$, and the overall impact of any discrete handicap is more likely to be negative as captive bases become more important: the comparison between "complete foreclosure" ($c = \bar{c} = 1/2$) and "full access" ($c = 0$) now yields:

$$\Delta\bar{\Pi}(\bar{c}) = \Pi(\bar{c}) - \Pi(0) = \frac{4-31\beta}{144},$$

which is negative whenever $\beta < 4/31 \simeq 0.13$, in which case degrading D_2's support reduces total industry profit for *any* cost handicap (*i.e.* for any $c > 0$).

E.2. *Hotelling model with advertising*

Consider a Hotelling segment $[0, 1]$ with a uniform distribution of consumers and two firms located at the end points. Suppose further that degrading D_2's support limits to $s < 1$ the fraction of consumers aware of the existence of its product; normalizing consumers' transportation cost to $t = 1$, and assuming that their willingness to pay, v, is in the appropriate

range (namely, $1<v<2$, so that all consumers are served when they are aware of both products, but only part of the market is covered when they are only aware of a single product), demands are then:

$$D_1(p_1,p_2) = s\frac{(1-p_1+p_2)}{2}+(1-s)(v-p_1),$$

$$D_2(p_2,p_1) = s\frac{(1-p_2+p_1)}{2}.$$

Equilibrium prices and profits are as follows:

$$p_1^*(s)=\frac{3s+4v(1-s)}{8-5s}, p_2^*(s)=\frac{4-s+2v(1-s)}{8-5s},$$

$$\Pi_1^*(s)=\frac{(2-s)(4v+s(3-4v))^2}{2(8-5s)^2}, \Pi_2^*(s)=\frac{s(s+2sv-2(2+v))^2}{2(8-5s)^2}.$$

It can be checked that $\Pi^*(s)\equiv\Pi_1^*(s)+\Pi_2^*(s)$ strictly increases in s.

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