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Abstract

While vertical integration is traditionally seen as a *solution* to the hold-up problem, this paper highlights instead that it can *generate* hold-up problems – for rivals.

We first consider a successive duopoly where competition among suppliers eliminates any risk of hold-up; downstream firms thus obtain the full return from their investments. We then show that vertical integration creates hold-up concerns for the downstream rival, by affecting the integrated supplier's incentives from both *ex ante* and *ex post* standpoints.

We also provide illustrations in terms of standard industrial organization models and of antitrust cases, and discuss the robustness of the insights.

Jel Codes: L13, L41, L42.

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1 Introduction

The literature on incomplete contracts has emphasized the role of vertical integration as a possible *solution* to hold-up problems.[1] Yet in practice antitrust authorities have instead voiced concerns that vertical integration may *generate* hold-up problems ... for rivals.[2] 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 two upstream suppliers. Despite the lack of *ex ante* contracting, under vertical separation the competition among suppliers eliminates any risk of hold-up, and firms obtain *ex post* the full return from their investments. By 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 the other supplier. *Ex post*, degrading the input provided to the rival can benefit 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 take this option, an integrated supplier takes instead advantage of the option 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 whenever doing so increases the profit obtained by its own downstream subsidiary. In such a case, vertical integration creates again hold-up problems for the downstream rival, even in the absence of any pre-commitment possibility, simply by making the integrated supplier less reliable.

Our paper builds on the literature on hold-up and vertical integration.[3] Hold-up

[1] See, *e.g.*, Williamson (1975), Klein, Crawford, and Alchian (1978) and Grossman and Hart (1986).
[2] See for example the quote from the TOMTOM/TELE ATLAS decision mentioned in Section 2.3.
[3] For a detailed discussion of this literature, see Hart (1995).

concerns arise when part of the return on an agent's investment can be appropriated *ex post* by a trading partner. This is the case when (i) the trading partner enjoys bargaining power (stemming from market power, or because the investment is relationship-specific); and (ii) contracting either cannot take place *ex ante*, before investments are sunk, or complete contracts are too costly to write or to enforce – see, e.g., 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 the hold-up problem. In this context, vertical integration has been viewed as a solution to hold-up problems – see for instance Williamson (1975, 1985), Klein, Crawford, and Alchian (1978), and Grossman and Hart (1986). These first papers however focus on bilateral monopolies. When several competitors have to invest, 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.[4] Also, competition among trading partners may 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 however *exacerbate* hold-up concerns for rivals, and reduce in this way their own investment incentives.[5]

Our paper also relates to the literature on foreclosure,[6] 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 by enabling 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.[7] We revisit this literature by focussing on hold-up and investment incentives, rather than on product market competition.[8] Fur-

[4] See also McLaren (2000).

[5] 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 integrated firm investment incentives; 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.

[6] See Rey and Tirole (2007) for an overview of this literature.

[7] 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 when downstream firms have some bargaining power in their negotiation with an upstream monopolist – see the discussion in subsection 4.3.

[8] In OSS – as well as in Hart and Tirole (1990) and Spiegel (2013) –, vertical integration is profitable

thermore, as stressed by Hart and Tirole (1990), the "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. By 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.[9] We thus also contribute to this literature by showing that such commitment is not required when the quality of support is non verifiable.

The paper is organized as follows. Section 2 shows how vertical integration generates *ex ante* incentives to create hold-up problems for independent rivals. We first present this insight in a framework where, before investment decisions, suppliers can pre-commit themselves to either appropriating a share of the profits, or dissipating part of these profits through a degraded support; we then discuss several illustrations. Section 3 shows further that, even in the absence of any pre-commitment, vertical integration also creates hold-up problems *ex post* when degrading the support provided to one firm benefits its rival. 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. To be active, each D_i must both invest and secure

from an *ex post* standpoint (i.e., for given investment levels – which, in turn, has implications for investment decisions). By contrast, in our setup vertical integration does not increase the profit achieved *ex post* by the integrated firms – in particular, it does not affect their investment behavior (i.e., their best response remains unchanged). Vertical integration is only profitable because it exacerbates hold-up concerns for the independent rivals, and distorts in this way their own investment behavior.

[9] 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.

some support, which either upstream firm can supply at no cost. With this support, investing I_i generates a return $r_i(I_j) I_i$, which decreases in the rival's investment I_j; without support, the investment generates no profit.

Throughout this section, we assume that each D_i can choose any investment scale $I_i \in [0,1]$ at cost $C_i(I_i)$, and maintain the following regularity conditions:

Assumption A. For $i = 1, 2$:

*A*1. $r_i(.)$ is C^1 and strictly decreasing, and $C_i(.)$ is C^2, increasing and strictly convex;

*A*2. $C_i'(0) < r_i(.) \leq C_i'(1)$;

*A*3. $\max_{I \in [0,1]} |r_i'(I)| < \min_{I \in [0,1]} C_i''(I)$.

Condition *A*1 ensures that firms' investment responses are uniquely defined. Under condition *A*2 they are moreover characterized by first-order conditions when firms obtain the full return on their investments. Finally, condition *A*3 guarantees the existence of a unique, stable investment equilibrium.

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 first use a simple model in which suppliers can pre-commit themselves to being "greedy" (section 2.1). We then show that the same insight applies when suppliers can threaten to dissipate, rather than appropriate, their customers' profits (section 2.2). We conclude by discussing several illustrations (section 2.3).

2.1 A simple model

We allow here suppliers, if they wish so, to commit themselves *ex ante*, before investment decisions, to a particular sharing rule (exogenously given for the moment being; we endogenize it at the end of this section). We view this assumption mainly as a convenient expositional device for discussing *ex ante* incentives to raise hold-up concerns, but note that, in practice, a supplier may indeed influence its *ex post* bargaining power in various ways, e.g., by posting bonds, exchanging (economic) "hostages," limiting its freedom of actions, delegating decision powers to appointed arbitrators, and so forth[10] – see, e.g., the discussion of patent trolls in section 2.3.

We thus consider the following game, where all decisions are observed by all firms:

- Stage 1: Each supplier can 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 2: Downstream firms make their investment decisions.

- Stage 3: 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); downstream firms then choose their suppliers.

To analyze 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 (and only 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 1. To see this, observe that the supplier cannot make a profit from dealing with integrated downstream firms, as they can obtain internal support at cost; and when competing for independent downstream firms, pre-committing itself to the rule $\hat{s}$ would not only cost ε but may also prevent the supplier from outbidding its rival in stage 3.

Hence, if both suppliers are independent, no supplier ever pre-commits itself in stage 1; it follows that in stage 3, Bertrand-like competition leads suppliers to provide support at cost. Therefore, in stage 2 each D_i expects to obtain the full return from its investment, and thus seeks to maximize

$$r_i(I_j) I_i - C_i(I_i). \qquad (1)$$

Suppose now that U_A is vertically integrated with D_1. If U_A does not adopt the rule $\hat{s}$, then Bertrand competition enables again D_2 to be supplied at cost, and thus each D_i

[10] For a discussion of *ex ante* measures that can influence *ex post* bargaining positions of negotiating partners, and their role in alleviating hold-up concerns, see, e.g., Aghion *et al.* (1994).

[11] We assume for simplicity that the sharing rule $\hat{s}$ then applies to all downstream partners.

chooses I_i so as to maximize (1). By contrast, if U_A adopts the rule $\hat{s}$, then in stage 3 U_B wins *ex post* the competition for the supply of D_2, by offering an only slightly better sharing rule; therefore, in stage 2 D_2's objective becomes $\hat{s}r_2(I_1)I_2 - C_2(I_2)$, whereas the objective of the integrated firm $U_A - D_1$ remains given by $r_1(I_2)I_1 - C_1(I_1)$.

It follows that committing to the rule $\hat{s}$ allows the integrated firm $U_A - D_1$ to expose its downstream rival D_2 to being held-up 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 Assumption A:*

i) Independent suppliers never commit themselves to the sharing rule $\hat{s}$; absent vertical integration, upstream competition thus eliminates any risk of hold-up.

ii) By contrast, an integrated supplier commits itself to the sharing rule $\hat{s}$, so as to create hold-up problems for the downstream rival.

Proof. See Appendix A. ■

So far, the literature has mainly viewed vertical integration as a solution to hold-up problems. By contrast, here upstream competition disciplines suppliers under vertical separation, and thus vertical integration has only adverse effects: It has no impact on the integrated subsidiary, but generates hold-up problems for the independent rival. Note that this also benefits the independent supplier, who enjoys greater power and can appropriate some of the return on D_2's investment.[12]

Remark: 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 it would still contribute to exacerbate them for downstream rivals. Consider for instance the case of a monopolistic supplier, having all the bargaining position in *ex post* bilateral negotiations. If it did not commit to the sharing rule $\hat{s}$, then *ex post* it would appropriate all investment benefits, thereby discouraging downstream firms from undertaking any investment. In the absence of vertical integration, the supplier will therefore choose

[12] That is, as long as D_2 keeps investing. See also the discussion below on the choice of $\hat{s}$.

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

to commit itself to the sharing rule $\hat{s}$, in order to limit hold-up concerns and encourage investment, the benefits of which it then partly appropriates. By contrast, if vertically integrated the supplier may choose not to commit to $\hat{s}$, so as to discourage the downstream rival's investment – it will do so when the benefits to its downstream subsidiary more than offset the loss of profit from not supplying the rival.

Remark: Choosing the sharing rule $\hat{s}$. For simplicity, we have considered here the case where a supplier could only pre-commit itself to a given rule $\hat{s}$; however, the insights apply as well when suppliers can opt in stage 1 (at an arbitrarily small cost) for any sharing rule $\hat{s} \in [0, 1]$. Again, under vertical separation no supplier chooses to pre-commit itself, and in stage 3 upstream competition enables downstream firms to obtain the full returns on their investments. By contrast, an integrated U_A benefits from pre-committing itself to a rule $\hat{s} < 1$, so as to expose D_2 to being held-up by U_B. The integrated firm would actually wish to discourage D_2's investment as much as possible, but cannot insist in too low a share, as U_B would then have an incentive to pre-commit itself as well, in order to limit hold-up concerns. We show in Appendix B that, in equilibrium, U_A commits itself in stage 1 to $\hat{s}_{A2} = s^*$, where s^* maximizes U_B's profit; that is,

$$s^* = \arg\max_s (1 - s) r_2(I_1(s)) I_2(s),$$

where $(I_1(s), I_2(s))$ are the continuation equilibrium investments when D_2 expects to keep a share s of the profit it generates. U_B then wins the competition for D_2 in stage 3 by matching U_A's offer. Obviously, $s^* < 1$ (as suppliers would obtain zero profit otherwise), and thus vertical integration still creates hold-up problems for the independent rival.

2.2 Hold-up through profit dissipation

The above model supposes that suppliers can pre-commit themselves to capturing a share of their customers' profits. We now show that the above insights carry over when suppliers can instead threaten to dissipate part of the investment benefits. In practice, suppliers could achieve this in various ways, e.g., by limiting access to some input, granting low-priority access to premium resources,[14] exploiting commercially sensitive

[14] See Bolton and Whinston (1993) for a study of the impact of vertical integration on access to a scarce input in the case of an upstream monopoly.

information,[15] and so forth. We will simply assume here that suppliers can adjust the quality $s \in [0, 1]$ of their support; without loss of generality, we will also assume that they offer their support in exchange for a (lump-sum) tariff T.[16]

To parallel the previous model, we make the following assumptions:

• *Profit dissipation:* When D_i obtains support of quality s_i, its return on investment is

$$s_i r(I_j) I_i. \tag{2}$$

Degrading the support ($s_i < 1$) is thus akin to *sabotage*: It reduces D_i's profit but has no impact on the rival's profit.[17] The case where degrading the support benefits the rival is considered in the next section.

• *Hold-up incentives:* Negotiations take place *ex post*, once investments have been made; however, if they wish so, suppliers can limit *ex ante* the quality of the support they offer to $\hat{s} < 1$.[18] Thus, as before *ex post* negotiations introduce a risk of hold-up, which suppliers can now try and exacerbate by degrading the quality of their support.

The precise timing is as follows, where all decisions are again observed by all firms:

- Stage 1: Each supplier can commit itself, at an arbitrarily small cost ε, to offering a degraded support $\hat{s}$ to independent downstream firms.

- Stage 2: Downstream firms make their investment decisions.

- Stage 3: Each U_h offers each D_i a contract (s_{hi}, T_{hi}) (where $s_{hi} = \hat{s}$ if U_h has committed itself in stage 1, and is not integrated with D_i);[19] each downstream

[15] Asker and Ljungqvist (2010) show for instance that this is a concern in the relationship between investment banks and competing customers.

[16] Lump-sum tariffs are *ex post* efficient here, as the "quantity" traded is either zero or one.

[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, e.g., Weisman (1995), Economides (1998), and Beard *et al.* (2001). More recently, Gilbert and Riordan (2007) show that a regulated bottleneck may engage in tying in order to discourage a rival from investing in product improvement.

[18] For simplicity, we assume that the integrated firm always provides good support to its own subsidiary. Degrading this support would have a direct impact on its profit and discourage its investment. The assumption is thus innocuous when investments are strategic substitutes, as degrading the support provided to its subsidiary would then also foster the rival's investment. When instead investments are strategic complements, degrading the support provided to its subsidiary could be desirable only if the indirect impact on the rival's investment was large enough to offset the direct negative effects.

[19] We do not allow here 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

firm then chooses its supplier.[20]

The following Proposition characterizes the impact of vertical integration on the equilibria of this game:

Proposition 2 *Previous insights carry over; under Assumption A:*

i) Independent suppliers never commit themselves to offering a degraded support.

ii) By contrast, an integrated supplier commits itself to offering a degraded support, so as to create hold-up problems for the downstream rival.

Proof. See Appendix C. ■

The analysis thus confirms the previous insights. Absent vertical integration, upstream competition leads suppliers to provide the best support at cost; downstream firms therefore obtain the full return on their investments. By contrast, vertical integration between, say, U_A and D_1 creates hold-up concerns for the independent rival D_2: By committing itself to offering a degraded support, U_A exposes D_2 to being held-up by U_B; in this way, U_A discourages D_2's investment, to the benefit of the subsidiary D_1.

2.3 Illustrations

The insights from the first simple model may shed some light on the role of Patent Assertion Entities (PAEs).[21] In technology industries such as ICT markets, in recent years some vertically integrated firms have taken steps to delegate the monetization of (parts of) their patent portfolios to such entities, often referred to as "patent trolls." This can be interpreted as a way to committing to insisting on higher royalty rates,[22] and

(or "pay-for-delay" contracts, for generic drugs) are likely to be deemed illegal, as exemplified by the recent US Supreme Court decision *FTC v. Actavis*, 570 U.S. (2013), available at: http://$www.supremecourt.gov/opinions/12pdf/12-416_m 5n0.pdf$.

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.

[20]Whether contracts are publicly observed or not is of no consequence in this framework, as tariffs do not affect variable profits.

[21]We thank Tim Simcoe for prompting this discussion.

[22]According to common wisdom, a patent troll "enforces patent rights against accused infringers in an attempt to collect licensing fees [...] thus engaging in economic rent-seeking." See http://en.wikipedia.org/wiki/Patent_troll.

indeed these entities have been accused of raising royalty costs for technology users[23] – the downstream subsidiary can however retain the use of the patented technology, e.g., through a royalty-free licensing or non-asserting agreement.[24]

Interestingly, and in line with the insights from our simple model, following its acquisition of Nokia's handset business, Microsoft entered in an agreement with such a PAE (Mosaid, now Conversant) for the management of a large portfolio of patents reading on devices; this prompted claims of patent trolling by rivals such as Google (who feared that this could adversely affect rival device makers, who – in contrast to Microsoft - Nokia – could contribute to the diffusion of the Android platform), and Huawey (which triggered the Chinese merger agency, MOFCOM, to impose behavioral remedies for clearing the merger).[25]

To illustrate how a supplier may instead dissipate profit, consider the following standard model of patent race:

- Each downstream firm can innovate with probability I at cost $C(I) = cI^2/2$.
- If only one firm innovates, it obtains a competitive edge generating a profit Δ; otherwise, neck and neck competition dissipates all profit.

Assume further that obtaining this competitive edge requires close cooperation with a support provider, which involves the exchange of key information about the innovation. In this context, 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. Suppose for instance that, with probability $1 - s_i$ the innovation is imitated, thereby eliminating the competitive edge; D_i's expected return is then given by:

$$s_i r(I_j) I_i = s_i I_i (1 - I_j) \Delta,$$

[23] Distributing a portfolio of complementary patents among several PAEs would moreover create double marginalization problems; such "royalty stacking" strategy would further enable integrated firms to commit themselves to higher licensing rates.

[24] In practice, whether a given technology (e.g., U_B's technology) infringes on a given patent (e.g., U_A's patent) may be unclear. In such a situation, even an independent U_A may benefit from hiring a patent troll that will litigate potential users, so as to discourage them from turning to U_B's technology. We thank Paul Heidhues for pointing this out.

[25] These remedies include licensing patents under "fair, reasonable and non-discrimininatory" ("FRAND") terms, and not seeking injunctions or grant-back provisions; see Freshfields (2014).

which satisfies our regularity conditions as long as $c > \Delta$.

As the return on D_i's investment decreases in the competitor's investment I_j, Proposition 1 shows that an integrated supplier benefits from building a reputation to "take advantage" of independent customers' sensitive information, so as to expose its rival to hold-up and discourage it from investing. More precisely:

- Under separation, both firms invest:

$$I^{VS} = \frac{1}{\eta + 1},$$

  where $\eta \equiv c/\Delta > 1$.

- When instead U_A is vertically integrated with D_1, then it commits itself to offering D_2 a degraded support $\hat{s}$, so as to expose D_2 to being held-up by U_B; this discourages D_2's investment, which reduces to

$$I_-^{VI} = s\frac{\eta - 1}{\eta^2 - s} < I^{VS},$$

  and in reaction (investment being strategic substitutes) D_1 increases its own investment to

$$I_+^{VI} = \frac{\eta - s}{\eta^2 - s} > I^{VS}.$$

In case of full degradation (i.e., $\hat{s} = 0$, implying that the innovation would be imitated for sure), there is "complete foreclosure:" D_2 leaves the market ($I_2 = 0$), which D_1 thus monopolizes (with $I_1 = 1/\eta$).

Such concern was at the heart 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 for navigation in Europe and North America. In its decision,[26] the European Commission stressed the importance of information exchanges: "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

[26] Case No COMP/M.4854 - TOMTOM/TELE ATLAS, 14/05/2008.

latest version of their devices. They did this for four main reasons, firstly, to negotiate better prices, secondly, to incorporate existing features in new products, thirdly to encourage the map suppliers to develop new features, and finally, in order to ensure technical interoperability of new features with the core map and the software."[27] The Commission also noted that 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). This would in turn reduce the incentive of TomTom's competitors to cooperate with Tele Atlas on pricing policy, innovation and new business concepts, all of which would require exchange of information. 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".[28]

The sale in 2003 of the Israeli supermarket chain Blue Square provides another illustration.[29] 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 buyers. In a conference,[30] Alon-Dor's CEO complained that information concerns prevented his company from obtaining financing 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 the probability of obtaining the deal.

[27] Commission decision at § 256. For a discussion of strategic information disclosure in bargaining situations, see Crocker (1983).

[28] Commission decision 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 (see COMP/M.4942 - NOKIA/NAVTEQ, 02/07/2008).

[29] We thank Yossi Spiegel for bringing this example to our attention.

[30] See http://www.presidentconf.org.il/en/indexNew.asp.

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 may then suffice to alter a supplier's *ex post* incentive to degrade the support provided to a downstream rival, thus exposing the rival to being held-up by the other supplier. We show in section 3.1 that this is indeed the case when degrading the support provided to one firm directly benefits the rival firm but reduces total industry profit. Section 3.2 provides a discussion on this condition and shows that it is verified in common industrial organization models. Section 3.3 discusses several illustrations.

3.1 Unverifiable quality

We now exclude any pre-commitment possibility, and suppose instead that suppliers choose *ex post* the quality of their support, which is unverifiable and thus cannot be contracted upon. We also extend the previous framework by allowing the support provided to one firm to affect the rival's profit as well; to keep the analysis tractable, we restrict attention to binary investment and support decisions: $I_i = 0$ (no investment) or $I_i = 1$ (investment, at cost $c_i = C_i(1)$), and $s_i \in \{\underline{s}, \overline{s}\}$, where $\underline{s} < \overline{s}$. Formally, D_i's return from 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:

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

We thus 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 support D_i.

- Stage 3: Each D_i selects a supplier, who then chooses the quality of its support, $s_{hi} \in \{\underline{s}, \overline{s}\}$. To break indifference, we assume that a supplier incurs an arbitrarily small cost ε when providing a degraded support $\underline{s}$.[31]

In equilibrium, an independent supplier will always provide high-quality support: Degrading the quality brings no direct benefit, and only exposes the supplier to pay the cost ε. Hence, when both suppliers are independent, upstream competition leads suppliers to provide high-quality support at cost. For the sake of exposition, we will assume that investing is then a dominant strategy: For $i = 1, 2$,

$$c_i < r_i \left(1; \overline{s}, \overline{s}\right) \left(< r_i \left(0; \overline{s}, \overline{s}\right)\right). \tag{3}$$

Obviously, an integrated supplier does not have any incentive to degrade the quality of the support provided to its own subsidiary. By contrast, it does have an incentive to degrade the quality supplied to the independent rival, so as to increase the profit of its downstream subsidiary. The integrated firm would actually be willing to offer a subsidy to convince the downstream rival to accept this degraded quality: If for instance U_A is vertically integrated with D_1, and D_2 invested in stage 1, then in stage 2 U_A would be willing to offer D_2 a subsidy of up to $-B$, where

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

denotes D_1's benefit from degrading the quality supplied to D_2. Hence, U_A's best offer gives D_2 a net profit of $r_2(1; \underline{s}, \overline{s}) + B$, whereas U_B's best offer (namely, offering high-quality at cost) yields $r_2(1; \overline{s}, \overline{s})$. As a result, which supplier wins the competition depends on whether degrading the support increases or reduces total industry profit: When $\Delta\Pi > 0$, where

$$\Delta\Pi \equiv r_1(1; \overline{s}, \underline{s}) + r_2(1; \underline{s}, \overline{s}) - r_1(1; \overline{s}, \overline{s}) - r_2(1; \overline{s}, \overline{s}), \tag{4}$$

then degrading the quality increases total industry profit, in which case the integrated firm will successfully "bribe" D_2 into accepting a degraded quality. That is, U_A offers a

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

degraded support, but *wins* the competition for D_2 by offering a subsidy to match U_B's best offer.[32] As a result, *ex post* industry profits are increased, and D_2 obtains the same profit as with full 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.

By contrast, when $\Delta\Pi < 0$, degrading the quality supplied to D_2 hurts D_2 more than it benefits D_1, and thus the integrated firm is not willing to offer a subsidy large enough to offset the degradation 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 for its support. Formally, we have:

Proposition 3 *Independent suppliers do not have an incentive to degrade ex post the quality of the support they provide; by 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 degrading the quality of the support provided to one firm reduces total industry profit in case both firms have invested, then vertical integration creates hold-up problems for the independent rival.

Proof. See Appendix D. ■

Hence, when degrading the quality of the support provided to one firm 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 D_2); it however generates hold-up concerns, which distort D_2's investment incentives:

Corollary 4 *We have:*

i) If (3) *holds for* $i = 1, 2$, *then both firms invest in case of vertical separation, and an integrated firm invests as well.*

ii) If in addition $c_j > r_j(1; \overline{s}, \overline{s}) + \Delta\Pi$, *where* $\Delta\Pi$ *is given by* (4), *then vertical integration between* U_h *and* D_i *deters* D_j *from investing.*

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

Proof. See Appendix E. ■

Remark: Partial contractibility. So far we have assumed that the quality was unverifiable, and thus could not be contracted upon; our results still apply, however, when quality is "partially contractible" in the sense that it can be verified *ex post* 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 support provided 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, i.e., the 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. By 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]

$$p\Phi < r_1(1; \overline{s}, \underline{s}) - r_1(1; \overline{s}, \overline{s}).$$

[33]If the maximum amount of compensation Φ follows the expected damage rule, the condition simply boils down to $p < \frac{\pi_1(1;\overline{s},\underline{s}) - \pi_1(1;\overline{s},\overline{s})}{\pi_2(1;\overline{s},\overline{s}) - \pi_2(1;\underline{s},\overline{s})}$.

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 subsidy of $-B$ (including any expected compensation),[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 3 shows that hold-up concerns arise when degrading the support provided to one firm reduces total industry profit (that is, $\Delta\Pi < 0$). Consider for instance the patent race illustration developed in section 2.3, and suppose that each firm obtains $\delta > 0$ when both firms innovate (thus giving an incentive to imitate). Then $\Delta\Pi < 0$ as long as imitation dissipates the rent of innovation, *i.e.*, whenever $\Delta > 2\delta$.

More generally, when degrading the support makes the firm less effective in the downstream market, such degradation is likely to harm industry profit as well when downstream competition is sufficiently imperfect. To see this, consider first 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 F.1, we first consider the case where degrading D_i's support increases its production cost or decreases the quality of its offering, and show that this reduces industry profit when the resulting handicap is not too large and/or the two firms are sufficiently differentiated, as in both cases D_i maintains a substantial market share. We further show that a similar analysis obtains when downstream firms have captive customer bases.

Intuitively, the same applies to *price competition* settings: Altering one firm's offer-

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

ings is likely to harm industry profit when firms cater to different types of customers. We show further in appendix F.2 that making advertising campaigns less effective can likewise reduce total industry profit when doing so results in significant demand reduction.

3.3 Illustration

For the sake of exposition, suppose that firms are symmetric (in particular, $c_i = c$) and that D_i' profits is determined by the "effective capacities" of the two firms, K_1 and K_2:

$$R(K_j)\, K_i,$$

where these effective capacities depend on the quality of the support received by the firms as well as on their investments.[35]

Suppose first that degrading the support s_i provided to D_i reduces its own capacity, from $K_i = \overline{s} = 1$ to $K_i = \underline{s}$. Firm i's return on investment is thus of the form

$$r_i\left(I_j; s_i, s_j\right) = R(s_j I_j) s_i.$$

The conditions outlined in Corollary 4 then boil down to

$$R\left(\underline{s}\right) - \left(1 - \underline{s}\right) R(\overline{s}) < c < R(\overline{s}) \; (< R(0)),^{36}$$

and ensure here that an integrated supplier benefits from degrading the support offered to independent rivals, so as to limit their effective capacity in the downstream market.

A case in point is provided by the SNCF, the French incumbent rail company, which in 2012 was fined by the national competition authority for having prevented, through various means, rival freight operators from accessing facilities that were essential to their business (freight yards, train paths, ...). For instance, the SNCF strategically overbooked train paths, and did not release those that were not used (or did so very

[35] This capacity game appears more relevant for the cases discussed below, in which returns on investments seem less risky than for R&D projects or takeover bids; the previous patent race model could however be used as well here.

[36] If for instance $R(K) = a - bK$, these conditions define an admissible range for c whenever $a/b < 2$, and $R(.)$ remains positive in the relevant domain as long as $a/b > \underline{s}$.

late). And in some cases, competing firms were constrained to resort to freight road transportation, which increased their cost and therefore limited their business.[37]

Suppose now that degrading the support s_j provided to D_j generates instead spillovers $e_j = 1 - s_j$ for its rival D_i, who benefits from a larger capacity $K_i = 1 + e_j I_j$. If D_i invests, its return is now given by (using $K_j = 0$ if $I_j = 0$):

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

If for instance $\overline{s} = 1$ and where $\underline{s} = 1 - \hat{e}$, then the conditions of Corollary 4 boil down to:

$$R(1 + \hat{e}) + \hat{e}R(1) < c < R(1)(< R(0)).^{38}$$

Under these conditions, an integrated supplier has an incentive to build a reputation to take advantage of its customers, so as to generate spillovers for its own subsidiary; this again enables U_B to hold D_2 up, and discourages in this way D_2's investment.

Such concerns are particularly relevant in case of free-riding and business stealing. 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. In the US, in 2010 the Federal Trade Commission (FTC) put conditions on a vertical merger between PepsiCo and its two largest bottlers and distributors, who were also servicing its rival Dr Pepper Snapple (henceforth "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 [...]". 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." The FTC eventually ordered PepsiCo and TCCC to set-up a firewall in

[37] See Decision n° 12-D-25 of the French competition authority, available at http://www.autoritedelaconcurrence.fr/pdf/avis/12d25.pdf.

[38] For $R(K) = a - bK$, these conditions define again an admissible range for c when $a/b < 2$, and $R(.)$ now remains positive in the relevant domain as long as $a/b > 1 + \hat{e}$.

order to regulate the use of this commercially sensitive information.[39]

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 now extend our insights to the case of imperfect upstream competition (section 4.1) and to customer foreclosure (section 4.2). We also enrich our analysis by considering partial vertical integration (section 4.3) and counter-fighting strategies by the independent rivals (section 4.4).

4.1 Imperfect upstream competition

The analysis extends to upstream oligopolies, as long as degrading the perceived quality of the integrated supplier confers greater market power to the other suppliers. This however requires 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: That is, D_2's return on investment is as before $r_2(I_1; s_2, s_1)$ when dealing with U_B, and $r_2(I_1; s_2, s_1) + \gamma$ when dealing with U_A, for some $\gamma > 0$. U_A thus enjoys market power in the upstream market. Absent vertical integration, standard (asymmetric) Bertrand competition ensures that U_A wins the competition for both

[39] For the above quotations, and the analysis of the FTC in these two cases, see "In the Matter of PepsiCo Inc.," FTC-file 091-0133 of 02/26/2010, and "In the Matter of The Coca-Cola Company," FTC-file 101-0107 of 09/27/2010.

downstream firms and moreover appropriates the additional surplus γ. Hence, for D_2 the situation is the same as in the benchmark case $\gamma = 0$, 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.[40] 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 contract with other car makers, which were reluctant to rely on Delphi as long as it was a unit of GM.[41] A similar concern may underlie AT&T's 1995 voluntary divestiture of its manufacturing arm, AT&T Technology (now Lucent), as the coming Telecommunication Act (1996) was due to allow the Regional Bell Operating Companies (RBOCs) to compete with AT&T on the long distance market.[42]

In the same spirit, Loertscher and Riordan (2013) study a monopolist's incentives to divest its upstream division when alternative suppliers can invest in uncertain cost reductions. Remaining 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.

[40] The hold-up problem is however somewhat mitigated here, as U_B must compensate D_2 for the loss of the surplus γ: 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, $r_2(1; \underline{s}, \overline{s}) + \gamma$.

[41] http://money.cnn.com/1999/05/31/companies/gm/

[42] See e..g. 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."

4.2 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. Indeed, 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 "[private label development] 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 customers of the producers. This privileged position increases the leverage enjoyed by retailers over branded goods producers."[43] 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.[44]

Consider for instance the following framework, that mirrors 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 (that is, there is no intrabrand competition). As in section 3.1, the resulting profit depends on the quality of the distribution: That is, M_h's product generates a profit $r_h(I_k, s_h, s_k)I_h$ (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.[45]

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 two brands. It follows that, under separation, Bertrand competition leads the two retailers to offer each M_h the full profit generated by its product: $T_{h1} = T_{h2} = r_h(I_k, \overline{s}, \overline{s})\, I_h$. Likewise, an integrated retailer will provide good services for the distribution of its own brand. By contrast, it does have an incentive to degrade the distribution of the rival brand, in

[43] 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.

[44] See DIW (2010); similar observations apply for packaging imitation.

[45] 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.

order to enhance the profit from its own brand. And again this creates hold-up problems for the rival manufacturer whenever doing so reduces total industry profit.

4.3 Partial vertical integration

The analysis also applies to partial vertical integration, that is, when U_A acquires a stake in D_1 (forward integration) or when D_1 acquires a stake in U_A (backward integration).

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 *forward* integration: That is, U_A acquires a fraction $\alpha < 1$ of D_1's shares.[46] As before, in equilibrium an independent supplier has no incentive to degrade the quality of its support, and likewise a partially integrated firm provides good support to its downstream subsidiary.

Consider now the partially integrated supplier. In stage 3, degrading the support provided to D_2 brings U_A a benefit $B_\alpha = \alpha\left[r_1(1;\overline{s},\underline{s}) - r_1(1;\overline{s},\overline{s})\right]$, which increases in α. As long as $B_\alpha > \varepsilon$, U_A is thus willing to degrade D_2's support: That is, Proposition 3(i) still holds with partial forward integration. Hence, in stage 2, U_A is willing to offer a subsidy of up to B_α, 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

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

As $B_\alpha < B$, 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 3(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 4(ii) applies) in a wider range of situations.

Consider next the case of *backward* integration: That is, 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 willing to offer D_2 a subsidy of up to B, and hold-up concerns arise when $\Delta\Pi < 0$. By contrast, hold-up concerns do not arise if D_1 does not control U_A, as

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

U_A then behaves as an independent supplier.[47]

In our framework, partial forward integration thus leads 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). By contrast, Spiegel (2013) obtains opposite results in a framework with an upstream monopoly (and balanced bargaining power): Partial forward (resp., backward) integration then leads to less (resp., more) foreclosure than full integration. In this framework, in the case of integration, the independent D_2 must 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). By contrast, in our framework the existence of an alternative supplier suppresses this mechanism: As D_2 can deal with U_B, there is no need for compensating the negative externality exerted on D_1's investment. Finally, holding a stake in D_1 does not affect the behavior of a supplier who enjoys a monopoly situation, but affects the intensity of supply competition in our framework.

4.4 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: (i) absent integration, both downstream firms invest (and obtain good support at cost); and (ii) 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

[47] 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 profits. 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.

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.[48]

When there are more downstream firms than suppliers, however, 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 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), 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 each 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).

Hence, while further integration constitutes an effective counter-fighting strategy in response to a vertical merger, such a merger remains profitable when there is a scarcity of trading partners – namely, when there are more investors than sources of support. This is consistent with the merger wave observed in the GPS industry, already mentioned above, where *TomTom* and *Nokia* acquired the two suppliers of navigable digital databases, *Tele Atlas* and *Navteq*, which led other downstream competitors such

[48] The second merger may no longer be profitable if it is costly, in which case the first merger may be profitable. If for instance vertical integration involves a fixed cost K, then the second merger is not profitable if $K > \underline{K} \equiv r_2(1; \bar{s}, \bar{s})$, in which case the first merger is profitable if $K < \bar{K} \equiv r_1(0; \bar{s}, \underline{s}) - r_1(1; \bar{s}, \bar{s})$. Hence, if discouraging D_2's investment increases total industry profit (i.e., $r_1(0; \bar{s}, \underline{s}) > r_1(1; \bar{s}, \bar{s}) + r_2(1; \bar{s}, \bar{s})$), there exists a range for the fixed cost (namely, $K \in (\underline{K}, \bar{K})$) for which the first merger is not profitable whereas the second is not. See Allain *et al.* (2011) for a more detailed discussion.

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 highlight this using a simple model in which 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. By contrast, an integrated supplier relies on this option 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.

Our analysis also revisits 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, in contrast with the literature on raising rivals' costs, vertical foreclosure can arise even in the absence of any pre-commitment to denying or degrading access. Vertical integration alone triggers incentives to degrade them, even *ex post*, whenever doing so brings direct benefits to the downstream subsidiary. As long as degrading access reduces total industry profits, the threat of such degradation exposes independent rivals to being held-up (by the other suppliers), thereby generating innovation foreclosure.

We present several illustrations and discuss the robustness of the analysis. In particular we extend the analysis to upstream and downstream oligopolies as well as to partial integration, and note that the insights apply to customer foreclosure as well as to input foreclosure. Finally, we also discuss counter-fighting strategies.

A direct implication of the analysis is that the balance of upstream and downstream profits affects firms' incentives to integrate or divest vertically related activities. For instance, an integrated firm may trade-off the benefit of exposing downstream rivals to hold-up (which depends among other things on how competitive their alternative suppliers are) against the foregone profit from supplying these potential customers.

Furthermore, vertical integration increases the upstream rival's profit, which may trigger excessive entry motivated by rent-seeking; alternatively, it may foster investment incentives if upstream investments were also considered. We leave these developments to future research.

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.

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Appendix

A Proof of Proposition 1

To establish Proposition 1, we first characterize the investment equilibria, for given sharing rules s_1 and s_2, before drawing the implications for hold-up incentives.

A.1 Investment equilibria

If D_i anticipates keeping a share s_i of the profit it generates in stage 3 (where $s_i = 1$ in case of integration), then in stage 2 it chooses I_i so as to maximize:

$$\pi_i (I_i, I_j; s_i) = s_i r_i (I_j) I_i - C_i (I_i) .$$

Assumption $A1$ ensures that this objective function is continuously differentiable and strictly concave in I_i. There it thus a unique best response, $I_i^r (I_j; s_i)$, which from the boundary conditions $A2$ is either 0 or characterized by the first order condition (FOC):

$$C_i' (I_i) = s_i r_i (I_j) .$$

Assumption $A3$ further ensures that this best-response has a slope lower than 1 in absolute value:[49]

$$\left| \frac{\partial I_i^r}{\partial I_j} (I_j; s_i) \right| \leq s_i \frac{|r_i' (I_j)|}{C'' (I_i)} < 1.$$

It follows that, for any (s_1, s_2), there is a unique investment equilibrium, $I_1^* (s_1, s_2)$ and $I_2^* (s_2, s_1)$. The first condition in $A2$ further ensures that D_i's equilibrium investment is positive whenever $s_i = 1$: $I_i^* (1, s_j) > 0$ for any s_j.

A.2 Hold-up incentives

In the absence of vertical integration, no supplier pre-commits itself to $\hat{s}$, and in stage 3 Bertrand competition yields $s_1 = s_2 = 1$. It follows from the above that both firms invest: $I_i^{VS} = I_i^* (1, 1) > 0$ for $i = 1, 2$. Let π_i^{VI} denote the resulting profits.

[49] The first inequality stems from the fact that the slope is 0 in the range where $I^r (.; s_i) = 0$.

Suppose now that U_A is vertically integrated with D_1, and thus $s_1 = 1$. Letting s denote D_2's sharing rule, the investment equilibrium is therefore of the form $I_1^{VI}(s) = I_1^*(1,s) > 0$, such that

$$C_1'\left(I_1^{VI}\right) = r_1\left(I_2^{VI}\right), \tag{5}$$

whereas D_2 invests $I_2^{VI}(s) = I_2^*(s,1)$, which is either 0 (if $C_2'(0) \geq sr_2\left(I_1^{VI}\right)$) or such that:

$$C_2'\left(I_2^{VI}\right) = sr_2\left(I_1^{VI}\right). \tag{6}$$

Reducing D_2's share of profit discourages its investment. Indeed, differentiating (5) and (6) with respect to I_1, I_2, and s yields

$$\frac{dI_2^{VI}}{ds} = \frac{C_1''\left(I_1^{VI}\right) r_2\left(I_1^{VI}\right)}{C_1''\left(I_1^{VI}\right) C_2''\left(I_2^{VI}\right) - sr_2'\left(I_1^{VI}\right) r_1'\left(I_2^{VI}\right)} > 0, \tag{7}$$

where the inequality stems from the numerator being positive under $A1$, and the denominator being positive under $A3$. It follows that reducing D_2's share of profit is profitable for the integrated firm whenever D_1 benefits from discouraging D_2's investment: Letting $\pi_{A-1}^{VI}(s)$ denote the equilibrium profit of the integrated firm, as a function of D_2's sharing rule, we have:

$$\begin{aligned} \pi_{A-1}^{VI}(s) &= r_1\left(I_2^{VI}(s)\right) I_1^{VI}(s) - C_1\left(I_1^{VI}(s)\right) \\ &= \max_{I_1 \in [0,1]} r_1\left(I_2^{VI}(s)\right) I_1 - C_1(I_1), \end{aligned}$$

and thus the envelope theorem yields:

$$\frac{d\pi_{A-1}^{VI}}{ds} = I_1 r_1'\left(I_2^{VI}\right) \frac{dI_2^{VI}}{ds} < 0,$$

where the inequality stems from (7) and $r_1'\left(I_2^{VI}\right) < 0$. Therefore:

- If U_A does not pre-commit itself to $\hat{s}$, then at stage 3 Bertrand competition yields again $s_2 = 1$; the investment equilibrium therefore remains the same as under separation: $I_2^{VI}(1) = I_2^{VS} > 0$ and the integrated firm thus obtains $\pi_{A-1}^{VI}(1) = \pi_1^{VS}$.

- If instead U_A pre-commits itself to $\hat{s}$, then in stage 3 U_B wins the competition for

D_2 by matching U_A's offer.[50] Anticipating this, in the subgame that follows D_2 reduces its equilibrium investment: $I_2^{VI}(\hat{s}) < I_2^{VS}$, and the integrated firm thus obtains a higher profit, $\pi_{A-1}^{VI}(\hat{s}) > \pi_1^{VS}$.

It follows that U_A chooses to pre-commit itself to $\hat{s}$.

B Endogenous sharing rule at the pre-commitment stage

We consider here a variant of the simple model in which suppliers can, if they wish so, pre-commit themselves in stage 1 to any sharing rule $\hat{s} \in [0, 1]$.

We start with the case of vertical separation. We first note that it cannot be the case that both suppliers choose to pre-commit themselves in stage 1. To see this, suppose that U_h opts for $\hat{s}_h$ and the rival U_k opts for $\hat{s}_k$ in stage 1:

- If $\hat{s}_h < \hat{s}_k$, then U_k loses the competition and would be better off not pre-committing itself in stage 1, so as to save the cost ε.
- If $\hat{s}_h = \hat{s}_k$, then at least one supplier does not win the competition for sure, and would be better-off not pre-committing itself so as to undercut the other in stage 3.

Therefore, at least one supplier does not pre-commit itself in stage 1. But then, the other one is better off not pre-committing itself either, so as to save the cost ε and avoid being undercut for sure at stage 3. It follows that, under separation, no supplier pre-commits itself in stage 1; Bertrand competition in stage 3 then enables downstream firms to obtain the full benefits from their investments, and thus each D_i invests $I_i^{VS} = I_i^*(1, 1)$.

Let us now turn to the case where U_A is vertically integrated with D_1; D_1 thus obtains support at cost, and the only relevant competition is for D_2.

If U_A does not pre-commit itself in stage 1, then U_B cannot hope to make a profit in stage 3: If in stage 1 it opts for some $\hat{s}_B < 1$, then in stage 3 U_A will undercut

[50] Technically, in stage 3 the only continuation equilibrium is indeed that U_B offers exactly $s_{B2} = \hat{s}$ and D_2 picks U_B as supplier.

it; and if it does not pre-commit itself (or opts for $\hat{s}_B = 1$) in stage 1, then in stage 3 Bertrand competition drives profit down to zero. It is therefore best for U_B not to pre-commit itself, so as to save the cost ε. Therefore, any candidate equilibrium in which U_A does not pre-commit itself in stage 1 is such that D_2 fully benefits from Bertrand competition in stage 3, and thus yields the same outcome as under separation; in particular, $I_2 = I_2^{VS} > 0$. But then, U_A would profitably deviate by pre-committing itself to, say, $\hat{s}_A = 0$, so as to expose D_2 to being fully held-up by U_B, and discouraging in this way D_2 from investing anything (that is, $\hat{s}_A = 0$ would induce $I_2 = 0$).

Suppose that U_A opts instead for a rule $\hat{s}_A$ in stage 1, and let s^* denote the sharing rule that maximizes U_B's profit: $s^* = \arg\max_s \pi_B(s)$, where

$$\pi_B(s) \equiv (1-s) r_2(I_1^*(1,s)) I_2^*(s,1).$$

Note that, by construction, $s^* < 1$. As long as $\hat{s}_A < s^*$, it is best for U_B to pre-commit to $\hat{s}_B = s^*$ in stage 1, so as to outbid U_A and obtain the profit $\pi_B^* = \pi_B(s^*)$; but then, U_A would be better-off not pre-committing in stage 1 so as to save the cost ε. If instead U_A opts for $\hat{s}_A = s^*$ in stage 1, then U_B's best response is to (save the cost ε and) slightly outbid U_A in stage 3; this induces an equilibrium outcome where D_2 invests $I_2 = I_2^*(s^*,1)$. Finally, suppose that U_A opts for a more generous sharing rule $\hat{s}_A > s^*$ in stage 1, and let

$$s^r(\hat{s}_A) \equiv \arg\max_{s \geq \hat{s}_A} \pi_B(s)$$

denote the sharing rule that maximizes U_B's profit, among those that are at least as generous as $\hat{s}_A$. U_B's best response can be of two types:

- If $s^r(\hat{s}_A) = \hat{s}_A$, then U_B's best response to $\hat{s}_A$ is to save the cost ε and win the competition by matching U_A's offer in stage 3; this yields a candidate equilibrium in which D_2 invests $I_2^*(\hat{s}_A,1)$. But then, U_A could profitably deviate by pre-committing itself to any $\hat{s} \leq s^*$, to as to induce U_B to offer s^* in stage 3 and in this way reduce D_2's investment, from $I_2^*(\hat{s}_A,1)$ to $I_2^*(s^*,1)$.

- If instead $s^r(\hat{s}_A) > \hat{s}_A$, then U_B's best response to $\hat{s}_A$ is to opt for $\hat{s}_B = s^r(\hat{s}_A)$ in stage 1; this yields a candidate equilibrium in which D_2 invests $I_2^*(\hat{s}_B,1)$. But then, U_A could profitably deviate by not pre-committing itself in stage 1, as this would save the cost ε without affecting D_2's investment.

Hence, the only equilibrium is such that U_A pre-commits itself to $\hat{s}_A = s^*$ in stage 1, whereas U_B waits and slightly outbids U_A in stage 3. In this equilibrium, D_2 must share its profit with U_B (as $s^* < 1$), and thus invests less than under separation: $I_2^{VI} = I_2^*(s^*, 1) < I_2^{VS} = I_2^*(1, 1)$.

C Proof of Proposition 2

First, it is a dominant strategy for an independent supplier not to commit to offering a degraded support: doing so would be costly and could only put the supplier at a competitive disadvantage when competing for customers. 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 ($T = 0$).

Suppose now that U_A is integrated with D_1. If U_A commits itself to offering D_2 a degraded support $\hat{s}$, then in stage 3 U_B holds D_2 up: U_A's best offer to D_2 is to offer its degraded support at price $T_{A2} = 0$, and U_B wins the competition by offering full support ($s_{B2} = 1$), but at a price matching U_A's best offer (namely, $T_{B2} = (1-\hat{s})r(I_1)I_2$), leaving D_2 with only a share of its profit, equal to

$$\hat{s}r(I_1)I_2.$$

Anticipating this, in stage 2 D_2 chooses a lower investment than if U_A did not degrade its support. Whenever it benefits from reducing the investment of its downstream rival D_2, an integrated U_A thus prefers to commit itself to offering a degraded support to D_2, so as to put it at the mercy of the other supplier, U_B.

D Proof of Proposition 3

As noted in the text, it is a dominant strategy for an independent supplier to provide *ex post* high-quality support. Suppose now that U_A is vertically integrated with D_1. Obviously, D_1 still obtains high-quality support at cost (e.g., from U_A). Consider now the suppliers' best offers to D_2. U_B provides high-quality support, and its best offer is to provide at cost: $\hat{T}_{B2} = 0$. By contrast, U_A provides poor quality, so as to increase D_1's profit from $r_1(1; \overline{s}, \overline{s})$ to $r_1(1; \overline{s}, \underline{s})$. To win the competition for D_2, U_A is thus willing to offer a subsidy of up to $\hat{T}_{A2} = -[r_1(1; \overline{s}, \underline{s}) - r_1(1; \overline{s}, \overline{s})] (< 0)$. Therefore, U_A's best offer gives D_2 a net profit of

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

whereas U_B's best offer gives D_2 a profit of

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

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

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

That is, U_B wins the competition whenever degrading the quality of D_2's support reduces total industry profit ($\Delta\Pi < 0$), 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 $r_2(I_2; \overline{s}, \overline{s}) - T_{B2} = \hat{\pi}_2^A$, or:

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

E Proof of Proposition 4

In the case of vertical separation, in stage 3 Bertrand-like competition enables downstream firms to obtain high-quality support at cost. Each D_i thus obtains a profit equal to $[r_i(I_j; \overline{s}, \overline{s}) - c_i] I_i$; hence, if $c_i < r_i(1; \overline{s}, \overline{s}) (< r_i(0; \overline{s}, \overline{s}))$, then at stage 1 it is a dominant strategy to invest: $I_1 = I_2 = 1$. Suppose now that U_A is vertically integrated with D_1. As D_1 still obtains again high-quality support at cost, it keeps investing: $I_1 = 1$. By contrast, if in addition $c_2 > r_2(1; \overline{s}, \overline{s}) + \Delta\Pi$ (which implies $\Delta\Pi < 0$), then D_2 is better off not investing, as it would only obtain $\hat{\pi}_2^B - T_{B2} = r_2(1;\overline{s},\overline{s}) + \Delta\Pi < c_2$. A similar reasoning applies if instead D_2 is vertically integrated, replacing the last condition with $c_1 > r_1(1;\overline{s},\overline{s}) + \Delta\Pi$.

F $\Delta\Pi < 0$: Examples

F.1 Linear differentiated Cournot duopoly

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

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

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 $c > 0$).

F.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:

$$\begin{aligned} D_1(p_1, p_2) &= s\frac{(1 - p_1 + p_2)}{2} + (1 - s)(v - p_1), \\ D_2(p_2, p_1) &= s\frac{(1 - p_2 + p_1)}{2}. \end{aligned}$$

Equilibrium prices and profits are:

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

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

It is straightforward to check that $\Pi^*(s) \equiv \Pi_1^*(s) + \Pi_2^*(s)$ strictly increases in s.