Foreclosure, Bundling, and Innovation in Competitive Markets*

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Abstract

It is well-established that bundling by a monopolist can harm consumers, but bundling is widely considered harmless in competitive markets. This paper models a merged entity that faces competition in its respective markets. The novel theory of harm developed here combines a typical concern about vertical mergers (input foreclosure) with a typical concern about mergers of complements (bundling). Whereas bundling alone is loss-making, combined with input foreclosure, it can be profitable. Consumers risk paying higher prices and not benefiting from higher innovation because, in competitive markets, the merged entity appropriates the benefits of its innovation.

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1 Introduction

The debate on the effects of bundling (or tying) is not settled. Antitrust authorities agree that bundling can cause harm.[1] However, antitrust decisions sometimes differ across jurisdictions. In the abuse of dominance case against Microsoft regarding the bundling of Windows and Internet Explorer, U.S. and EU authorities agreed[2] but in several mergers of complements, they did not. Most prominently, decisions differed in the attempted GE / Honeywell merger, which was cleared in the United States but blocked in the European Union.[3] More recently, whereas the U.S. Federal Trade Commission cleared the proposed $47bn acquisition of NXP by Qualcomm (in the chip industry) unconditionally, the European Commission cleared the merger of complements subject to remedies.[4] This paper supports concerns that the European Commission raised – on foreclosure, bundling, and innovation.[5]

According to a consensus view in the literature, bundling (or tying) can be harmful only if exercised by a firm with a monopoly (or at least dominant) position in a relevant market (see, e.g. Fumagalli, Motta, and Calcagno, 2018, p. 425). The literature on anticompetitive bundling focuses on whether a monopolist can bundle products to protect its monopoly power from entry or extend its power to other markets. Influential scholars of the Chicago school have argued that a monopolist has no incentive to bundle because increasing sales in the tied market necessarily involves lowering the price in the tying market, such that a monopolist cannot earn more than the (single) monopoly profit from the tying market (Posner, 1976; Bork, 1978). According to them, tying cannot be anticompetitive. Whinston (1990) revised this view. He shows that a monopolist in one market can bundle its products to deter entry into another market, thereby monopolising that other market too. This theory of harm appears, with some variation, in the subsequent three papers (all related to the aforementioned Microsoft case). For example, Carlton and Waldman (2002) find that a monopolist can use bundling to deter entry into the monopolised market (the tying market) and a newly emerging market. Similarly, Choi (2004) finds that a monopolist can use bundling to commit to more aggressive R&D and deter a

[1] Possible anticompetitive effects notwithstanding, consumers can benefit from bundling, see Fumagalli, Motta, and Calcagno (2018), p. 353-8.

[2] See the U.S. Department of Justice (1998) complaint and the European Commission (2009) decision on remedies.

[3] See U.S. Department of Justice (2001).

[4] See Vandenborre, Sibon, and Hoffmann (2019).

[5] Ultimately, the merger was not consummated because Chinese authorities did not clear the transaction amid the Sino-U.S. trade war (Martina and Nellis, 2018).

rival's investment in the tied market.[6] Choi and Stefanadis (2001) show that a monopolist who faces potential entry in each of its two markets can foreclose entrants by bundling its two products (here again, bundling makes the incumbent more aggressive).[7]

I build on the existing literature, but instead of a monopolist, consider two merging parties who face competition in their respective markets, both pre and post-merger.[8] In this paper, the merged entity has two levers: it can (i) engage in input foreclosure (i.e., stop to supply an input to rivals) and (ii) bundle its two goods. Input foreclosure alone is strictly loss-making. Pure bundling alone is strictly loss-making too (this is in line with the literature).[9] However, a strategy that combines input foreclosure and pure bundling can be profitable: it reduces entry such that the merged entity reaps more of the benefits from its innovation – to the overall detriment of consumers. Therefore, antitrust intervention can be necessary to prevent bundling even in competitive markets.

The model is based on the proposed Qualcomm / NXP merger. In that case, the merging parties supplied complementary components used in smartphones. Qualcomm's and NXP's markets featured different characteristics. Qualcomm was the incumbent producer of high-end LTE connectivity chips (which, among others, manage the data transmission between a smartphone and the cellular network). Its chips were superior to those of its competitors, but Qualcomm risked being displaced if a potential entrant succeeded in innovating. NXP produced secure element chips ("SEs", which, among others, help to store sensitive data on smartphones securely)[10] and owned a non-essential but advantageous technology for SEs (MIFARE, a security technology for contactless payments in, among others, transport systems).[11] NXP licensed MIFARE to rival producers of SEs.[12]

[6]Earlier papers already establish an incentive for strategic over-investment to deter entry in a market: see Spence (1977, 1979). See Fudenberg and Tirole (1984) for strategic incentives to under-invest.

[7]Choi and Stefanadis (2001) describe this as a "price squeeze" effect, which occurs if there is entry in only one (rather than two) markets. On entry in multiple markets, see also Etro (2019) and Williamson (1979), p.962-3.

[8]Much of the relevant literature does not explicitly consider mergers: whether bundling by a multi-product firm is anticompetitive can be a, theoretically, equivalent question to whether a merger that would lead to bundling by a multi-product firm is anticompetitive. My model yields the same results if, instead of bundling by a merged entity, one considers bundling by a multi-product firm.

[9]Deciding to engage in (pure) bundling can be interpreted as deciding to make one's products (fully) incompatible with those of third-party firms. Matutes and Regibeau (1988) consider the decision of firms to produce compatible or incompatible products and model heterogeneous consumers.

[10]SEs are used for, e.g., secure connections, authentication, data protection, and secure key storage, see NXP (2022).

[11]MIFARE is particularly used for contactless payments in transport systems, see European Commission (2018a), p. 29.

[12]European Commission (2018a), p. 48.

Developing an alternative to MIFARE was deemed prohibitively costly.[13] The MIFARE technology can be described as an input or complement to SEs; henceforth, I describe it as an input. The European Commission was concerned, among others, that the merged entity would stop supplying NXP's technology to rivals in the SE market to strengthen Qualcomm's position and, thereby, limit innovation and entry in the LTE chip market.[14]

I model a consumer product that consists of two components (e.g., a smartphone that consists of a connectivity chip and a SE).[15] The two component markets differ. In market A (e.g., the market for SEs), the owner of a non-essential technology (e.g., MIFARE) can either sell component A directly to consumers or, instead, let others sell component A and collect revenues from licensing (i.e., supplying) its technology to competitive fringe producers. In market B (e.g., the market for connectivity chips), an incumbent producer is more efficient than a competitive fringe. It can invest in reducing its cost. However, it faces potential displacement by a potential entrant who can also invest. First, the technology owner in market A decides whether to license. Second, the incumbent and entrant in market B choose their respective investment levels. Third, firms compete on price based on their available production technologies and consumers (e.g., smartphone manufactureres) choose the cheapest of each component.[16]

Pre-merger, the technology owner licenses to rivals whenever they are more efficient at using the technology (this way, it obtains a higher profit via a royalty than if it sells directly). Because the technology is non-essential, the ability of fringe producers to do without it constrains the technology owner.[17] In market B, both the incumbent and the potential entrant invest. If the potential entrant, who invests in probabilistic innovation, is unsuccessful in innovating, the incumbent competes against the competitive fringe and wins; otherwise, the incumbent competes against the more efficient potential entrant and loses. Component B is cheaper with entry.

Let the technology owner in market A and the incumbent in market B merge. Imagine the merged entity pursues a strategy that combines stopping to license to rivals in market

[13] *Ibid.*, p. 93-4.

[14] *Ibid.*, p. 131-2.

[15] Though I motivate the model with complementary components, as long as each buyer consumes both goods, they need not be perfect complements and can, as remarked by Whinston (1990), be independent instead.

[16] In the Qualcomm / NXP case, the merging parties were upstream suppliers to a downstream manufacturer (e.g., a smartphone manufacturer). However, the theory of harm remains the same with a downstream firm (that has or does not have bargaining power, see section 2.6). Therefore, I do not include a downstream firm in the baseline setup but include it in the online appendix.

[17] In this sense, the technology is a non-drastic innovation.

A (input foreclosure) and pure bundling (of components A and B).[18] Then, the merged entity no longer earns licensing profits. Refusal to license is akin to "burning the bridge" of earning profits when rivals sell. Whinston (1990) shows that when the merged entity bundles, it competes more fiercely because it only earns profits when it sells its bundle. Here also, the merged entity prices more aggressively (relative to the merging parties pre-merger) when entry occurs. This, in turn, implies the potential entrant needs to be not only more efficient than the incumbent in market B to sell but also needs to "make up" the post-merger competitive advantage of the technology owner over the fringe in market A. As a result, the entrant's payoff to innovation decreases. Therefore, it invests less and is less likely to enter. Unlike in Whinston (1990), where the mere threat of aggressive behaviour suffices to foreclose a competitor in market B fully, here, the merged entity has to give up profit (licensing revenues) in market A to become credibly more aggressive. As a result, a strategy that combines input foreclosure and pure bundling is profitable if the loss in market A sufficiently lowers the likelihood of entry into market B.

With full foreclosure (i.e. when the potential entrant in market B decides not to invest at all post-merger), the merged entity competes against the fringes in markets A and B. Prices increase post-merger, to the detriment of consumers. Even if the merged entity invests more than the incumbent did pre-merger, none of the benefits are passed on to consumers because the merged entity prices at the maximum level (determined by the competitive fringes). Thus, the merged entity appropriates a larger share of the benefits of innovation. With partial foreclosure (i.e. when the probability of entry is reduced but not to zero), prices are high with a higher likelihood than pre-merger. However, when entry does occur, prices are lower than pre-merger because competition is fiercer (as the merged entity invests more and is more competitive in market B). The expected price can increase or decrease with partial foreclosure. As a result, consumer welfare effects are ambiguous with partial foreclosure but unambiguous with full foreclosure.

The two most closely-related papers are Whinston (1990) and Etro (2019). Whinston (1990) shows that, contrary to the Chicago school argument, bundling by a monopolist can be profitable and can harm consumers. In one of the cases Whinston considers, the merging parties are not monopolists but, instead, face competition in both markets pre-merger. In his model, the merged entity can monopolise market B post-merger through bundling (which is not possible here). Among other differences, Whinston (1990) models

[18] See Choi (2008) on mergers of complements with mixed bundling. (Mixed bundling occurs in settings with heterogeneous consumers, which I do not consider here.)

neither input foreclosure nor innovation. Etro (2019) analyses endogenous innovation[19] and considers a similar setup to the one considered here. However, there is no input foreclosure either in Etro (2019). Moreover, in that paper, the merging parties are monopolists in both markets pre-merger. Therefore, the standard Cournot benefit of mergers of complements (Cournot, 1838) materialises, whereas it does not materialise here.[20] (Indeed, when one or both of the merging parties are monopolists, a merger yields certain benefits to consumers that are absent here because the merging parties face competition.)[21] As a result, in Etro (2019), merger effects are more likely to be beneficial precisely because the merging parties are monopolists.[22]

Because the present paper features refusing to license post-merger, it is also related to the literature on input foreclosure in vertical mergers. On this topic, see Ordover, Saloner, and Salop (1990, 1992), Salinger (1988), and Salop and Scheffman (1983, 1987). In that literature, the merged entity forecloses an input to a downstream rival to harm that same downstream rival, which produces a *substitute* product, whereas here, the merged entity forecloses firms in market A to harm a potential entrant in the *complementary* market B.

The subsequent sections are structured as follows. Section 2 lays out the baseline model and merger effects (with full and partial foreclosure). Section 3 discusses key features of the model and discusses implications of the model with regards to the European Commission's Qualcomm / NXP case decision. Section 4 concludes.

2 Model

2.1 Baseline setup

Two goods, A and B, are consumed in a one-to-one proportion. There are competitive fringe producers of each good: no seller ever sells good A or B at its monopoly price.

[19] For research specifically on the relation between market structure and innovation, see Schmutzler (2013), Spulber (2013), and Vives (2008).

[20] See Dari-Mattiacci and Parisi (2006) and Kadner-Graziano (2023) on competition and the lack of merger benefits.

[21] Therefore, the intuition from horizontal mergers that mergers are more harmful the higher the market power of the merging parties (Valletti and Zenger, 2018) does not necessarily carry over to mergers of complements. However, Cournot effects can materialise even with competition: in a differentiated product Cournot model, Economides and Salop (1992) find that prices are lower with competition between producers of systems (where each firm offers components A and B, whether separately or jointly only) rather than with competition between producers of components (where each firm produces only one component) because merged entities internalise Cournot externalities.

[22] A related literature shows that pools of essential patents benefit consumers, see Quint (2014).

In the market for good A, the owner of a superior technology and competitive fringe producers have constant unit production costs c_{AT} and $\overline{c_A}$ respectively. If any fringe producer has access to the superior technology, its unit cost drops to $\underline{c_A} < c_{AT} < \overline{c_A}$.

In the market for good B, an incumbent and competitive fringe producers have constant unit production costs c_{BI} and $\overline{c_B}$ respectively, where $c_{BI} < \overline{c_B}$. The incumbent can reduce its unit cost deterministically by i_I at investment cost $k(i_I)$. In addition, a potential entrant can choose to innovate with probability $i_E \in [0,1]$ at investment cost $\theta(i_E)$. With probability i_E, it successfully innovates and has zero production cost; otherwise, its investment fails and it cannot produce good B.

There are three stages. In stage one, the technology owner in market A decides whether to license its technology to fringe producers of A at the unit royalty r.[23] In stage two, the incumbent and potential entrant invest in market B. In stage three, producers of each good compete (simultaneously) in posted prices.[24] The producer of $i \in \{A,B\}$ that offered the lowest price v_i sells quantity $Q(v_A + v_B)$ at profit $(v_i - c_i)Q(v_A + v_B)$, where c_i is its unit cost. The table below summarises the timing.

Table 1: Timing

Stage	Action
1	In market A, the technology owner chooses whether to license (and, if so, chooses the royalty r).
2	In market B, the incumbent and potential entrant invest.
3	All producers compete (simultaneously) in posted prices.

This paragraph lays out sufficient conditions for a unique interior investment equilibrium pre-merger. Let the investment cost functions of the incumbent and potential entrant be strictly convex with $k(0) = \theta(0) = k'(0) = \theta'(0) = 0$,[25] and let $k(c_{BI})$ as well as $\theta(1)$ be prohibitively costly (the incumbent never finds it profitable to reduce its production cost to zero, and the potential entrant never finds it profitable to succeed with certainty).

[23] Not licensing is equivalent to setting a prohibitively high royalty. I assume the licensor cannot discriminate: it sets the same royalty for all third-party firms. The licensing contract signed with any third parties stipulates r and is valid for a prolonged time such that if the technology owner decides to license, it is committed to its decision.

[24] At equal bids, the firm with the lowest cost wins.

[25] These assumptions are identical to those of Etro (2019), except that I assume $k(0) = 0$. Assuming otherwise means one or both parties may not invest at all.

To ensure there exists a unique investment equilibrium pre-merger, I make two assumptions. First, let a producer's profit be concave in its price. This is satisfied, for example, when demand is log-concave (though log-concavity of demand is not necessary). Second, because the convexity of investment costs is insufficient for single-crossing, let $k''' \leq 0$ and $\theta''' \geq 0$.[26] This is satisfied, for example, for quadratic investment costs.[27]

2.2 Pre-merger results

The game is solved by backward induction. However, here I provide an intuitive explanation of the pre-merger results by advancing through stages one to three sequentially.

In stage one, the technology owner decides whether to supply fringe producers. Either it licenses its technology and earns licensing revenues or does not license (equivalently, it sets a prohibitively high royalty) and sells good A directly. If it does not license, it earns unit profit $\overline{c_A} - c_{AT}$ in stage three. If it licenses to fringe producers, it can obtain no higher royalty than $r^* = \overline{c_A} - \underline{c_A}$, it extracts a higher unit profit in stage three (because $\underline{c_A} < c_{AT}$). Consequently, the technology owner chooses to license in stage one.

In stage two, the incumbent and potential entrant have respective expected profits

$$\begin{aligned} \Pi_{BI} &= (1 - i_E) \left[\overline{c_B} - (c_{BI} - i_I) \right] Q\Big(\overline{c_A} + \overline{c_B} \Big) \; - \; k(i_I) \\ \Pi_{BE} &= i_E \left[c_{BI} - i_I \right] Q\Big(\overline{c_A} + c_{BI} - i_I \Big) \; - \; \theta(i_E) \end{aligned} \tag{1}$$

They both invest interior amounts in equilibrium.

In stage three, producers compete in posted prices. Competition in market A leads to price $\overline{c_A}$ (fringe producers have cost $\underline{c_A} + r = \overline{c_A}$). The technology owner does not sell but earns unit licensing revenue $r^* = \overline{c_A} - \underline{c_A}$. Competition in market B leads to price $\overline{c_B}$ when the incumbent sells (without entry) and price $c_{BI} - i_I$ when the entrant sells (with entry).[28]

Proposition 1. *In stage 1, the technology owner licenses at $r^* = \overline{c_A} - \underline{c_A}$. In stage 2, the incumbent and the potential entrant both invest strictly positive amounts. In stage 3, prices are $v_A + v_B = \overline{c_A} + \overline{c_B}$ when the entrant innovates and $v_A + v_B = \overline{c_A} + c_{BI} - i_I$ when it does not.*

[26] It is not guaranteed that there is a unique equilibrium pre-merger if $k'''(i_I) \leq 0$, or $k'''(i_I) \leq 0$ for some $i_I \in [0, c_{BI}]$ but $k'''(i_I) > 0$ for other $i_I \in [0, c_{BI}]$.

[27] See the appendix for a graphical representation.

[28] The technology owner has expected profit $\Pi_{AT} = [\overline{c_A} - \underline{c_A}] \Big[(1 - i_E^*) Q(\overline{c_A} + \overline{c_B}) + i_E^* Q(\overline{c_A} + c_{BI} - i_I^*) \Big]$.

Remark 1. *The incumbent's investment does not benefit consumers when the incumbent sells. Instead, the incumbent's investment only benefits consumers when the incumbent does not sell: when competition with the successful entrant drives the price for B below* $\overline{c_B}$.

The intuition for the remark above goes as follows. When the incumbent sells, it competes against the competitive fringe. Because the incumbent is constrained at price $\overline{c_B}$, it never charges a lower price. Therefore, the incumbent's cost does not affect the consumer price: the price equals $\overline{c_B}$ however much the incumbent invests. In contrast, when the incumbent competes against a more efficient entrant, the incumbent competes more fiercely the more efficient it is (consumers then pay $c_{BI} - i_I$ for good B). Therefore, the incumbent's investment benefits consumers when there is competition with the entrant (in which case the entrant sells).

2.3 Post-merger strategies

Consider a merger between the technology owner in market A and the incumbent producer in market B. The timing post-merger is identical to pre-merger, except that the merged entity can additionally decide in stage 1 whether to engage in pure bundling (to commit to selling either both its goods jointly or none at all). The timing is shown in the table below.

Table 2: Timing, post-merger

Stage	Action
1	The merged entity chooses whether to engage in pure bundling and whether to license (and, if so, chooses the royalty r).
2	In market B, the incumbent and potential entrant invest.
3	All producers compete (simultaneously) in posted prices.

The merged entity has four possibilities in stage one. These are shown in the table below. However, the only post-merger strategy that can be strictly profitable is one that combines input foreclosure with bundling. To see this, consider the three other strategies. Without input foreclosure and without bundling, the merger has no effect. Bundling without input foreclosure is loss-making. The merged entity becomes less (not more) aggressive with bundling and without input foreclosure, because when entry occurs the

merged entity has opportunity cost r of selling (which the incumbent in market B did not have pre-merger). Input foreclosure without bundling is loss-making too. Then, the merged entity loses licensing profits in market A without any gain in market B.

Table 3: Expected profitability of post-merger strategies in stage 1

$\Pi_M - \Pi_{AT} - \Pi_I$	No bundling	Bundling
No input foreclosure	$= 0$	< 0
Input foreclosure	< 0	$\lessgtr 0$

Proposition 2. *In stage 1 post-merger, no strategy other than one that combines input foreclosure and bundling can be strictly profitable.*

When the merged entity bundles, effectively, there is competition on the total price $v_A + v_B$ in stage 3. Intuitively, it can be profitable to refuse to license and bundle because the merged entity thereby "burns its bridge" of earning revenue on good A when others sell and, consequently, behaves more aggressively in stage three. (Refusal to license works as a commitment device not to sell via others.) The merged entity will credibly compete more aggressively against the potential entrant by setting a price as low as $c_{AT} + c_{BI} - i_I$ when the entrant succeeds (where the merged entity may select a higher investment than the incumbent in market B pre-merger). As a result, the entrant invests less post-merger. Providing further intuition: post-merger, the potential entrant needs to make up the competitive disadvantage of its "bundle partner" in good A relative to the merged entity's cost for good A, $\overline{c_A} - c_{AT}$, in order to win in stage three. This decreases its incentive to invest and therefore decreases the likelihood with which consumers benefit from lower prices for good B. Limiting competition from the potential entrant can lead the merger to be strictly profitable.

Remark 2. *Refusal to license does not affect the competitiveness (the unit cost) of third-party producers of good A (with or without a license, third-party producers of good A have unit cost $\overline{c_A}$). Instead, refusal to license eliminates the merged entity's outside option of not selling: from earning royalty r^* to zero. In this way, refusal to license increases the bidding aggressiveness of the merged entity.*

The potential entrant is ***fully foreclosed*** if it invests zero. If the potential entrant does not invest, the merged entity invests $i_I^*(0) = k'^{-1}(Q(\overline{c_A} + \overline{c_B}))$. Full foreclosure is an

equilibrium if $i_I^*(0)$ is such that

$$c_{BI} - i_I^*(0) - (\overline{c_A} - c_{AT}) \leq 0 \tag{2}$$

Intuitively, the condition in (2) states: the potential entrant is fully foreclosed if, after accounting for the competitive disadvantage in good A, the entrant would incur a loss were it to sell. Conversely, the potential entrant is ***partially foreclosed*** in any equilibrium where it is not fully foreclosed.

In the subsequent sections, I consider merger results when the merged entity refuses to license and engages in pure bundling in stage 1.

2.4 Post-merger results, with full foreclosure

By definition, the potential entrant never enters post-merger when it is fully foreclosed. In stage three, the merged entity obtains a total price of $\overline{c_A} + \overline{c_B}$ with certainty. In stage two, the merged entity chooses investment level i_I to maximise its profit

$$\Pi_M = \left[\overline{c_A} + \overline{c_B} - (c_{AT} + c_{BI} - i_I)\right] Q\left(\overline{c_A} + \overline{c_B}\right) - k(i_I) \tag{3}$$

The merged entity invests more post-merger compared to pre-merger because investment yields a benefit with certainty. It reaps all the benefits from its increased investment. Consumers, on the other hand, do benefit from that investment: with full foreclosure, the merger harms consumers unambiguously.

Proposition 3. *When input foreclosure and bundling results in full foreclosure of the potential entrant,*

1. *The potential entrant does not invest (by definition), whereas the merged entity invests more than the merging parties pre-merger.*

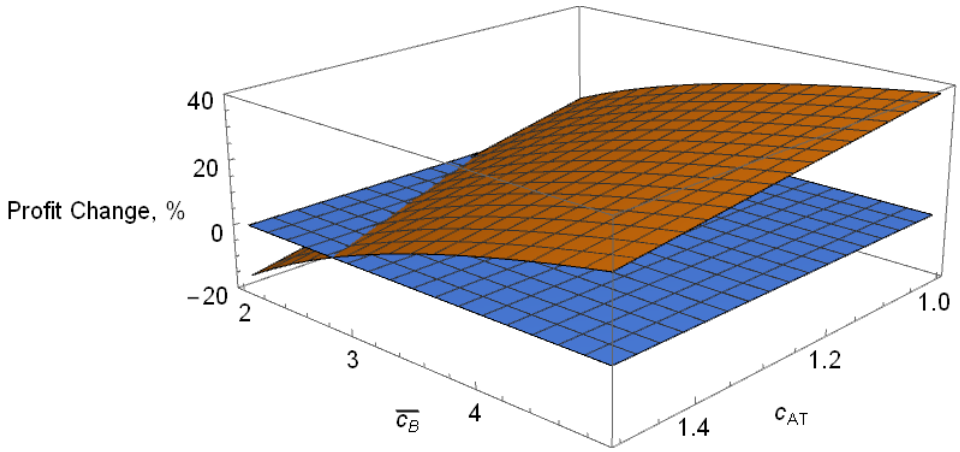
2. *The total price rises unambiguously to $\overline{c_A} + \overline{c_B}$: the merged entity reaps all benefits from its increased investment, and the merger harms consumers.*

Remark 3. *According to the Cournot effect (Cournot, 1838), a merger of complements can decrease prices. In addition, mergers can raise investment in innovation. Here, in contrast, competition always constrains sellers such that the merged entity sets the maximum price and no benefits from innovation are passed on to consumers.*

The merger is strictly profitable if $\Pi_M > \Pi_{AT} + \Pi_{BI}$. The merger has five effects on the merging parties' joint profit. The merged entity earns a greater profit on good B post-merger than the incumbent did pre-merger because (i) it sells good B with certainty post-merger, and (ii) it has a lower unit cost thanks to its greater investment. These benefits come at (iii) greater investment costs post-merger. The merged entity earns less licensing profit than the technology owner did pre-merger because (iv) it always loses out on extracting licensing profits from the greater efficiency of fringe producers at using the technology and (v) it misses out on earning licensing revenues on the extra quantity $Q(\overline{c_A} + c_{BI} - i_I^*) - Q(\overline{c_A} + \overline{c_B})$ which was sold in the case of entry pre-merger.

Intuitively (and all else equal), the higher $\overline{c_B}$, the more profitable it is to fully foreclose the potential entrant in market B. Intuitively (and all else equal), the lower c_{AT}, the lower the cost of input foreclosure (of refusing to license). Conversely, the merger is not profitable for sufficiently low $\overline{c_B}$ and sufficiently high c_{AT}. This is illustrated in the figure below.

Figure 1: Change in the merging parties' expected profit (example)



Note: In this example, $\underline{c_A} = 1$, $\overline{c_A} = 3$, $c_{BI} = 2$, $k(i_I) = i_I^2$, $\theta(i_E) = 2i_E^2$, with $Q = 1$ – let there be unit demand $Q(v_A + v_B) \in \{0, 1\}$. The orange surface depicts the change in the merging parties' expected profit post-merger; the blue surface is the 0-plane.

2.5 Post-merger results, with partial foreclosure

With partial foreclosure, the merged entity and the potential invest in stage two knowing that, in stage three, prices are $\overline{c_A} + \overline{c_B}$ without entry and $c_{AT} + c_{BI} - i_I^*$ with entry.

Therefore, they select their investment levels i_I and i_E to maximise their respective profits

$$\begin{aligned}\Pi_M &= (1-i_E)\left[\overline{c_A}+\overline{c_B}-(c_{AT}+c_{BI}-i_I)\right]Q\left(\overline{c_A}+\overline{c_B}\right)-k(i_I)\\ \Pi_{BE} &= i_E\left[c_{BI}-i_I-(\overline{c_A}-c_{AT})\right]Q\left(c_{AT}+c_{BI}-i_I\right)-\theta(i_E)\end{aligned} \tag{4}$$

The potential entrant invests less post-merger than pre-merger because it needs to compensate the competitive disadvantage in good A of its bundle partner, which reduces the return on investment. As a result, the merged entity's investment rises in equilibrium (relative to the incumbent's investment pre-merger).

Therefore, the total price for the two goods is more likely to be at the high level of $\overline{c_A}+\overline{c_B}$ post-merger. But when entry occurs, the total price is lower post-merger than pre-merger – for two reasons. First, the merged entity invests more than the incumbent did pre-merger and sets a more aggressive (lower) price post-merger. Second, the price of good A also falls because the merged entity competes on the entire bundle. Surprisingly perhaps, the expected price for goods A and B can decrease post-merger with partial foreclosure. Whether it does depends, among others, on how investment by the potential entrant changes with a decrease in the investment payoff.

Proposition 4. *When input foreclosure and bundling result in partial foreclosure of the potential entrant,*

1. *The potential entrant invests less than pre-merger, whereas the merged entity invests more than the merging parties pre-merger.*

2. *The total price equals $\overline{c_A}+\overline{c_B}$ with a higher likelihood than pre-merger. However, when entry occurs, prices are lower than pre-merger. The merger can lead to a decrease in the expected total price (even with a totally inelastic demand) or to an increase in the expected total price.*

The merger is profitable if the gains from reduced entry exceed the loss of licensing revenues. Intuitively, the merger can be profitable despite that the average price decreases because the merged entity appropriates a larger share of the gains of innovation.

2.6 Brief discussion of the model

For conciseness, the model setup does not explicitly include a downstream firm. Imagine a downstream firm consumes the two goods (A and B) as inputs. If suppliers set prices

by competing à la Bertrand, then the results described hitherto remain unaltered. If the downstream firm has some bargaining power over prices, then the theory of harm remains unaltered qualitatively too. However, with bargaining and complete information, two differences appear: first, there is investment hold-up[29] and second, the merger can lead to lower expected prices even with full foreclosure.[30] Intuitively, prices can decrease with full foreclosure because the downstream firm benefits from any investment. Intuitively, the merged entity can profit even if expected prices decrease because it appropriates the benefits of its investment with a higher likelihood.

Note that countermergers are no solution: the potential entrant in market B cannot use a countermerger to make up for its competitive disadvantage because there is only one superior technology, which is prohibitively costly to replicate.[31]

Finally, in the baseline setup, the merger does not strictly harm third-party producers of component A. The model can be altered such that these third-party firms earn a positive expected profit pre-merger.[32] Then, input foreclosure would strictly harm these firms.

3 Antitrust discussion

In the Qualcomm / NXP merger case, the European Commission imposed a remedy stipulating that the merged entity must continue to supply a technology owned by NXP (MIFARE) to third parties on FRAND terms (fair, reasonable, and non-discriminatory licensing terms).[33] Such a remedy prevents input foreclosure; therefore, no harm occurs in market A. Consequently, the merged entity cannot limit entry in market B. The model developed in the present paper shows that such a remedy effectively prevents the foreclosure of a potential entrant and any associated consumer harm.

Below, I address five questions related to this remedy and to the model. First, why

[29] Loertscher and Marx (2019, 2022) show that with incomplete information, there is no hold-up with bargaining.

[30] In addition, the technology owner now has an additional incentive to license: by licensing to fringe producers, it avoids bargaining with and losing rent to the downstream firm.

[31] On countermergers in a vertical chain, see Ordover, Saloner, and Salop (1990). On endogenous profitability of horizontal mergers (how one merger may render a series of further mergers to be profitable), see Nocke and Whinston (2010).

[32] E.g. by assuming a producer has cost $\underline{c_A}$ with probability y and cost $\underline{c_A} - x$ with probability $1-y$. For small enough x and large enough y, the technology owner prefers to set $r = \overline{c_A} - \underline{c_A}$ (rather than $r = \overline{c_A} - \underline{c_A} + x$), which leaves a third party producer with unit profit x. Similarly, the model can be adapted such that the technology owner supplies component A directly with some positive probability. For conciseness, this is left out here.

[33] See European Commission (2018b).

does the merger of complements not yield some benefits to consumers? Mergers of complements can benefit consumers in several ways. A merged entity internalises both a negative externality and a positive externality.[34] It internalises negative pricing externalities and may lower prices (Cournot, 1838). It internalises positive innovation externalities and may invest more in innovation.[35] These benefits materialise when the merging parties are monopolists, but when the merging parties are sufficiently constrained by competition pre-merger, no such benefits materialise:[36] this paper shows that, when competitive constraints bind pre and post-merger, an innovator prices up to the point where it captures all benefits from its innovation, such that no benefits are passed on.

Second, must the price of one component depend on the price of complementary components? In its Qualcomm / NXP decision, the EC wrote that it is "non-standard" to assume "that pre-merger the prices for different inputs are [obtained] without taking into account the price of complementary inputs", as it is unclear why the price of "one input would pre-merger not be affected by the price for complementary inputs that are bought by the same buyer and that are needed to produce a given final good".[37] However, with sufficient competition, the price set by one supplier does not reflect the price of other components: even if an incumbent is by far dominant relative to its competitors, the incumbent can be constrained by a (possibly far worse) outside option of the downstream firm. In this case, the seller maximises its price, subject to constraints in its own component market only.

Third, if the technology of the technology owner is described as a "must have" feature,[38] does this alter results? No. If parties describe the licensed technology as "must have", the alternative – which may be far worse – is still the relevant outside option: it is what a consumer (e.g. a downstream firm) would fall back on were it not to obtain that technology. For example, for a downstream smartphone manufacturer to obtain the "best-of-breed" goods can be an equilibrium outcome rather than necessarily a "make or

[34] According to some practitioners, antitrust authorities have viewed mergers of complements too benevolently, see, e.g., Caffarra, Crawford, and Valletti (2020) and Masson, Dalkir, and Eisenstadt (2014).

[35] See Etro (2019). NXP argued this also: "United in a common strategy, the complementary nature of our technologies and the scale of our portfolios will give us the ability to drive an accelerated level of innovation and value for the whole ecosystem" (NXP, 2016).

[36] See Dari-Mattiacci and Parisi (2006) and Kadner-Graziano (2023).

[37] European Commission (2018a), p.123-4.

[38] In the Qualcomm / NXP case, MIFARE was described as a "must have" such that some smartphone makers would not consider SE (security element) suppliers who did not provide MIFARE. See European Commission (2018a), p.51.

break" condition to produce and release a new smartphone model at all.[39]

Fourth, why does the Single Monopoly Profit Theorem[40] not apply to the present setting? Pre-merger, the technology owner – who has a monopoly over a *non-essential* technology – extracts the maximum surplus it can obtain from component A. Post-merger, the merged entity no longer licenses and loses profit on good A. With bundling and input foreclosure, the merged entity becomes more aggressive, partially or even fully foreclosing a potential entrant in market B. The gain on good B can exceed the loss on good A, depending on how strongly the potential entrant reduces its investment.

Fifth, how important is the commitment to pure bundling? If, after observing the potential entrant's innovation outcome, the merged entity can backtrack on its licensing decision at no cost, licensing decision is not credible ex ante and has no effect. Several factors influence the ex ante credibility of bundling strategies, e.g. timing and whether the components are physically tied (Kühn, Stillman, and Caffarra, 2005; Whinston, 1990). For example, if the merged entity produces components A and B that are physically tied, unbundling may be very costly or impossible without damaging or destroying the product. Timing also plays a role: changing the licensing decision after observing the entrant's investment outcome may be too late for alternative suppliers of A to develop a functioning product in time for the bidding stage.

4 Conclusion

It is well-established that bundling can harm consumers when exercised by a firm with a monopoly in at least one of the two markets. In the present paper, two firms merge and gain an advantage over rivals in two markets without having a monopoly position in either market. The merger can harm consumers due to, first, the absence of standard Cournot benefits and due to, second, anticompetitive strategies. The merged entity uses a strategy that combines (i) input foreclosure in one market with (ii) bundling in order to limit entry into another market.

Pre-merger, licensing is profitable: it allows the technology owner to profit from the

[39] A "must-have" input would be one without which no new consumer product (e.g., smartphone) would be produced at all. If MIFARE were such a "must-have", then NXP should have earned a far higher margin of its license pre-merger already (see Kadner-Graziano, 2023).

[40] This is also known in the literature as the "One-Monopoly-Rent Theorem", see Hermalin and Katz (2013). Hermalin and Katz (2013) consider a differentiated duopoly rather than a monopoly in the tying market. The results of the present paper do not rely on differentiation in the tying market.

greater efficiency of third-party producers of good A. If the merger between the technology owner and the incumbent in market B is strictly profitable, post-merger, the merged entity engages in input foreclosure in market A and bundles. Input foreclosure is costly to the merged entity, as it no longer extracts surplus from more efficient third-party producers of good A. However, the strategy limits entry into market B. Investment by the merged entity increases because it captures more of the social gains from innovation. With reduced competition post-merger, consumers share less in the gains of innovation. Put differently: even if innovation rises post-merger, consumers can be harmed because, with weakened competition, less (or none) of the benefits are passed onto consumers.

In the competitive markets studied here, input foreclosure alone is not profitable. Bundling alone is not profitable either. However, the combination of input foreclosure and bundling can be profitable and harm consumers.

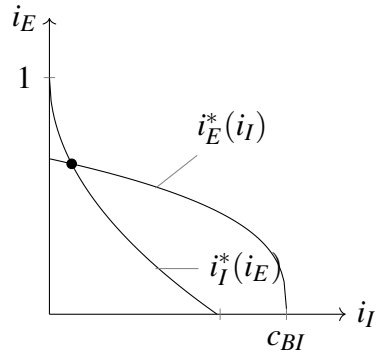
APPENDIX: Proofs

Proof of Proposition 1. In stage 3, the producer of each component $i \in \{A,B\}$ with the lowest cost wins. The two markets can be treated separately. In market A: if the technology owner does not license, it sets $v_A = \overline{c_A}$ and wins. If it licenses at royalty r, it competes price down to $c_{AT} + r$ (its cost, inclusive of the opportunity cost of selling) whereas fringe producers compete down to their cost, which is $\min\{\underline{c_A} + r, \overline{c_A}\}$. In market B: if the potential entrant succeeds in its investment, then it sets $v_B = c_{BI} - i_I$ and wins; if it does not succeed, the incumbent sets $v_B = \overline{c_B}$ and wins.[41]

In stage 2, the incumbent and the potential entrant select their investment levels to maximise their respective profits given in (1); equilibrium investments are characterised by

$$\begin{aligned} i_I^* &= k'^{-1}\left[(1-i_E)Q(\overline{c_A}+\overline{c_B})\right] \\ i_E^* &= \theta'^{-1}\left[(c_{BI}-i_I)Q(\overline{c_A}+c_{BI}-i_I)\right] \end{aligned} \tag{5}$$

The investment cost $k(\cdot)$ is strictly convex with $k(0) = k'(0) = 0$. Because $k''' \leq 0$, $k'(\cdot)$ is weakly concave and $k'^{-1}(\cdot)$ is weakly convex. The effect of i_E on $(1-i_E)Q(\overline{c_A}+\overline{c_B})$ is linear, therefore i_I^* is weakly convex in i_E. Similarly, the investment cost $\theta(\cdot)$ is strictly convex with $\theta(0) = \theta'(0) = 0$. Because $\theta''' \geq 0$, $\theta'(\cdot)$ is weakly convex and $\theta'^{-1}(\cdot)$ is weakly concave. Profit $(c_{BI}-i_I)Q(\overline{c_A}+c_{BI}-i_I)$ is concave in i_I. Hence, i_E^* is weakly concave in i_I. Investment costs $k(c_{BI})$ and $\theta(1)$ are prohibitively costly: $i_I^* < c_{BI}$ and $i_E^* < 1$. The unique pre-merger equilibrium in stage 2 is an interior one: it is illustrated below.



In stage 1, the technology owner decides whether to license. If it does not license, it earns unit profit $\overline{c_A} - c_{AT}$ in stage 3. For any fringe producer to license, the royalty must

[41] With competitive fringes, producers maximise set the highest price possible (i.e., they do not set the monopoly price).

satisfy $r \leq \overline{c_A} - \underline{c_A}$. At any $r \in (\overline{c_A} - c_{AT}, \overline{c_A} - \underline{c_A})$, the technology owner earns a greater profit than without licensing. Consequently, it licenses in stage 1 at the maximum royalty $r^* = \overline{c_A} - \underline{c_A}$. □

Proof of Proposition 2. As a preliminary remark: input foreclosure is economically equivalent to $r > \overline{c_A} - \underline{c_A}$. No input foreclosure (continuing to license) therefore means that $r \leq \overline{c_A} - \underline{c_A}$. However, the merged entity never benefits from charging strictly less than $\overline{c_A} - \underline{c_A}$; hence, without input foreclosure $r^* = \overline{c_A} - \underline{c_A}$.

Of the four feasible post-merger strategies in stage 1, this proof considers each of the following three strategies and shows that each of these three is weakly unprofitable.

First, consider a strategy whereby the merged entity neither bundles nor engages in input foreclosure. In stage 3, a fringe producer sells at $\overline{c_A}$ and the merged entity earns unit royalty r^* in market A. The merged entity earns price $\overline{c_B}$ without entry and the potential entrant earns price $c_{BI} - i_I$ with entry. In stage 2, profit functions from investment are identical to the pre-merger functions in (1). Consequently, investment levels are the same as pre-merger: nothing changes in markets A or B. Hence, the merger has no effect on profits.

Second, consider the strategy of bundling without input foreclosure. In stage 3, the merged entity has unit cost (inclusive of the opportunity cost r)

$$c_{AT} + r^* + c_{BI} - i_I = c_{AT} + \overline{c_A} - \underline{c_A} + c_{BI} - i_I$$

The potential entrant, if it sells, obtains price $c_{BI} - i_I + c_{AT} - \underline{c_A}$, where $c_{AT} - \underline{c_A} > 0$ reflects that it obtains more than pre-merger (see (5)). Therefore, for any investment level by the merged entity, the potential entrant has a higher payoff from innovation and thus a higher incentive to invest. In equilibrium, the potential entrant invests more and the merged entity invests less than the incumbent did pre-merger. Therefore, the merger is strictly unprofitable. To see this: for any investment level i_I, the merged entity earns a strictly lower expected profit than the merging parties earned pre-merger, i.e. $\Pi_M(i_I) < \Pi_{AT}(i_I) + \Pi_{BI}(i_I)$. Without entry, the merger is strictly unprofitable as the merged entity earns profit

$$(\overline{c_A} + \overline{c_B} - c_{AT} - c_{BI} + i_I) Q\big(\overline{c_A} + \overline{c_B}\big)$$

where the quantity sold is the same as pre-merger but the unit profit is lower than pre-merger because $\overline{c_A} - c_{AT} < \overline{c_A} - \underline{c_A}$ (the merged entity has higher costs when it sells input

A directly). With entry, the merger is strictly unprofitable as the merged entity earns

$$(\overline{c_A} - \underline{c_A})Q\big(c_{AT} + \overline{c_A} - \underline{c_A} + c_{BI} - i_I\big)$$

where the unit profit is the same as pre-merger but the quantity sold is strictly lower than the pre-merger quantity $Q(\overline{c_A} + c_{BI} - i_I)$ because $c_{AT} - \underline{c_A} > 0$. With or without entry, the merged entity earns less than pre-merger (and in equilibrium, the probability of entry increases).

Third, consider the strategy of input foreclosure without bundling. In stage 3, the merged entity sells component A at price $\overline{c_A}$ with unit profit $\overline{c_A} - c_{AT}$. In stage 2, profit functions from investment are identical to the pre-merger functions in (1). Consequently, investment levels are the same as pre-merger: nothing changes in market B but the merged entity loses profits in market A. Hence, input foreclosure without bundling is strictly unprofitable. □

Proof of Proposition 3. In stage 3, the total price is $\overline{c_A} + \overline{c_B}$ with full foreclosure. (With entry, which does not occur, the price would be $c_{AT} + c_{BI} - i_I$.)

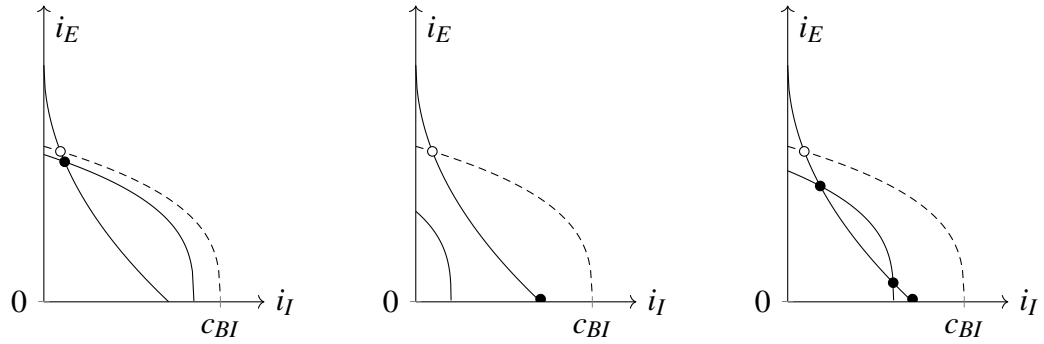
In stage 2, the merged entity and potential entrant select their respective investment levels i_I and i_E to maximise their respective profits shown in (4) with first-order conditions

$$\begin{aligned} i_I^* &= k'^{-1}\Big[(1 - i_E)Q\big(\overline{c_A} + \overline{c_B}\big)\Big] \\ i_E^* &= \theta'^{-1}\Big[(c_{BI} - i_I - (\overline{c_A} - c_{AT}))Q\big(c_{AT} + c_{BI} - i_I\big)\Big] \end{aligned} \tag{6}$$

Comparing (6) to (5): the merged entity's first-order condition is identical to that of the incumbent pre-merger; however, the potential entrant now invests less post-merger for any given level of investment i_I (the price it earns in case of entry drops by $\overline{c_A} - c_{AT}$ post-merger). In equilibrium, the potential entrant invests less than pre-merger and the merged entity invests more than the incumbent did pre-merger. With full foreclosure, condition (2) holds: the potential entrant invests zero. □

Remark 4. *Graphically: with an inwards-shift of the entrant's best response function post-merger, there can exist either a unique equilibrium with partial foreclosure or a unique equilibrium with full foreclosure or three equilibria, two of which with partial foreclosure (of which one is unstable) and one with full foreclosure. Each of these possibilities is, respectively, illustrated below. (The dashed lines depict the potential entrant's*

pre-merger investment best response function. Each white dot depicts the pre-merger Nash equilibrium. Each black dot depicts a post-merger Nash equilibrium.)



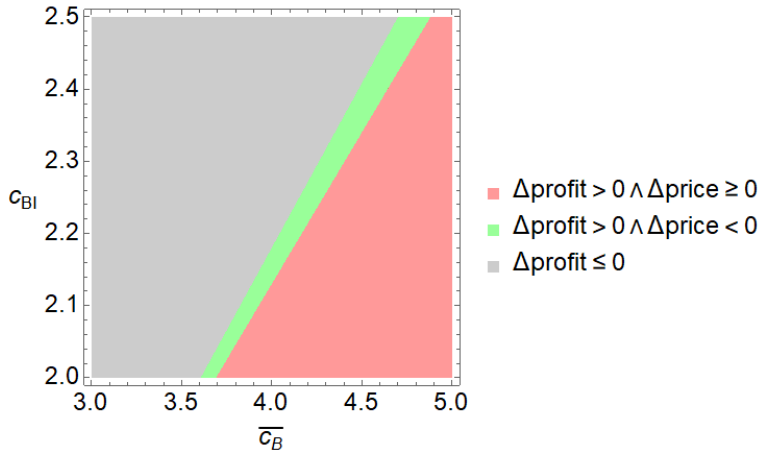
Proof of Proposition 4. In stage 3, the total price is $\overline{c_A} + \overline{c_B}$ without entry and $c_{AT} + c_{BI} - i_I$ with entry.

In stage 2, the merged entity and potential entrant select their respective investment levels i_I and i_E to maximise their respective profits shown in (4) with first-order conditions given by (6). Comparing (6) to (5): the merged entity's first-order condition is identical to that of the incumbent pre-merger; however, the potential entrant now invests less post-merger for any given level of investment i_I (the price it earns in case of entry drops by $\overline{c_A} - c_{AT}$ post-merger). In equilibrium, the potential entrant invests less than pre-merger and the merged entity invests more than the incumbent did pre-merger.

Therefore, stage 3 prices equal $\overline{c_A} + \overline{c_B}$ with a higher likelihood than pre-merger, but with entry prices are lower than pre-merger because $c_{AT} < \overline{c_A}$ and because the merged entity's investment is higher than the incumbent's investment pre-merger.

Finally, I prove by example that the expected total price $v_A + v_B$ can increase or decrease. Consider the following example: let $\overline{c_A} = 1.5$, $c_{AT} = 1.4$, $\underline{c_A} = 1.39$, $k(i_I) = 1.25 i_I^2$, $\theta(i_E) = 1.25 i_E^2$, and quantity be fixed at 1. The green area in the graph below depicts a parameter values of $\overline{c_B}$ and c_{BI} for which the merger is profitable and for which the total price $v_A + v_B$ decreases in expectation. (Thus, even with fixed quantity, the expected price can decrease.)

Figure 2: Change in the merged entity's expected profit and in expected prices (example)



Note: The merger is profitable but expected prices decrease with, e.g., $c_{BI} = 2$ and $\overline{c_B} = 3.65$.

□

References

Bork, Robert (1978). *The Antitrust Paradox: A Policy at War with Itself*. Basic Books.

Caffarra, Cristina, Gregory Crawford, and Tommaso Valletti (May 2020). "'How tech rolls': Potential competition and 'reverse' killer acquisitions". In: *VOX, CEPR Policy*.

Carlton, Dennis W and Michael Waldman (2002). "The Strategic Use of Tying to Preserve and Create Market Power in Evolving Industries". In: *RAND Journal of Economics*, pp. 194–220.

Choi, Jay Pil (2004). "Tying and innovation: A dynamic analysis of tying arrangements". In: *The Economic Journal* 114.492, pp. 83–101.

— (2008). "Mergers with bundling in complementary markets". In: *The Journal of Industrial Economics* 56.3, pp. 553–577.

Choi, Jay Pil and Christodoulos Stefanadis (2001). "Tying, investment, and the dynamic leverage theory". In: *RAND Journal of Economics*, pp. 52–71.

Cournot, Antoine Augustin (1838). *Recherches sur les principes mathématiques de la théorie des richesses*. L. Hachette.

Dari-Mattiacci, Giuseppe and Francesco Parisi (2006). "Substituting complements". In: *Journal of Competition Law and Economics* 2.3, pp. 333–347.

Economides, Nicholas and Steven C Salop (1992). "Competition and integration among complements, and network market structure". In: *The Journal of Industrial Economics*, pp. 105–123.

Etro, Federico (2019). "Mergers of complements and entry in innovative industries". In: *International Journal of Industrial Organization* 65, pp. 302–326.

European Commission (Dec. 2009). *Case COMP/C-3/39.530 – Microsoft (tying)*. Commission Decision.

— (Jan. 2018a). *Case M.8306-QUALCOMM / NXP SEMICONDUCTORS*. Commission Decision.

— (Jan. 2018b). *Mergers: Commission approves Qualcomm's acquisition of NXP, subject to conditions*. Press Release.

Fudenberg, Drew and Jean Tirole (1984). "The fat-cat effect, the puppy-dog ploy, and the lean and hungry look". In: *The American Economic Review* 74.2, pp. 361–366.

Fumagalli, Chiara, Massimo Motta, and Claudio Calcagno (2018). *Exclusionary practices: The economics of monopolisation and abuse of dominance*. Cambridge University Press.

Hermalin, Benjamin E and Michael L Katz (2013). “Product Differentiation through Exclusivity: Is there a One-Market-Power-Rent Theorem?” In: *Journal of Economics & Management Strategy* 22.1, pp. 1–27.

Kadner-Graziano, Alessandro S. (2023). “Mergers of Complements: On the Absence of Consumer Benefits”. In: *International Journal of Industrial Organization*.

Kühn, Kai-Uwe, Robert Stillman, and Cristina Caffarra (2005). “Economic theories of bundling and their policy implications in abuse cases: an assessment in light of the Microsoft case”. In: *European Competition Journal* 1.1, pp. 85–121.

Loertscher, Simon and Leslie M Marx (2019). *Countervailing Power*. Working Paper.

— (2022). “Incomplete information bargaining with applications to mergers, investment, and vertical integration”. In: *American Economic Review* 112.2, pp. 616–49.

Martina, Michael and Stephen Nellis (July 2018). *“Qualcomm ends $44 billion NXP bid after failing to win China approval”*. Reuters. URL: https://www.reuters.com/article/us-nxp-semicondtrs-m-a-qualcomm-idUSKBN1KF193.

Masson, Robert T, Serdar Dalkir, and David Eisenstadt (2014). “A note on complementary goods mergers between oligopolists with market power: Cournot effects, bundling and antitrust”. In: *Review of Law & Economics* 10.1, pp. 59–79.

Matutes, Carmen and Pierre Regibeau (1988). “"Mix and match": product compatibility without network externalities”. In: *RAND Journal of Economics*, pp. 221–234.

Nocke, Volker and Michael D Whinston (2010). “Dynamic merger review”. In: *Journal of Political Economy* 118.6, pp. 1200–1251.

NXP (Oct. 2016). *Qualcomm to Acquire NXP*. Press Release.

— (Oct. 2022). *SE050 Plug & Trust Secure Element*. Product data sheet. Last accessed: March 6th 2023. URL: https://www.nxp.com/docs/en/data-sheet/SE050-DATASHEET.pdf.

Ordover, Janusz A, Garth Saloner, and Steven C Salop (1990). “Equilibrium vertical foreclosure”. In: *American Economic Review*, pp. 127–142.

— (1992). “Equilibrium vertical foreclosure: Reply”. In: *American Economic Review* 82.3, pp. 698–703.

Posner, Richard A (1976). *Antitrust Law: An Economic Perspective*. Chicago: University of Chicago Press.

Quint, Daniel (2014). “Pooling with essential and nonessential patents”. In: *American Economic Journal: Microeconomics* 6.1, pp. 23–57.

Salinger, Michael A (1988). "Vertical mergers and market foreclosure". In: *The Quarterly Journal of Economics* 103.2, pp. 345–356.

Salop, Steven C and David T Scheffman (1983). "Raising Rivals' Costs". In: *American Economic Review* 73.2, pp. 267–271.

— (1987). "Cost-raising strategies". In: *The Journal of Industrial Economics*, pp. 19–34.

Schmutzler, Armin (2013). "Competition and investment—A unified approach". In: *International Journal of Industrial Organization* 31.5, pp. 477–487.

Spence, A Michael (1977). "Entry, capacity, investment and oligopolistic pricing". In: *Bell Journal of Economics*, pp. 534–544.

— (1979). "Investment strategy and growth in a new market". In: *Bell Journal of Economics* 10, p. 345.

Spulber, Daniel F (2013). "How do competitive pressures affect incentives to innovate when there is a market for inventions?" In: *Journal of Political Economy* 121.6, pp. 1007–1054.

U.S. Department of Justice (May 1998). *United States of America v. Microsoft Corporation*. Civil Action No. 98-1232. Complaint.

— (Nov. 2001). *GE-Honeywell: The U.S. Decision*. Remarks of Deborah Platt Majoras.

Valletti, Tommaso and Hans Zenger (2018). "Should Profit Margins Play a More Decisive Role in Merger Control?–A Rejoinder to Jorge Padilla". In: *Journal of European Competition Law & Practice* 9.5, pp. 336–342.

Vandenborre, Ingrid, Amaury S Sibon, and Michael Hoffmann (May 2019). "Hybrid theories: A closer look at the Qualcomm/NXP decision". In: *Competition Law Insight*.

Vives, Xavier (2008). "Innovation and competitive pressure". In: *The Journal of Industrial Economics* 56.3, pp. 419–469.

Whinston, Michael D (1990). "Tying, foreclosure, and exclusion". In: *American Economic Review* 80.4, pp. 837–59.

Williamson, Oliver E (1979). "Assessing vertical market restrictions: Antitrust ramifications of the transaction cost approach". In: *U. Pa. Law Review* 127, p. 953.

ONLINE APPENDIX

In this online appendix, consider a vertical industry and bargaining. A downstream firm sources one unit of each good, A and B. It has complete information and bargaining power $1-\beta$, with $\beta \in (0,1)$. It uses the following price formation mechanism here: first, producers of each good compete à la Bertrand (they submit price offers). Subsequently, and for each input, the downstream firm bargains with the producer that offered the lowest price, using the second-lowest offer as the outside option.

Pre-merger results

Pre-merger in market A, the technology owner licenses at $r^* = \overline{c_A} - \underline{c_A}$. Licensing now not only serves to extract profit from the greater efficiency of fringe producers but also serves to avoid bargaining with the downstream firm and sharing rents as a result.

Pre-merger in market B, without entry, the downstream firm and the incumbent maximise the generalised Nash product $[\Pi_D(v_B) - \Pi_D(\overline{c_B})]^{1-\beta} \times \Pi_I(v_B)^{\beta}$. They agree to the price $v_B = c_{BI} - i_I + \beta[\overline{c_B} - (c_{BI} - i_I)]$. (Thus, there is hold-up in investment.) With entry, the downstream firm and the entrant maximise the generalised Nash product $[\Pi_D(v_B) - \Pi_D(c_{BI} - i_I)]^{1-\beta} \times \Pi_{BE}(v_B)^{\beta}$. They agree to price $v_B = \beta(c_{BI} - i_I)$.

Given these price outcomes, the incumbent supplier and the potential entrant choose their investment levels to maximise their respective profits

$$\Pi_I = (1 - i_E)\beta[\overline{c_B} - (c_{BI} - i_I)] - k(i_I)$$
$$\Pi_{BE} = i_E\beta(c_{BI} - i_I) - \theta(i_E)$$

Maximising yields the equilibrium conditions

$$i_I^* = k'^{-1}\left[(1 - i_E)\beta\right] \in (0, c_{BI})$$
$$i_E^* = \theta'^{-1}\left[\beta(c_{BI} - i_I)\right] \in (0,1)$$

Hold-up reduces equilibrium investment levels.

Post-merger results, with full foreclosure

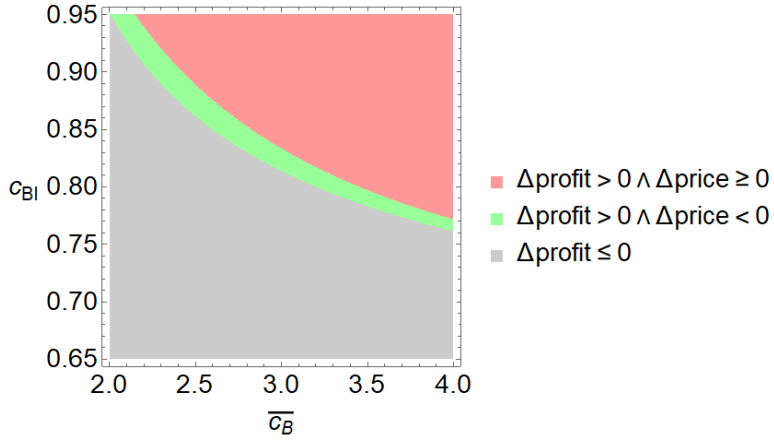
When the merged entity engages in input foreclosure and bundling, and when this leads to full foreclosure of the potential entrant,[42] the merged entity obtains unit price v, which maximises the Nash product $[\Pi_D(v) - \Pi_D(\overline{c_A} + \overline{c_B})]^{1-\beta} \times \Pi_I(v)^{\beta}$. The bundle price reflects markets for A and B separately:

$$v = \overline{c_A} - (1-\beta)(\overline{c_A} - c_{AT}) + \overline{c_B} - (1-\beta)[\overline{c_B} - (c_{BI} - i_I)]$$

The merged entity's unit profit in market A decreases from $\overline{c_A} - \underline{c_A}$ pre-merger to $\beta(\overline{c_A} - c_{AT})$ post-merger for two reasons. First, when bargaining, it loses a share of the trade-specific surplus to the downstream firm. Second, it no longer benefits from the greater efficiency of other firms. The merged entity's unit profit on good B increases because the potential entrant invests less, and therefore, the merged entity invests more.

As in section 2, the total price for goods A and B can increase post-merger. This harms the downstream firm and consumers. Unlike in section 2, with bargaining, expected prices can decrease even with full foreclosure. Intuitively, this can happen because the downstream firm captures some of the surplus of the merged entity's larger investment.

Figure 3: Change in the merged entity's expected profit and in expected prices, with bargaining and full foreclosure (example)



Note: In this example, $\beta = 0.5$, $\underline{c_A} = 0.29$, $c_{AT} = 0.3$, $\overline{c_A} = 0.66$, $k(i_I) = 0.8i_I^2$, and $\theta(i_E) = i_E^2$.

[42] The condition for full foreclosure is still given by (2).