Upstream Bundling and Leverage of Market Power*

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Abstract

Motivated by the recent Google-Android antitrust case, we present a novel rationale for bundling by a multiproduct upstream firm. Consider a market where downstream firms procure components from upstream suppliers. $U_1$ is the only supplier of component $A$, but faces competition for component $B$. Suppose that component $A$ increases demand for the downstream product and that contractual frictions induce positive wholesale markups. By bundling $A$ and $B$, $U_1$ reduces its $B$-rivals’ willingness to offer slotting fees to the downstream firm, thereby allowing $U_1$ to capture more of the industry profit. Bundling harms the downstream firm and the $B$ rivals, and can be anticompetitive.

Keywords: bundling, exclusion, vertical relations.

JEL Classification: L1, L4.

1 Introduction

Competition authorities in Europe and in the US have recently been investigating potentially anti-competitive practices by Google on the mobile applications market. Google, which develops the open-source mobile operating system Android and many mobile applications, has in particular been accused by the European Commission of abusing its dominant position by imposing restrictions on Android device manufacturers.¹

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One such restriction is application bundling: manufacturers who want to install Google Play also have to pre-install other Google applications (notably Google Search and the Google Chrome browser). Because Google Play is by far the largest Android application store, the Commission argues that it is commercially important for manufacturers to be able to offer it to their customers. On the other hand, the “tied” applications (Search, Chrome, and others) face stronger competition, and Google’s practices prevent its competitors from being installed either exclusively or in a prominent position on most devices.

The main existing theories of anticompetitive tying (see the literature review below) rely on a “predatory” logic: tying is only profitable to the extent that it successfully induces the exit or prevents the entry of rivals (see Rey and Tirole, 2007 for a discussion). In the Android case, the predation story is unconvincing: Google’s practices have been in place for several years, and there are still credible rivals on the browser or search engine markets. Motivated by features of the Android case, we present a new rationale for (potentially anticompetitive) bundling that does not rely on a predatory logic.

Suppose a final product (e.g., a smartphone), sold by a downstream firm $D$, is made of various components (e.g., applications) provided by upstream firms. There are two categories of components, $A$ (e.g., an app store) and $B$ (e.g., a browser). $A$ is solely produced by upstream firm $U_1$, whereas two versions of $B$ exist, one produced by $U_1$ and the other by $U_2$. Upstream firms offer contracts to the downstream firm, who chooses which component(s) to use and then sells to consumers. For our theory to apply, the following three conditions need to hold: (i) substitutability between the two versions of $B$ leads the downstream firm to install at most one version; (ii) the demand for the final product is higher if component $A$ is installed than if it is not (retail-complementarity); (iii) contractual frictions leave upstream firms with a positive mark-up. In other words, upstream firms cannot offer efficient two-part tariffs. An example of such frictions is if upstream firms can exert some non-contractible effort to increases final demand.

In such an environment, because of contractual frictions, providers of the B component obtain a positive markup for each consumer served. Since $D$ can only choose one $B$ provider, each one is willing to offer a positive slotting fee. This slotting fee is increasing in the expected demand for $D$’s product. By bundling $A$ and $B_1$, $U_1$ can reduce the slotting fee offered by $U_2$: indeed, under bundling $U_2$ expects that a final product that has component $B_2$ will not have $A$, and will therefore be bought by fewer consumers. Facing a less aggressive rival, $U_1$ can reduce the slotting fee it offers to $D$ and thereby increase its profit. Such a strategy is always profitable when $B_1$ is more efficient than $B_2$, but also when the reverse is true provided that the presence of $A$ has a large enough effect on the final demand. In the latter case, bundling is anti-competitive.

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2 An application store allows consumers to search for and install applications that are not already on their device.

3 Another example of friction is downstream risk aversion coupled with a stochastic demand.
After discussing related literature in Section 2, we present our mechanism in Section 3 by focusing on the simplest form of contractual friction, where upstream firms can only offer fixed fees. There we discuss how our mechanism differs from the standard rationales for bundling. In Section 4 we allow for more general contracts. There we show that some form of contractual friction is necessary for bundling to be profitable. We then discuss a model with upstream moral hazard and two-part tariffs which delivers results that are qualitatively similar to those of the model with fixed fees. One difference is that two-part tariffs enable $U_1$ to leverage its market power without actually bundling $A$ and $B_1$. This suggests that a ban on bundling would not be sufficient to restore efficiency, even though the anticompetitive outcome would no longer be the unique equilibrium. Section 5 concludes with a discussion of some extensions. In particular, our model can naturally be reinterpreted as one of wholesale bundling in a standard retail supply chain.

2 Literature

**Bundling and foreclosure** First dealt a blow by the Chicago School’s Single Monopoly Profit Theory (e.g., Director and Levi, 1956; Stigler, 1963), the leverage theory of bundling was reinvigorated by various scholars who showed bundling could be profitably used to deter entry (e.g., Whinston, 1990; Choi and Stefanadis, 2001; Carlton and Waldman, 2002; Nalebuff, 2004). Our mechanism does not rely on entry deterrence and is thus quite different from these.

In Carbajo, De Meza, and Seidmann (1990) and Chen (1997), bundling softens competition by generating horizontal differentiation (one firm offers product $A$ while the other offers $A$ and $B$ as a bundle).

An important feature of our model is the vertical dimension of the market: bundling occurs at the upstream level. Previous papers have looked at this practice from different angles (see, e.g., Burstein, 1960; Shaffer, 1991a; O’Brien and Shaffer, 2005; Ho, Ho, and Mortimer, 2012). Closest to us is Ide and Montero (2016), who show how bundling by an upstream multiproduct firm can be profitably used to exclude an upstream rival. The mechanisms are different though, as illustrated by the different implications: in Ide and Montero (2016) bundling is necessary to achieve leverage (unlike here, see Section 4) and, more importantly, downstream competition is necessary for bundling to be profitable.

In our model, contracting frictions introduce cross-group externalities between upstream firms and consumers: upstream firms benefit from greater downstream demand. The paper therefore also relates to the literature on bundling in two-sided markets: (Choi, 2010; Amelio and Jullien, 2012; Choi and Jeon, 2016). In particular, Choi and Jeon (2016) is also motivated in part by the Google Android case. The modelling setup is quite different.

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Fumagalli, Motta, and Calcagno (2018) provides an up-to-date review of the various theories and their applications.
however, since they do not model the vertical chain, and rely on a different kind of friction (the impossibility of charging negative prices to consumers) to show the possibility of leverage through tying, whereas our theory relies on the possibility of negative payments, i.e. slotting fees.\footnote{See also Lee (2013) and Pouyet and Trégouët (2016) for papers on vertical integration in multi-sided markets, the latter with a particular focus on the smartphone industry.}

**Slotting fees** Earlier literature has emphasized the role of slotting allowances as signalling/screening mechanisms (Chu, 1992), as well as their potential anticompetitive effects (Shaffer, 1991b; Shaffer, 2005; Foros and Kind, 2008; Caprice and Schlippenbach, 2013). In our paper slotting fees result both from the positive wholesale markup induced by the contractual friction (a mechanism discussed by Farrell, 2001) and from the constraint preventing the downstream firm from procuring both $B$ components (see, e.g., Marx and Shaffer, 2010, for a discussion of this point). The purpose of bundling is then to reduce $U_2$’s willingness to offer high slotting fees, thereby softening the competition for access to final consumers.

**Exclusive contracts** Because of the constraint preventing the downstream firm from using two different $B$ components, a bundled offer is a sort of exclusive contract whereby the downstream firm agrees to buy both components from the same supplier. The difference with the standard models of exclusive dealing (e.g., Aghion and Bolton, 1987; Rasmusen, Ramseyer, and Wiley Jr, 1991; Segal and Whinston, 2000) is that the upstream firm can commit not to deal with a firm who rejects the exclusivity clause. Within that literature, Calzolari, Denicolò, and Zanchettin (2016) recently emphasized the role of contractual frictions in making exclusive dealing profitable. While they also focus on frictions that lead upstream firms to charge unit prices above marginal costs, their mechanism is quite different from ours. In particular, they do no rely on the kind of strategic effect (making rivals softer competitors) that is at the core of our argument.

### 3 Baseline model

**Basic institutional environment** A downstream firm, $D$, sells a finished good to consumers at price $p$. The finished good is made of components, obtained from upstream suppliers. There are two categories of components, $A$ and $B$. Upstream firm $U_1$ is the sole producer of the $A$ component, but firms $U_1$ and $U_2$ each compete to sell their own version of $B$: $B_1$ and $B_2$ respectively. $D$ can only install one version of component $B$.\footnote{The debate around bundling of smartphone applications has mostly focused on the manufacturer’s choice of a default application (or on which application makes it onto the phone’s home screen). Capacity is constrained because there can be only one default for each task and space on the home screen is limited. Jeon and Menicucci (2012) also study bundling in a setup where the buyer has a limited capacity. The difference between their model and ours is that the capacity constraint is over the whole set of
Our main motivating example is the market for smartphones (where components are pre-installed applications). In keeping with this motivation, we assume that component $B_i$ generates a direct revenue $nr_i$ for $U_i$ when it is used by $n$ consumers. This revenue may come from advertising, sale of consumer data to third parties, or “in-app purchases”.\(^7\)

Demand for the final product is $Q(p, S)$, where $p$ is the price and $S \in \{\{B_i\}, \{A, B_i\}\}$ is the set of components installed by $D$.\(^8\) We assume that, for any $S$, $D$’s revenue function $pQ(p, S)$ is quasi-concave in $p$ and maximized at $p_S$. We also assume $Q(p, \{A, B_1\}) = Q(p, \{A, B_2\})$ and $Q(p, \{B_1\}) = Q(p, \{B_2\})$—the two $B$ components are perfect substitutes from consumers’ perspective (this assumption is not essential but makes the exposition cleaner).

We write $\Pi \equiv p_{\{A,B_i\}}Q(p_{\{A,B_i\}}, \{A, B_i\})$ and $\pi \equiv p_{\{B_i\}}Q(p_{\{B_i\}}, \{B_i\})$ respectively for the profit when $A$ is and is not installed alongside $B$.

The two key ingredients of our theory are retail complementarity and a contractual friction.

**Retail complementarity**  We assume demand is such that

$$Q \equiv Q(p_{\{A,B_i\}}, \{A, B_i\}) > Q(p_{\{B_i\}}, \{B_i\}) \equiv q \quad \text{and} \quad \Pi > \pi.$$  

In words: when component $A$ is installed, (i) more consumers buy the finished good (ii) downstream sales revenue is larger.

**Contractual friction**  Our final ingredient is a contractual friction that leaves upstream firms with a positive per-unit income from each consumer. To make the mechanism clear, we begin with a very simple such friction: upstream firms can only offer lump-sum transfers (implying that $U_i$ earns $r_i$ per consumer served). We write $F_X$ for the lump-sum that the upstream producer of component $X$ demands from $D$ ($F_X < 0$ corresponds to a payment to $D$, i.e. a slotting fee).

**Payoffs**  Given $D$’s optimal choice of price conditional on $S$, firms’ payoffs are as follows.

If the downstream firm installs $A$ and $B_i$, its profit is $V_D = \Pi - F_A - F_{B_i}$. If it only installs $B_i$, $V_D = \pi - F_{B_i}$. Firm $U_1$’s profit if both $A$ and $B_1$ are installed is $V_1 = F_A + F_{B_1} + r_1Q$.

If only $B_1$ is installed, $V_1 = F_{B_1} + r_1q$. Firm $U_2$’s profits is $V_2 = F_{B_2} + r_2Q$ if $B_2$ is installed alongside $A$, and $V_2 = F_{B_2} + r_2q$ if $B_2$ is installed without $A$.

products, whereas we impose a constraint on the $B$-applications only. More specifically, we don’t allow the manufacturer to install $B_1$ and $B_2$ only, i.e., $A$ never competes against the $B$ applications.

\(^7\)For brevity, we normalize application $A$’s revenue to zero. But our analysis easily extends to positive revenues for $A$.

\(^8\)For brevity we assume that component $B$ is essential.
Timing and equilibrium The game proceeds as follows: At $t = 0$, $U_1$ announces whether it bundles $A$ and $B_1$. At $t = 1$, upstream firms make simultaneous offers to the downstream firm. At $t = 2$ the downstream firm decides which component(s) to install, and chooses a final price. Payoffs are realized at $t = 3$. We restrict attention to subgame-perfect equilibria in undominated strategies. We study the two subgames without bundling and with bundling in turn.

3.1 Separate marketing

Let us start with the case where components $A$ and $B_1$ are sold separately.

Lemma 1. Suppose that $r_i \geq r_j$. Under separate marketing:

(i) The downstream firm chooses components $A$ and $B_i$ in equilibrium.\(^9\)

(ii) $B_j$’s (rejected) offer is $F_{B_j} = -(Qr_j - \epsilon)$.\(^10\)

(iii) The accepted offers are $F_A = \Pi - \pi$ and $F_{B_i} = -Qr_j$.

(iv) If $r_1 \geq r_2$, firm $U_1$’s profit is $V_1 = \Pi - \pi + Q(r_1 - r_2)$. If $r_1 < r_2$, it is $V_1 = \Pi - \pi$.

Firm $U_2$’s profit is then $V_2 = Q(r_2 - r_1)$. In both cases the downstream firm’s profit is $V_D = \pi + \min\{r_1, r_2\}Q$.

Proof. (i) Suppose $S = \{A, B_j\}$. $B_j$ cannot offer a slotting fee above $Qr_j$ as this would generate negative profits. But then there exists an $F'_{B_i}$ that $B_i$ can offer to $D$ representing a Pareto improvement for the pair (e.g., $F'_{B_i} = -Qr_j - \epsilon$). A similar reasoning holds for $A$. (ii) Given $A \in S$, each $U_k$ is willing to offer up to $Qr_k$. The standard logic of asymmetric Bertrand competition implies that the least efficient firm makes the best offer it could afford, in this case $F_{B_j} = -r_jQ$. (iii) Given $F_{B_j} = -r_jQ$, the downstream firm prefers to install $A$ and $B_i$ rather than $B_i$ alone (denoted $\{A, B_i\} \succeq \{B_i\}$) iff $\Pi - F_A - F_{B_i} \geq \pi - F_{B_i}$. Similarly, $\{A, B_i\} \succeq \{B_j\}$ implies $F_A + F_{B_i} \leq \Pi - \pi - r_jQ$. Lastly, $\{A, B_i\} \succeq \{A, B_j\}$ requires $F_{B_i} \leq F_{B_j}$. Together, these constraints imply $F_A = \Pi - \pi$ and $F_{B_i} = -r_jQ$. (iv) Component $A$ generates profit $F_A$ for $U_1$; $B_i$ generates profit $Qr_i + F_{B_i}$ for $U_i$; $V_D = \Pi - F_A - F_{B_i}$. \hfill \blacksquare

Under separate marketing, competition on the $B$ market forces firms to offer slotting fees $F_{B_i} < 0$, and therefore to transfer part of the rent to the downstream firm.

On the $A$ market, firm $U_1$ can capture the direct value it brings to the downstream firm, $\Pi - \pi$. Component $A$ also brings some indirect value to the downstream firm, through

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\(^9\)If $r_i = r_j$ then there is also the mirror allocation.

\(^10\)Here we assume that $\epsilon$, small, is the minimal size of a price change. In the remainder of the paper we simplify notations by removing the $\epsilon$. Without the minimal size assumption the equilibrium in undominated strategies would be such that firm $j$ mixes over $(-Qr_j, -Qr_j + \epsilon)$ for $\epsilon$ small enough, leading to equivalent outcomes. See Kartik (2011).
B firms’ increased willingness to pay slotting fees (from $qr_i$ to $Qr_i$). However, $U_1$ cannot capture this indirect value. This is a key difference with standard models of bundling with complements, where, if consumption of $A$ increases the utility from $B$ by $\Delta$, the $A$ firm can charge $v_A + \Delta$ and therefore capture all its marginal value. To see why such a logic does not work here, suppose that $r_i = r_j = r$, and that $F_A = \Pi - \pi + r(Q - q)$ so that firm 1 fully captures the marginal value of $A$. The downstream firm would never agree to pay such a fee, as it would be better-off only buying from the $B$ firm making the most generous offer.

As we now show, bundling the two components allows firm 1 to capture more of $A$’s marginal value.

### 3.2 Bundling

Now let firm 1 bundle $A$ and $B_1$ with a single transfer offer $\hat{F}_1 = \hat{F}_A + \hat{F}_{B_1}$. Thus, $D$ is constrained to choose $S \in \{\{B_2\}, \{A, B_1\}\}$. Firm 1 would only bundle if it expects to be chosen by $D$; we thus restrict attention to this case. We have:

**Lemma 2.** Under bundling:

(i) $U_2$ offers $\hat{F}_{B_2} = -qr_2$;

(ii) Firm 1 offers $\hat{F}_1 = \Pi - \pi - qr_2$;

(iii) Firm 1’s profit is $\hat{V}_1 = \Pi - \pi + qr_1 - qr_2$. The downstream firm’s profit is $\hat{V}_D = \pi + qr_2$.

**Proof.** (i) $F_{B_2} < -r_2q$ is dominated: if it were accepted $U_2$’s profit would be $r_2q + F_{B_2} < 0$. Suppose $F_{B_2} > -qr_2$ and firms do not expect $B_2$ to be installed. $D$ must be indifferent between installing $B_2$ and the bundle (otherwise, $U_1$ could increase $\hat{F}_1$ a little). But that means that $U_2$ could reduce $\hat{F}_{B_2}$ and be installed for positive profit. (ii) Given $\hat{F}_{B_2} = -r_2q$, $D$ chooses the bundle if $\Pi - \hat{F}_1 \geq \pi + r_2q$, yielding $\hat{F}_1$. (iii) $U_1$’s profit is $\hat{V}_1 = \hat{F}_1 + r_1Q$. $D$’s profit is $\hat{V}_D = \Pi - \hat{F}_1$.

Bundling allows firm $U_1$ to extract the whole joint marginal value of components $A$ and $B_1$ by keeping the downstream firm at its outside option $\pi + qr_2$. The key to understand this is that bundling reduces firm $U_2$’s willingness to pay a slotting fee. Indeed, $U_2$ anticipates that, should $B_2$ be chosen, component $A$ would not be installed. It is therefore only willing to offer up to $r_2q$ to be installed.

**Proposition 1.** If $r_1 < r_2$, firm 1 is better-off under bundling (i.e. $\hat{V}_1 > V_1$) if $r_1Q > r_2q$.

If $r_1 \geq r_2$, firm 1 is always better-off under bundling than under separate marketing.

The proof follows immediately as a corollary of Lemmas 1 and 2. When $r_1 < r_2$, bundling creates an inefficiency. The gain for $U_1$ stems from the weaker competition from
$U_2$, who now only bids $r_2q$ instead of $r_2Q$. Bundling is more likely to be profitable if (i) the inefficiency $(r_2 - r_1)$ is small, and (ii) component $A$ is important to attract consumers ($Q - q$ is large).

When $r_1 \geq r_2$, there is no inefficiency associated with bundling. Because firm 2 is still less aggressive than under separate pricing, firm 1 can demand a larger fixed fee, and bundling is always profitable.

### 3.3 Discussion

**Novelty of the mechanism**

That joint marketing of complementary products can increase profit is certainly not a new result. However the mechanism we highlight is, to the best of our knowledge, novel. Let us briefly discuss how it differs from established theories of joint marketing and bundling.

First, the increase in profit does not come from solving the double-marginalization problem (Cournot, 1838). This point is made clearer by our focus on lump-sum transfers: there are no pricing externalities between the products and joint control cannot be used to raise overall demand for them.

Second, bundling can also be profitable when there are no externalities, by reducing the level of heterogeneity in the population (Adams and Yellen, 1976; Schmalensee, 1984). Again, this is not what is driving our result: we only have one buyer (the downstream firm), and therefore no heterogeneity. Buyers’ homogeneity also makes mixed-bundling redundant.

Third, our theory differs from the one offered by Whinston (1990). We do not rely on firm $U_2$ incurring entry costs (or other economies of scale). Indeed, while Whinston (1990)’s theory is one of entry deterrence, ours can also be interpreted as exclusion of an established rival. In particular bundling is profitable in the short run even if the rival does not exit immediately.

**Timing and commitment**

The simultaneity of the offers plays a role in making bundling profitable. To see this, suppose that $r_2 > r_1$. If negotiation over component $A$ occurred first, bundling would no longer be optimal: $U_1$ would offer a payment $F_A = \Pi - \pi + r_1(Q - q)$. In the second stage, both firms would offer $F_B = r_1Q$ if the first period offer had been accepted, $F_B = r_1q$ otherwise. $U_1$’s profit would be $\Pi - \pi + r_1(Q - q)$, greater than the profit under bundling $\hat{V}_1$.

$U_1$ would therefore have incentives to push the negotiations over $A$ early. Two points are worth mentioning here. First, the downstream firm would have the opposite incentives, and would do its best to accelerate the negotiations over $B$. Second, a strong degree of commitment is required for such a strategy to work: $U_1$ must commit not to make a subsequent offer at the start of the second period of negotiations if $D$ has rejected the
first offer. Given that details of the negotiations are secretly held most of the time, it would be hard for outsiders to observe a deviation from the commitment not to make a second offer, and therefore reputation *vis-à-vis* third parties is unlikely to help sustain this commitment.

Of course our model also requires a certain degree of commitment power by $U_1$, as do all models where pure bundling occurs in equilibrium: $U_1$ must be able to commit not to offer $A$ on a stand-alone basis if $D$ accepts $B_2$’s offer. Unlike the type of commitment discussed above, reputation *vis-à-vis* third parties is more likely to help here: it would be fairly easy to observe that $D$ has installed $B_2$ alongside $A$, and therefore that $U_1$ has reneged its commitment.

**Side payments** Would bundling still be profitable if upstream firms could contract with one another? This question is particularly relevant when $B_2$ is more efficient than $B_1$. Suppose accordingly that $r_2 > r_1$.

A first possibility is a contract whereby firm $U_1$ agrees not to offer $B_1$ to the downstream firm. For $U_1$ to accept such a contract, $U_2$ must offer a payment at least equal to $Qr_1 - qr_2$—the extra profit generated by bundling. If firm $U_1$ accepts, firm $U_2$ no longer needs to offer any positive payment to the manufacturer, and its profit is at least $Qr_2$, which is larger than $Qr_1 - qr_2$. Even though such a contract dominates bundling, it would likely be deemed anti-competitive.

A second possibility would be for $U_2$ to pay $U_1$ not to bundle $A$ and $B_1$, without requiring it not to offer $B_1$. As before, firm $U_1$ must receive a payment at least equal to $Qr_1 - qr_2$ to accept. This time, though, firm $U_2$ still faces competition on the $B$ market, and its profit is $V_2 = Q(r_2 - r_1)$ (see Lemma 1). Therefore, when $2Qr_1 > (Q + q)r_2$, $U_2$ cannot profitably induce firm $U_1$ to unbundle $A$ and $B_1$.

### 4 More general contracts

We now allow upstream firms to offer more general contracts, in the form of two-part tariffs. Under a tariff $T_i = (w_i, F_i)$, $D$ pays $nw_i + F_i$ to the producer of component $i$ if it chooses to install it and if the final demand is $n$.

#### 4.1 Frictionless contracting

The timing is as follows: at $t = 0$, $U_1$ publicly announces whether it bundles $A$ and $B_1$ or not. At $t = 1$, $U_1$ and $U_2$ offer two-part tariffs to $D$. At $t = 2$, $D$ selects the set of components it installs, and chooses a final price $p$. At $t = 3$ payoffs are realized.

Unlike fixed fees, the level of the unit fees $w$ affects the optimal price chosen by $D$. If $D$ installs components $A$ and $B_i$, the joint profit of the involved firms would be maximized...
by setting \( w_A = 0 \) and \( w_{B_i} = -r_i \), so that \( D \)'s price reflects the true marginal cost of the vertical structure.\(^{11}\) We denote this maximal joint profit by \( \Pi_i \),\(^{12}\) and \( Q_i \) is the corresponding quantity sold given that the price is chosen optimally. If \( D \) installs only \( B_i \), the optimal unit fee is again \( w_{B_i} = -r_i \), and the corresponding joint profit and quantity are denoted \( \pi_i \) and \( q_i \).

Notice that in any equilibrium where \( D \) installs \( A \) and \( B_i \) the joint profit must equal \( \Pi_i \).

We make the following set of assumptions:

**Assumption 1.** If \( r_i \geq r_j \), we have:

1. \( \Pi_i \geq \Pi_j, Q_i \geq Q_j, \pi_i \geq \pi_j \) and \( q_i \geq q_j \).
2. \( \Pi_i - \pi_i \geq \Pi_j - \pi_j \)
3. \( \Pi_j \geq \pi_i \) and \( Q_j \geq q_i \)

By part (i), the most efficient component facilitates higher sales and a larger joint profit. Part (ii) means that adding \( A \) to the product is more valuable if the chosen \( B \) component is the most efficient one. Part (iii) implies that the asymmetry between \( B_1 \) and \( B_2 \) is not too large compared to the value of installing \( A \).

Our first result is a negative one:

**Proposition 2.** Bundling \( A \) and \( B_1 \) is not profitable if upstream firms can offer two-part tariffs.

The proofs of this section appear in the online appendix. Intuitively, competition in two-part tariffs leads firms to offer the efficient level of the unit fee, \( w_{B_i} = -r_i \) and \( w_A = 0 \). Competition therefore only takes place with respect to the fixed fees. But this set-up is equivalent to one in which the “single monopoly profit theory” applies: when \( B_2 \) is more efficient than \( B_1 \), \( U_1 \) can charge a higher price for product \( A \) if it does not bundle it with \( B_1 \).

### 4.2 Upstream moral hazard

We now discuss the profitability of bundling when some contracting friction prevents firms from designing contracts that achieve the joint first-best. For our purpose, any friction leading to a positive upstream mark-up \( (w_{B_i} > -r_i) \) would work; we focus on moral hazard.

Suppose that, after \( D \) has chosen which \( B \) component to install, the selected upstream firm can exert a non-contractible effort that increases the final demand.\(^{13}\) Such effort could

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\(^{11}\)If \( r_i > 0 \) the marginal cost of \( B_i \) is negative.

\(^{12}\)i.e., \( \Pi_i = \max_p \{(p + r_i)Q(p, \{A, B_i\})\} \).

\(^{13}\)Only the supplier of the \( B \)-component can exert such effort. Later we discuss the possibility of investment by the \( A \) supplier.
consist of advertising or product improvement. A two-part tariff such that \( w_i = -r_i \) would leave \( U_i \) with no incentives to exert effort, because its profit would be independent of the number of units sold. Equilibrium contracts should therefore involve positive upstream markups so as to induce effort.

To keep notations simple, we focus on the following technology: effort is binary with cost \( e \in \{0, 1\} \), and a positive effort increases demand by \( \Delta \). We assume that a positive level of effort is always desirable.

The timing is the following: at \( t = 0 \), \( U_1 \) publicly announces whether it bundles \( A \) and \( B_1 \) or not. At \( t = 1 \), \( U_1 \) and \( U_2 \) offer two-part tariffs to \( D \). A \( t = 2 \), \( D \) selects the set of components it installs. At \( t = 3 \) the supplier of the selected \( B \) component chooses whether to exert effort. At \( t = 4 \), \( D \) observes the level of effort and chooses a final price \( p \).

Optimal fee and notations If \( D \) has opted for component \( B_i \), \( U_i \) finds it optimal to exert effort if and only if \( (w_{B_i} + r_i)\Delta \geq 1 \). Therefore, assuming that it is optimal to induce effort by \( U_i \), the unit fee that maximizes the joint profit of \( D \) and its suppliers is \( w_{B_i} = -r_i + 1/\Delta \). Any smaller value leads to no effort; larger values exacerbate the double-marginalization problem. After payment of the unit fees, the \( B \) supplier is therefore left with a revenue of \( n/\Delta \) if \( n \) units are sold.

We define \( \Pi_i, \pi_i, Q_i, \) and \( q_i \) as the joint profits (excluding the cost of effort) and quantities, with and without \( A \), when \( w_{B_i} = -r_i + 1/\Delta \) and \( U_i \) exerts effort.\(^{14}\) Let \( \bar{\Pi}_i, \bar{Q}_i, \bar{\pi}_i \) and \( \bar{q}_i \) be the corresponding objects when \( w_{B_i} = -r_i \) and \( U_i \) does not exert effort. We maintain Assumption 1, and assume that the value of component \( A \) is not reduced when the \( B \) supplier exerts effort.

Assumption 2. For \( i = 1, 2 \), \( \Pi_i - \pi_i \geq \bar{\Pi}_i - \bar{\pi}_i \).

For the sake of brevity we only present results for the case where \( r_2 > r_1 \), implying bundling is inefficient.

4.2.1 Bundling

Because \( w_{B_i} > -r_i \), upstream profits depend on the number of consumers served. Thus, as in Section 3, bundling limits the slotting fees offered by \( U_2 \) by decreasing demand when \( B_2 \) is installed.

Lemma 3. There is a unique equilibrium under bundling, in which \( U_2 \) is foreclosed and \( U_1 \)'s profit is \( \Pi_1 - \pi_2 + Q_1/\Delta - 1 \).\(^{15}\)

\(^{14}\)i.e. \( \Pi_i \equiv (p^* + r_i) (Q(p^*, \{A, B_i\}) + \Delta) \) with \( p^* = \arg\max_p (p + r_i - 1/\Delta) (Q(p, \{A, B_i\}) + \Delta) \), etc.

\(^{15}\)The term \(-1\) is the cost of effort.
In equilibrium both upstream firms offer the efficient unit fee that induces effort, \( w_i = -r_i + 1/\Delta \). \( U_2 \)'s losing bid offers all the joint profit (without \( A \)), \( \pi_2 \), to \( D \). \( U_1 \)'s offer makes \( D \) indifferent between \( \Pi_1 - F_1 \) and \( \pi_2 \), and \( U_1 \) gets the mark-up \( 1/\Delta \) for the \( Q_1 \) units sold.

### 4.2.2 No bundling

There is now a multiplicity of equilibria in the subgame without bundling, some of which deliver outcomes that are similar to the equilibrium under bundling.\(^{16}\)

**Lemma 4.** Suppose that \( r_2 > r_1 \). In the model with upstream moral hazard and two-part tariffs, there are two types of equilibria.

1. **Efficient equilibria**, such that \( D \) installs \( \{ A, B_2 \} \), always exist. Firm \( U_1 \)'s profit ranges from \( \Pi_1 - \pi_1 \) to \( \Pi_2 - \pi_2 \).

2. There also exist inefficient equilibria, i.e. such that \( D \) installs \( \{ A, B_1 \} \), whenever \( (Q_1 - q_2)/\Delta - 1 \geq \Pi_2 - \Pi_1 \). \( U_1 \)'s profit ranges from \( \Pi_2 - \pi_2 \) to \( \Pi_1 - \pi_2 + (Q_1 - q_2)/\Delta - 1 \).

In an efficient equilibrium, unit fees are \( w_A = 0 \) and \( w_{B_i} = -r_i + \frac{1}{\Delta} \). The logic is then similar to Lemma 1: \( U_2 \) anticipates that \( D \) will also install \( A \) and is therefore willing to offer a large slotting fee (up to \( Q_2/\Delta \)). More specifically, the best equilibrium for \( U_1 \) has \( F_A = \Pi_2 - \pi_2 \), \( F_{B_2} = \pi_2 - \pi_1 - \frac{Q_2}{\Delta} \) and \( U_1 \)'s rejected offer for \( B_1 \) is \( F_{B_1} = -\frac{Q_1}{\Delta} \).

In an inefficient equilibrium, \( U_1 \) adjusts the unit fees so as to make it unprofitable for \( D \) to install \( B_2 \) alongside \( A \), while keeping \( w_A + w_{B_1} \) at the efficient level. In effect, firm 1 creates a virtual bundle through its choice of contracts. Anticipating this, \( U_2 \) is no longer willing to offer a large slotting fee. One strategy profile that sustains \( U_1 \)'s preferred equilibrium is: \( w_A = r_2 - r_1, w_{B_1} = -r_2 + \frac{1}{\Delta} \), \( F_A = \Pi_1 - \pi_2 \) and \( F_{B_1} = -\frac{Q_1}{\Delta} \). \( U_2 \)'s rejected offers are \( w_{B_2} = -r_2 + \frac{1}{\Delta} \) and \( F_{B_2} = -\frac{Q_1}{\Delta} \).\(^{17}\)

The next Proposition is obtained as a corollary from Lemmas 3 and 4.

**Proposition 3.** When \( (Q_1 - q_2)/\Delta - 1 > \Pi_2 - \Pi_1 \), the unique equilibrium under bundling delivers the same profit to \( U_1 \) as the best equilibrium under no bundling.

When \( (Q_1 - q_2)/\Delta - 1 < \Pi_2 - \Pi_1 \), bundling is not profitable for \( U_1 \).

With two-part tariffs and upstream moral hazard, explicitly bundling \( A \) and \( B_1 \) is no longer necessary to foreclose \( B_2 \). The value of (explicit) bundling comes from the first-mover advantage it gives to \( U_1 \), allowing it to select its preferred equilibrium.

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\(^{16}\)The multiplicity of equilibrium payoffs comes from the fact that the binding constraint on the fixed fees paid to \( D \) only pins down \( F_A + F_{B_i} \).

\(^{17}\)Off the equilibrium path, if \( U_2 \) offers \( F_{B_2} < -\frac{Q_2}{\Delta} \), \( D \) installs \( B_2 \) alone even though it is indifferent with installing \( B_2 \) and \( A \). In the proof we construct an equilibrium that does not rely on this tie-breaking assumption.
Discussion of moral hazard with A  Our assumption that the effort only concerns producers of the B component is less innocuous than our assumption that A does not generate any revenue. Indeed, with moral hazard on both markets there would be an efficiency argument for having $B_1$ instead of $B_2$: a mark-up on A (necessary to induce effort on the A component) would reduce the need for a further markup on $B_1$, but not on $B_2$, to induce effort. This logic is similar to the logic of double marginalization in the pricing of complements. While it would make the analysis of the game much more intricate, it would not affect the key insight that bundling reduces $B_2$’s willingness to offer slotting fees. In terms of welfare, bundling would be less likely to be inefficient, given that, provided $r_2$ is not too large compared to $r_1$, the efficiency gains from having a single upstream provider (outlined just above) would offset the fact that $r_2 > r_1$.

5 Conclusion

Upstream bundling can reduce rivals’ willingness to pay slotting fees and thereby enable profitable leverage. This can be achieved as the unique equilibrium through strict bundling, or as one equilibrium among many with appropriately designed contracts.

A motivation for our analysis is the case of smartphone application bundling. In this market consumers can modify the downstream firm’s offering by installing alternative applications. It is fairly straightforward to allow this in our model. Bundling can continue to be profitable, provided some consumers will not change the default application configuration (because, e.g., they have high switching costs, they are indifferent between applications, or they suffer from default bias).

Though motivated by the Android case, our model can be applied more broadly. First, observe that other markets share similar institutional features to smartphones. For instance, upstream cable TV networks offer bundles of channels (‘components’) to downstream cable companies and earn advertising revenue when their channel is viewed. Thus, our work speaks to ongoing policy concerns around wholesale bundling in the pay-TV market (see Crawford, 2015, for a discussion).

Secondly, the model can also be used to study bundling by manufacturers in standard retail supply chains. Recall that our analysis depends on two assumptions: retail complementarity and contractual frictions that give rise to slotting fees. If consumers value one-stop shopping then a downstream retailer attracts more customers by stocking more products; our retail complementarity assumption is then satisfied. Moreover, the analysis of Section 4 is unchanged if we let $r_i < 0$ (interpreted as an upstream manufacturer’s marginal cost of production). Thus, positive wholesale mark-ups and slotting fees offered to retailers endogenously arise under contractual frictions as before. Given that our assumptions are satisfied, we again find bundling by a manufacturer can foreclose a rival by denying them the chance to be stocked alongside important products.
Our setup involves a downstream monopolist. With downstream competition, bundling by $U_1$ has the potential to prevent downstream firms from differentiating by offering different versions of the $B$ product, which may intensify competition. Exploring this issue is a promising research avenue.

References


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A Proof of Proposition 2

(1) Case with \( r_2 > r_1 \). Suppose that \( U_1 \) bundles \( A \) and \( B_1 \). Let \( T_1 = (w_1, F_1) \) be \( U_1 \)'s offer, with \( w_1 = -r_1 \).

First, in equilibrium, \( U_2 \) must offer \( w_{B_2} = -r_2 \) and \( F_{B_2} = 0 \). Indeed, \( D \) must be indifferent between \( \{A, B_1\} \) and \( \{B_2\} \), and if \( w_{B_2} \neq -r_2 \) then \( U_2 \) could profitably deviate and induce \( D \) to choose \( \{B_2\} \). Given that \( w_{B_2} = -r_2 \), we obtain \( F_{B_2} = 0 \) using standard weak dominance arguments.

Given \( U_2 \)'s offer, \( U_1 \)'s accepted offer must then satisfy \( \Pi_1 - F_1 = \pi_2 \) for \( D \) to be indifferent between \( \{A, B_1\} \) and \( \{B_2\} \). \( U_1 \)'s profit is then \( \hat{\Pi}_1 = \Pi_1 - \pi_2 \).

Suppose instead that \( U_1 \) chooses not to bundle \( A \) and \( B_1 \) and sets \( w_A = 0, w_{B_1} = -r_1 \) and \( F_{B_1} = 0 \) (i.e. it makes the best possible offer for \( B_1 \)). For \( D \) to choose \( \{A, B_2\} \), three conditions must hold: (i) \( F_{B_2} \leq \Pi_2 - \Pi_1 \) (so that \( D \) prefers \( \{A, B_2\} \) to \( \{A, B_1\} \)), (ii) \( F_A \leq \Pi_2 - \pi_2 \) (so that \( D \) prefers \( \{A, B_2\} \) to \( \{B_2\} \)), and (iii) \( F_A + F_{B_2} \leq \Pi_2 - \pi_1 \) (so that \( D \) prefers \( \{A, B_2\} \) to \( \{B_1\} \)). The worst configuration for \( U_1 \) is when constraints (i) and (iii) are binding. In this case its profit is \( V_1 = F_A = \Pi_1 - \pi_1 \), which is still larger than \( \hat{\Pi}_1 \). Bundling is therefore not profitable.

(2) Case with \( r_1 > r_2 \). Under bundling, \( B_2 \)'s rejected offer must be \( w_{B_2} = -r_2 \) and \( F_{B_2} = 0 \). The profit of \( U_1 \) is therefore equal to the maximal fee it can charge \( D \), i.e. \( \hat{\Pi}_1 = \Pi_1 - \pi_2 \).

If \( U_1 \) does not bundle its products and offers \( w_A = 0 \) and \( w_{B_1} = -r_1 \), then \( D \) installs \( \{A, B_1\} \) in equilibrium. Again, \( B_2 \)'s rejected offer must be \( w_{B_2} = -r_2 \) and \( F_{B_2} = 0 \). The constraints that \( F_A \) and \( F_{B_1} \) must satisfy are (i) \( F_{B_1} \leq \Pi_1 - \Pi_2 \) (so that \( D \) prefers \( \{A, B_1\} \) to \( \{A, B_2\} \)), (ii) \( F_A \leq \Pi_1 - \pi_1 \) (so that \( D \) prefers \( \{A, B_1\} \) to \( \{B_1\} \)), and (iii) \( F_A + F_{B_1} \leq \Pi_1 - \pi_2 \) (so that \( D \) prefers \( \{A, B_1\} \) to \( \{B_2\} \)). By Assumption 1(2), constraint (iii) is binding, so that \( V_1 = \Pi_1 - \pi_2 = \hat{\Pi}_1 \).

B Proof of Lemma 3

If \( U_1 \) bundles \( A \) and \( B_1 \), in equilibrium \( D \) must be indifferent between \( \{A, B_1\} \) and \( \{B_2\} \) (otherwise \( U_1 \) could demand higher fixed fees). \( B_2 \)'s rejected offer must be \( w_{B_2} = -r_2 + 1/\Delta \) and \( F_{B_2} = -Q_2/\Delta \): \( w_{B_2} = -r_2 + 1/\Delta \) maximizes the joint profit, and \( F_{B_2} = -Q_2/\Delta \) allocates all the profit to \( D \). Lower values of \( F_{B_2} \) are dominated strategies, while higher values could not constitute an equilibrium (\( U_2 \) could reduce \( F_{B_2} \) and profitably induce \( D \) to install \( B_2 \)).

In equilibrium \( U_1 \) must offer \( w_1 = -r_1 + 1/\Delta \), so that the maximal fixed fee it can charge is given by \( \Pi_1 - F_1 = \pi_2 \). \( U_1 \)'s profit is therefore \( \hat{\Pi}_1 = F_1 + (r_1 + w_1)Q_1 - 1 = \Pi_1 - \pi_2 + Q_1/\Delta - 1 \).
C Proof of Lemma 4

Efficient equilibria First, in an efficient equilibrium, we must have \( w_A = 0 \) and \( w_{B_2} + r_2 = 1/\Delta \) to maximize the realized joint profit. \( w_{B_1} \) is not uniquely pinned down in equilibrium. For our purpose, we can focus on equilibria where the rejected \( B_1 \) offer would have induced effort if accepted, i.e. \( w_{B_1} = -r_1 + 1/\Delta \). Let \( F_{B_1} \) be the rejected offer’s fixed fee.

For \( D \) to select \( \{A, B_2\} \) rather than respectively \( \{A, B_1\} \), \( \{B_2\} \) or \( \{B_1\} \), we must have (i) \( F_{B_2} \leq \Pi_2 - \Pi_1 + F_{B_1} \), (ii) \( F_A \leq \Pi_2 - \pi_2 \) and (iii) \( F_A + F_{B_2} \leq \Pi_2 - \pi_1 + F_{B_1} \). By Assumption 1(3), (iii) is always binding. There is then a continuum of \( \{\Pi_2, F_{B_2}\} \) compatible with (i)-(iii). \( U_1 \)’s associated profit ranges from \( \Pi_1 - \pi_1 \) (when (i) also binds) to \( \Pi_2 - \pi_2 \) (when (ii) also binds). Let us check that these constitute equilibria of the subgame without bundling.

Let us take a \( \{F_A, F_{B_2}\} \) compatible with (i)-(iii). Neither \( D \) nor \( U_2 \) have a profitable deviation from such a strategy profile. Could \( U_1 \) profitably deviate? The only possibility would be to make offers such that \( D \) chooses \( \{A, B_1\} \). One constraint would then be that \( D \) prefers \( \{A, B_1\} \) to \( \{B_2\} \), i.e. \( \Pi_1 - F_A' + F_{B_1} \geq \pi_2 - F_{B_2} \). Because (iii) is binding, we have \( F_{B_2} = \Pi_2 - \pi_1 + F_{B_1} - F_A \). Therefore the deviation must satisfy \( \Pi_1 - F_A' - F_{B_1} \geq \pi_2 - (\Pi_2 - \pi_1 + F_{B_1} - F_A) \). Now, we know that in an \( \{A, B_2\} \) equilibrium, \( U_1 \)’s profit \( V_1 \) is equal to \( F_A \). So the previous constraint rewrites as \( \Pi_1 - \pi_1 + \Pi_2 - \pi_2 + F_{B_1} - V_1 \geq F_A' + F_{B_1} \). The best deviation by \( U_1 \) is therefore to make this constraint binding. Its new profit is then \( F_A' + F_{B_1} + Q_1/\Delta = \Pi_1 - \pi_1 + \Pi_2 - \pi_2 + F_{B_1} - V_1 + Q_1/\Delta \). The deviation is not profitable if \( \Pi_1 - \pi_1 + \Pi_2 - \pi_2 + F_{B_1} - V_1 + Q_1/\Delta \leq V_1 \) i.e. if \( 2V_1 \geq \Pi_1 - \pi_1 + \Pi_2 - \pi_2 + F_{B_1} + Q_1/\Delta \).

To sustain \( V_1 = V_1^E \) as an equilibrium, we must have \( F_{B_1} \leq \Pi_2 - \pi_2 - (\Pi_1 - \pi_1) - Q_1/\Delta \). This is not ruled out by weak dominance, since weak dominance only rules out \( F_{B_1} < -Q_1/\Delta \). Therefore any \( V_1 \in [\Pi_1 - \pi_1, \Pi_2 - \pi_2] \) can be sustained in an efficient equilibrium.

Inefficient equilibria - OLD First, in equilibrium, we must have \( w_A + w_{B_1} = -r_1 + 1/\Delta \) so as to induce effort by \( U_1 \). \( U_2 \)’s rejected offer must also satisfy \( w_{B_2} = -r_2 + 1/\Delta \). Indeed, if that was not the case, \( U_2 \) could profitably induce \( D \) to install \( B_2 \) instead of \( B_1 \) (because in equilibrium \( D \) must be indifferent).

In an inefficient equilibrium, \( D \) cannot be indifferent between \( \{A, B_1\} \) and \( \{A, B_2\} \). If that was the case, then we would either have \( F_{B_2} = -Q_2/\Delta \) and \( U_1 \) would be better-off not serving \( B_1 \), or \( F_{B_2} > -Q_2/\Delta \) and \( U_2 \) could lower its fee and profitably induce \( D \) to switch to \( \{A, B_2\} \). Therefore \( D \) must be indifferent between \( \{A, B_1\} \) and either \( \{B_1\} \) or \( \{B_2\} \).

But \( D \) must be indifferent between \( \{A, B_1\} \) and \( \{B_2\} \), otherwise \( U_1 \) could increase its fixed fee. This means that \( D \) strictly prefers \( \{B_2\} \) to \( \{A, B_2\} \) in an inefficient equilibrium. One way for \( U_1 \) to achieve this is by setting a large \( w_A \) and a \( w_{B_1} \) such that \( w_A + w_{B_1} = -r_1 + 1/\Delta \).
D’s indifference between \{A, B_1\} and \{B_2\} implies that \(F_A + F_{B1} = \Pi_1 - \pi_2 + F_{B2}\). \(U_1\)’s profit is then \(V_1 = \Pi_1 - \pi_2 + F_{B2} + Q_1/\Delta - 1\).

We cannot have \(F_{B2} > -q_2/\Delta\). If that was the case \(U_2\) could lower its fixed fee and induce \(D\) to install only \(B_2\), with a profit. Thus we must have \(F_{B2} \leq -q_2/\Delta\).

Let us now check whether any strategy profile described above such that \(V_1 = \Pi_1 - \pi_2 + F_{B2} + Q_1/\Delta - 1\) and \(F_{B2} \leq -q_2/\Delta\) is an equilibrium.

\(U_2\)’s only available instrument is its fixed fee (because the unit fee maximizes the joint profit). But offering a lower fixed fee cannot make \(D\) prefer \{\(A, B_2\)\} to \{\(B_2\)\}. So if \(U_2\) induces adoption of \(B_2\), it will be on its own. Given that \(F_{B2} \leq -q_2/\Delta\), \(U_2\) would lose money by further lowering it. So \(U_2\) does not have a profitable deviation.

\(U_1\)’s only potential deviation would be to induce \(D\) to install \{\(A, B_2\)\}. Such a deviation would entail \(w_A' = 0\) (joint profit maximization). By setting \(F_{B1}\) arbitrarily large and \(F_A\) such that \(D\) is indifferent between \{\(A, B_2\)\} and \{\(B_2\)\}, i.e. \(F_A = \Pi_2 - \pi_2\), \(U_1\) can secure a profit of \(\Pi_2 - \pi_2\) with the deviation. This implies that, for \(F_{B2}\) to be part of an inefficient equilibrium, we must have \(F_{B2} \geq \Pi_2 - \Pi_1 - Q_1/\Delta + 1\) and \(F_{B2} \leq -q_2/\Delta\). This is possible only under the condition \((Q_1 - q_2)/\Delta - 1 \geq \Pi_2 - \Pi_1\)

**Inefficient equilibria** Take \(\epsilon\) arbitrarily close to zero and consider the following strategy profile: \(w_A = r_2 - r_1 + \epsilon, F_A = \Pi_1 - \pi_2 - \epsilon q_2, w_{B2} = -r_2 + \frac{1}{\Delta}, F_{B2} \in [\Pi_2 - \Pi_1 - \frac{Q_1}{\Delta} + 1 + \epsilon q_2, \frac{-q_2}{\Delta}], w_{B1} = w_{B2} - \epsilon, F_{B1} = F_{B2}\).

\(D\)’s profit if it installs \{\(A, B_1\)\} is \(\Pi_1 - F_A - F_{B1} = \pi_2 + \epsilon q_2 - F_{B2}\). If it installs \{\(A, B_2\)\}, its profit is \(\Pi_1 - \epsilon Q_1 - F_A - F_{B2} = \pi_2 - \epsilon Q_1 - F_{B2}\). If it installs \(B_1\) alone, its profit is \(\pi_2 + \epsilon q_2 - F_{B2}\). If it installs \(B_2\) alone, its profit is \(\pi_2 - F_{B2}\). So \(D\) chooses \{\(A, B_1\)\} whatever the value of \(F_{B2}\).

The key aspect of \(U_1\)’s strategy is that \((w_A, F_A)\) are chosen such that \(D\) always strictly prefers \{\(B_2\)\} to \{\(A, B_2\)\} for any value of \(F_{B2}\). Therefore, given that \(F_{B2} \leq \frac{-q_2}{\Delta}\), \(U_2\) is not willing to increase the slotting fee it offers (i.e. to offer \(F'_{B2} < F_{B2}\)) because it would lose money by doing so.

Under this strategy profile, \(U_1\)’s profit is \(V_1 = F_A + F_{B1} + \frac{Q_1}{\Delta} - 1 = \Pi_1 - \pi_2 - \epsilon q_2 + F_{B2} + \frac{Q_1}{\Delta} - 1\). The best possible deviation for \(U_1\) would be to induce \(D\) to install \{\(A, B_2\)\} by choosing \(w_A' = 0\) (so as to maximize the joint profit) and \(F_A' = \Pi_2 - \pi_2\) (along with high prices for \(B_1\)). The resulting profit would be \(V_1' = \Pi_2 - \pi_2\). When \(F_{B2} \geq \Pi_2 - \Pi_1 - \frac{Q_1}{\Delta} + 1 + \epsilon q_2\) such a deviation is not profitable.

As the possible equilibrium values of \(F_{B2}\) cover the interval \([\Pi_2 - \Pi_1 - \frac{Q_1}{\Delta} + 1 + \epsilon q_2, \frac{-q_2}{\Delta}]\), \(V_1\) goes from \(\Pi_2 - \pi_2\) to \(\Pi_1 - \pi_2 + \frac{Q_1 - q_2}{\Delta} - 1 - \epsilon q_2\).