Bundling, vertical differentiation, and platform competition∗

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Abstract

This paper studies two-product firms’ bundling decisions as they engage in duopolistic competition in a two-sided market and a complementary good market, highlighting horizontal differentiation in the former market and vertical differentiation in the latter. We find that the firm that owns the superior complementary good can commit to a more aggressive pricing strategy to consumers through bundling. In the presence of asymmetry in externality between the two sides in the platform market, bundling may be profitable without foreclosing the rival when platforms implement cross subsidies from the high-externality side (developers) to the low-externality side (consumers). Bundling has a positive effect on welfare because it allows for better internalization of indirect network effects and reduces the developer cost of multihoming, but also has a negative effect because some consumers buy the less-preferred platform and others consume the inferior complementary good. Consequently, bundling is socially desirable when platforms are not too differentiated and the vertical differentiation between the complementary goods is high.

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1. Introduction

In the market for mobile application, major competitors such as Google and Apple bundle application stores with their in-house operating systems (OSs). Samsung has attempted to increase market share for its Galaxy Apps store, which runs on Google’s Android, while simultaneously developing its own OS, Tizen. It is interesting to note that Samsung chooses not to bundle Galaxy Apps store with Tizen. Bundling a platform with a complementary good is commonly used in industries where two-sided market structures are prevalent. For instance, consider Nintendo, Sony, and Microsoft in the video game industry, they all bundle the console with the system software. One may notice that there is clearly a vertical difference between Tizen and Android or iOS. How the vertical differentiation in a complementary market affects competition in a two-sided market through bundling seems not to have attracted enough attention. As in other two-sided industries, such bundling practice has consequences on competition and welfare. This paper studies two-product firms’ pure bundling decisions as they engage in duopolistic competition in a two-sided market (e.g., Google Play vs. Galaxy Apps store) and a complementary good market (e.g., Android vs. Tizen). We highlight horizontal differentiation in the former market and vertical differentiation in the latter. The goal of this work is to develop a theoretical model to characterize the bundling strategy for firms and study its impact on welfare.

As noted in Whinston (1990), bundling works as a commitment device. Using a model in which consumers are homogeneous with respect to the valuation of the complementary goods, we show that the firm which owns the superior complementary good can effectively commit to a more aggressive pricing strategy to consumers through bundling. Bundling commits to a lower price for the bundle on the consumer side, consequently expanding demand and increasing profit through the market expansion effect on the developer side. In the

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presence of asymmetry in externalities between the two sides, bundling may be profitable for the bundling firm without leading to foreclosure of the rival when platforms implement cross subsidies from the high-externality side (developers) to the low-externality side (consumers). When the level of vertical differentiation between the complementary goods is very large, bundling leads to foreclosure of the rival firm.

Our results provide a theory to make sense of the observations from the mobile application store market. It explains why a firm (e.g. Samsung) that owns an inferior complementary good may not want to build an exclusive system by bundling the platform with the inferior complementary good. Bundling gives the firm that owns the superior complementary good a competitive advantage when facing a horizontally differentiated rival in the platform market, and this advantage cannot be competed away by the bundling practice of the firm that owns the inferior complementary good.

Bundling’s impact on social welfare is ambiguous. It improves social welfare through two channels. First, it allows the platform in the bundle to better internalize indirect network effects. Second, it decreases the mass of multihoming developers, hence the cost of multihoming. However, bundling also leads to three sources of inefficiency. First, the alternative system generates a utility loss due to lower participation on both side of its platform. Second, some consumers adopt the less-preferred platform. Third, the consumers who do not adopt the bundle consume the inferior complementary good. We show that bundling improves social welfare if platforms are not too differentiated and the vertical differentiation between the complementary goods is large.

This paper contributes to the recent discussion on Google’s potential anticompetitive behavior and related antitrust cases. Google effectively implements bundling of its apps, including Google Play, through Android’s Mobile Application Distribution Agreements contracts with manufacturers (Edelman, 2015). Google also deploys a non-compete clause in its Google Play Developer Distribution Agreement to block third-party application stores from appearing in the Play Store, creating more obstacles for those who wish to install third-

\(^3\)See https://play.google.com/about/developer-distribution-agreement.html
party stores. Consumers need to download the Android application package to install a third-party application store, then enable the installation from “Unknown sources” in Android settings. Even if consumers are willing to go through this hassle, they are often unable to get rid of Google Play, because without it, they would experience difficulty getting certain apps from Google or others. Thus, it is very costly for consumers to unbundle Google Play with Android. This paper discusses a few channels through which such bundling practices positively affect social welfare. However, we think it is important to note that the benefits of bundling in this paper largely stem from the utility gain from indirect network effects as bundling raises participation on both sides of the bundling platform. The positive feed-back loop between the two sides make the rival platform even more vulnerable in this market, and consequently limiting consumers’ choices. We suggest that competition authorities should scrutinize in detail of bundling practice when involving two-sided markets.

The rest of the paper is organized as follows. In Section 2 we review the parts of the literature that are closely related to the present study. Section 3 presents the setup of the model. We study the analysis of bundling when consumers are homogeneous with respect to the valuation of the complementary goods in Section 4. Additionally, in Section 5, we show that the insights obtained in the main model are robust. Section 6 concludes.


5 “Apps from Microsoft and Google will be available in the Play Store, while Samsung’s apps will always be available for download through its Galaxy Apps marketplace,” see https://www.sammobile.com/2015/03/23/some-pre-installed-apps-on-the-galaxy-s6-and-the-galaxy-s6-edge-can-be-deleted/ accessed July 2017.
2. Related literature

With in the tying literature that studies the use of bundling to leverage monopoly power to new markets, Whinston (1990) uses a setting in which a two-product firm is a monopolist in one market and faces competition in an unrelated market. The firm commits to a more aggressive pricing strategy by selling the two products as a bundle. He shows that pure bundling reduces equilibrium profits of all firms; hence, it is usually adopted to deter entry in the differentiated market. This paper considers the bundling market to be two-sided and highlights vertical differentiation in the bundled good market. Bundling can be profitable without foreclosing the rival firm because of the additional profit on the developer side.

This paper contributes to the literature on bundling and tying in two-sided markets. Within these markets, the need to get both sides to participate in the market creates a “chicken and egg” problem (Caillaud and Jullien, 2003). The design of pricing strategies to solve the aforementioned demand coordination problem has been a main theme of the literature on two-sided markets. Platforms may use cross subsidies to coordinate two-sided demands: subsidizing one side for participation and recouping the loss from the other side of the market (Rochet and Tirole, 2003; Armstrong, 2006). There are several papers studying bundling or tying in two-sided markets. Rochet and Tirole (2008) analyze the practice of tying credit and debit cards on the merchant side, the Honor All Cards rule (HAC). They show that HAC benefits the multi-card platform while raising social welfare by balancing interchange fees. Chao and Derdenger (2013) analyze the practice of bundling hardware with software. They show that in the presence of installed base effects, mixed bundling can be used as a price discrimination tool to segment the market more efficiently. Choi (2010), Chowdhury and Martin (2017), and Shim and Kwak (2015) focus on the exclusionary effect of tying while this paper highlights how bundling can be profitable without leading to foreclosure using a different mechanism.

This paper is closely related to Amelio and Jullien (2012) and Choi and Jeon (2016). Both papers study firms’ tying or bundling incentives, empha-
sizing the roles of the non-negative price constraint. In Amelio and Jullien (2012), platforms want to price below marginal costs and use tying to implement implicit subsidies on one side of the market to relax the non-negative price constraint. In Choi and Jeon (2016), the non-negative price constraint means additional revenue and also limits the rival’s response to tying. In our paper, prices are interpreted as markups, and hence can be negative. In Amelio and Jullien (2012), pure bundling only arises if a consumer’s valuation of the bundled good is below the marginal cost. We show that bundling is a commitment device for a more aggressive pricing strategy. Choi and Jeon (2016) show that a two-product firm can leverage its monopoly in one market to a two-sided market where it competes with a more efficient rival. Our paper emphasizes the competitive advantage of the firm that owns the more efficient complementary good as it competes with a horizontally differentiated rival in the two-sided market.

Our model of a platform and a complementary good is equivalent to “mix and match,” where consumers assemble systems in fixed proportions and neither good is valuable without the other. To this extent, our work is closely related to Matutes and Regibeau (1988, 1992). In both papers, two-component firms make compatibility decisions before engaging in duopolistic price competition in the absence of network effects. Gans and King (2006) study interfirm bundling of independent products. They use a model with two independent products, each produced by two horizontally differentiated firms. They show that two firms, each offering a different product, have an incentive jointly offer consumers a discount if they buy both products. When both pairs do this, the equilibrium profits are unchanged from the situation when all firms price independently, but consumer and total welfare are reduced. Brito and Vasconcelos (2015) modify the model of interfirm bundling with vertical differentiation. Our paper incorporates two-sidedness in the platform market and highlights vertical differentiation in the complementary good market. We show that bundling with the low-quality product has no effect on competition.

\textsuperscript{6}In Matutes and Regibeau (1988), firms cannot price the whole system differently from their individual components, while in Matutes and Regibeau (1992), firms can.
3. The model

We consider two markets, the application store market (market $A$) and the OS market (market $B$). Two firms, labeled as 1 (e.g., Google) and 2 (e.g., Samsung), each has a product in each market.

Market $A$ is facilitate interactions between consumers and developers. Platform $A_1$ (e.g., Google Play) and platform $A_2$ (e.g., Samsung Galaxy Apps) are exogenously located at the two ends of the Hotelling segment respectively, i.e., $x = 0$ and $x = 1$. Let $p_{ Ai}^C$ and $p_{ Ai}^D$ denote the prices platform $Ai$ charges to consumers and developers, respectively, $i \in \{1, 2\}$. The masses of consumers and developers on platform $T$ are denoted by $n_{ Ai}^C$ and $n_{ Ai}^D$, respectively. In market $B$, let $q_i$ denote the complementary $B_i$’s quality. $B_1$ (e.g., Android) has quality $q_1 = z$ and $B_2$ (e.g., Tizen) is has quality $q_2 = z - \delta$, where $0 < \delta \leq z$. Let $p_{Bi}$ denote the price of $Bi$. The marginal costs of all the products are normalized to zero. Prices in this paper should be interpreted as markups and therefore can be negative. Firms can decide whether to sell the two products separately or sell them as a bundle.

We use a model of “competitive bottlenecks” (Armstrong, 2006). The mass of consumers is normalized to 1, uniformly distributed along the unit interval; they singlehome. Let $x$ denote a consumer’s location on the unit interval between $A_1$ and $A_2$, and let $t$ denote the linear transportation cost in the distance needed to travel to the platform. Consumers see an identical intrinsic value, $v$, in the two platforms, which is large enough so that the whole market is covered. This intrinsic value cannot be realized without interacting with developers through a platform. Consumers have a taste for application variety: The availability of each additional developer positively generates additional utility $\alpha$ for each consumer. A consumer located at $x$ is indifferent towards

\footnote{Assume that, under separate selling, it is possible for consumers to assemble a system that is close to their ideal. If a firm practices pure bundling, consumers cannot buy its bundle, then drop the platform and use the other instead. Thus, bundling can be interpreted as a compatibility decision. Assume there is no cost advantage in bundling.}
the platforms if

\[ v + \alpha n_{A1}^D - p_{A1}^C - tx = v + \alpha n_{A2}^D - p_{A2}^C - t(1 - x). \]  

Each consumer has unit demand in market \( B \). Let \( q_{Bi} \) denote the quality of good \( Bi \). Each consumer’s marginal utility of product \( Bi \) is 1, i.e., they are homogeneous with respect to the valuation of product \( Bi \). A consumer derives utility \( u_{Bi} = q_{Bi} - p_{Bi} \) from consuming \( Bi \).

From the perspective of developers, the two platforms are identical. The mass of developers is normalized to 1. They differ in the cost of listing applications, denoted by \( y \), and are uniformly distributed along the segment \([0, 1]\). All applications are independent of one another, and each developer can list at most one application on each platform. Developers can multihome\(^8\) but the fixed listing cost per platform is incurred twice if a developer joins both platforms. Each developer gains additional utility of \( \beta \) from each consumer available on platform \( Ai \). The utility of developer \( y \) for joining platform \( Ai \) is

\[ u_{Ai}^D(y) = \beta n_{Ai}^C - p_{Ai}^D - y. \]

Assume that the following conditions hold throughout this paper:

**Assumption A1.** \( t > t^* = \frac{\alpha^2}{6} + \frac{2\alpha\beta}{3} + \frac{\beta^2}{6} \).

With Assumption A1, the conditions for unique and stable equilibrium \((t > \frac{\beta^2}{6} + \frac{\alpha^2}{6} + \frac{2\alpha\beta}{3})\) and second order condition \((t > \alpha\beta)\) are satisfied. Both platforms make positive profits in the symmetric equilibrium.

**Assumption A2.** \( \alpha + \beta < 2. \)

Assumption A2 rules out the corner solution that the developer demand for each platform is 1.

**Assumption A3.** \( \beta > \alpha. \)

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\(^8\)A recent survey shows that on average mobile developers use 2.6 mobile platforms (VisionMobile [2013]).
This paper only considers the case in which developers value consumer participation more.\footnote{\textit{Assumption A3} is consistent with previous literature that the singlehoming side of competitive bottlenecks are treated favorably (Rochet and Tirole 2003; Armstrong 2006) and the reality that the developer side is the profit-making side.}

We propose a two-stage game: In stage 1, firms decide whether to sell the two products as a bundle. The decisions are publicly observable. In stage 2, firms simultaneously set prices; consumers and developers make participation decisions. The equilibrium concept is subgame-perfect Nash equilibrium.

4. Platform competition

In this section, we present the equilibrium of the game described above. This game is solved by backward induction.

4.1. Price competition stage

At stage 2, firms compete in prices given their bundling decisions of stage 1. We thus analyze the following subgames.

4.1.1. Separate selling

First consider the subgame in which firms decides not to bundle at stage 1. Consumers make their choice over the two products independently. The following lemma presents the equilibrium outcomes of the separate selling subgame.

\textbf{Lemma 1.} Consider the baseline model in which consumers are homogeneous with respect to the valuation of $B_i$. If both firms decide not to bundle in stage 1, the prices and demands of the unique symmetric equilibrium in market $A$ are as follows:

\begin{align*}
  p^C_{Ai} &= t - \frac{\beta^2}{4} - \frac{3\alpha\beta}{4}, \\
  n^C_{Ai} &= \frac{1}{2}, \\
  p^D_{Ai} &= \frac{\beta}{4} - \frac{\alpha}{4}, \\
  n^D_{Ai} &= \frac{\beta}{4} + \frac{\alpha}{4}.
\end{align*}

Assumption A3 is consistent with previous literature that the singlehoming side of competitive bottlenecks are treated favorably (Rochet and Tirole 2003; Armstrong 2006) and the reality that the developer side is the profit-making side.
In the OS market, the equilibrium prices are given by $p_{B1}^* = \delta$ and $p_{B2}^* = 0$. All consumers adopt $B1$. Each firm’s profit is given by

$$\Pi_1^* = \frac{t}{2} - \frac{\alpha^2}{16} - \frac{3\alpha\beta}{8} - \frac{\beta^2}{16} + \delta, \Pi_2^* = \frac{t}{2} - \frac{\alpha^2}{16} - \frac{3\alpha\beta}{8} - \frac{\beta^2}{16}.$$ 

“Mix and match” allows all consumers to assemble a system that is close to their ideal. In market $A$, both platforms split the consumer market evenly. The equilibrium price is the standard Hotelling price adjusted downward by $\frac{\beta^2}{4} + \frac{3\alpha\beta}{4}$. The adjustment term measures the benefits to the platform of attracting an additional consumer, and can be further broken down into two factors, $\beta(\frac{\beta}{4} + \frac{3\alpha}{4})$. The first factor means that the platform attracts $\beta$ additional developers when it has an additional consumer. The second factor is the profit that the platform earns from each additional developer. The additional developer pays $\frac{\beta}{4} - \frac{\alpha}{4}$ for access to the platform, but also attracts $\alpha$ consumers. Platforms compare consumer preferences for platforms with the benefits of attracting an additional consumer to decide whether to subsidize consumers for participation. Platforms implement cross subsidies from developers to consumers when consumer preferences for platforms are weak ($t < t < \frac{\beta^2}{4} + \frac{3\alpha\beta}{4}$).

On the developer side, there is no full market coverage. Developers with low listing costs multihome (i.e., $y \leq \frac{\beta}{4} + \frac{\alpha}{4}$); the ones with higher costs do not participate (i.e., $y > \frac{\beta}{4} + \frac{\alpha}{4}$). The equilibrium developer price is the monopoly pricing $\frac{\beta}{4}$ adjusted downwards by $\frac{\alpha}{4}$, which is the added benefit that an extra developer brings to the platform from attracting consumers.

4.1.2. Bundling

Consider the subgame of firm 1’s unilateral bundling. A consumer either adopt the $(A1, B1)$ bundle or assemble a system with $A2$ and $B2$. We denote the variables under the bundling scheme with a tilde ($\tilde{\cdot}$). Let $\tilde{P}_1$ and $\tilde{n}_1$ denote the price and demand of the $(A1, B1)$ bundle, respectively. Firm 1 has more incentive to lower $\tilde{P}_1$ because it stimulates the demand for both components of the bundle. A consumer located at $x$ is indifferent towards the $(A1, B1)$
bundle and assembling a system with $A_2$ and $B_2$ if

$$v + \alpha \tilde{n}_{A_1}^D - \tilde{P}_1 - tx + z = v + \alpha \tilde{n}_{A_2}^D - \tilde{P}_{A_2}^C - t(1 - x) + z - \delta - \tilde{p}_{B_2}. \quad (2)$$

For expositional simplicity, let $\Phi = 6t - \beta^2 - 4\alpha\beta - \alpha^2$ for the remainder of the paper.\(^{10}\)

**Lemma 2.** Consider the baseline model in which consumers are homogeneous with respect to the valuation of $B_i$. If firm 1 decides to bundle in stage 1, the equilibrium prices are given by:

$$\tilde{P}_1^* = t - \frac{\beta^2}{4} - \frac{3\alpha\beta}{4} + \frac{\delta(4t - 3\alpha\beta - \beta^2)}{2\Phi}, \tilde{P}_{A_2}^C = t - \frac{\beta^2}{4} - \frac{3\alpha\beta}{4} - \frac{\delta(4t - \beta^2 - 3\alpha\beta)}{2\Phi},$$

$$\tilde{P}_{A_1}^D = (\frac{\beta - \alpha}{2})(\frac{1}{2} + \frac{\delta}{\Phi}), \tilde{P}_{A_2}^D = (\frac{\beta - \alpha}{2})(\frac{1}{2} - \frac{\delta}{\Phi}), \tilde{P}_{B_2}^* = 0.$$  

Each system’s demands are given by:

$$\tilde{n}_{A_1}^* = \frac{1}{2} + \frac{\delta}{\Phi}, \tilde{n}_{A_2}^C = \tilde{n}_{B_2}^* = \frac{1}{2} - \frac{\delta}{\Phi},$$

$$\tilde{n}_{A_1}^D = (\frac{\beta + \alpha}{2})(\frac{1}{2} + \frac{\delta}{\Phi}), \tilde{n}_{A_2}^D = (\frac{\beta + \alpha}{2})(\frac{1}{2} - \frac{\delta}{\Phi}).$$

Each firm’s equilibrium profit is given by:

$$\tilde{\Pi}_1^* = \frac{8t - \beta^2 - \alpha^2 - 6\alpha\beta}{16} (\frac{\Phi + 2\delta}{\Phi^2}), \tilde{\Pi}_2^* = \frac{8t - \beta^2 - \alpha^2 - 6\alpha\beta}{16} (\frac{\Phi - 2\delta}{\Phi^2}).$$

Bundling allows firm 1 to commit to a lower consumer price for its system ($\Delta = \frac{\delta(8t - 2\alpha^2 - 5\alpha\beta - \beta^2)}{2\Phi}$), and attracts consumers who slightly prefer platform $A_2$. Consequently, bundling equips firm 1 with more market power on the developer side, which leads to increased developer participation in a market where developers face heterogeneous listing costs. The more vertical differentiation in market $B$, the lower bundle price firm 1 commits to, the more consumer demand bundling stimulates. The effect of a marginal increase in $\delta$ on firm 1’s profit can be broken down into both direct and strategic effects.

\(^{10}\)Note that $\Phi > 0$ because $t > \bar{t}$. 
To see this,
\[
\frac{d\bar{\Pi}_1}{d\delta} = \frac{\partial \bar{\Pi}_1}{\partial \delta} + \frac{\partial \bar{\Pi}_1}{\partial \tilde{p}_{A2}^C} \frac{dp_{A2}^C}{d\delta} + \frac{\partial \bar{\Pi}_1}{\partial \tilde{p}_{A2}^D} \frac{dp_{A2}^D}{d\delta}.
\]

Note that the direct effect of a marginal increase in \(\delta\) on firm 1’s profit is \(\frac{d\Pi_1}{d\delta} = \bar{n}_1\). It indicates that \(B1\) is sold only as a component of the bundle. The strategic effects work through the two-sided prices of the rival platform. They show how the rival platform react to bundling on both sides of the platform and whether these reactions intensify or soften competition. The strategic effect on the consumer side is:
\[
\frac{\partial \bar{\Pi}_1}{\partial \tilde{p}_{A2}^C} \frac{dp_{A2}^C}{d\delta} = (\bar{P}_1 + \beta \tilde{p}_{A1}^D) \frac{\partial \bar{n}_1}{\partial \tilde{p}_{A2}^C} - (4t - \beta^2 - 3\alpha\beta) \frac{\partial \bar{\Pi}_1}{\partial \tilde{p}_{A2}^D} \frac{dp_{A2}^D}{d\delta}.
\]

Whether bundling intensifies or softens price competition on the consumer side depends on the relationship between consumer platform preferences and the benefits of attracting an additional consumer. When consumer preferences for platforms are weak (\(t < t < \frac{\beta^2}{4} + \frac{3\alpha\beta}{4}\)), platforms implement cross subsidies from developers to consumers, consumer prices are strategic substitutes (\(\frac{\partial \bar{P}_1(\tilde{p}_{C2}^*)}{\partial \tilde{p}_{C2}^*} < 0\)). Platform A2 moves against the rival’s pricing movement—i.e., reducing its consumer subsidy in response to bundling. Price competition is softened on the consumer side (\(\frac{\partial \bar{\Pi}_1}{\partial \tilde{p}_{A2}^C} \frac{dp_{A2}^C}{d\delta} > 0\)). This suggests that when consumer preferences for platforms are weak, platforms have little market power. The positive feedback effect on demands amplifies the effectiveness of bundling on stimulating consumer demand: The more application variety, the more attractive the becomes for consumers, insofar as it reduces the magnitude of the discount on the bundle price to make it profitable for firm 1. Thus, platform A2 is better off reducing consumer subsidy as it is very costly for it to compete with the aggressive rival. When consumer preferences for platforms get more intense (\(t > \frac{\beta^2}{4} + \frac{3\alpha\beta}{4}\)), platforms charge positive consumer prices, consumer prices are strategic complements (\(\frac{\partial \bar{P}_1(\tilde{p}_{C2}^*)}{\partial \tilde{p}_{C2}^*} > 0\)). Platform A2 follows the rival’s pricing movement to increase consumer subsidy in response to bundling. Price competition is intensified on the consumer side (\(\frac{\partial \bar{\Pi}_1}{\partial \tilde{p}_{A2}^C} \frac{dp_{A2}^C}{d\delta} < 0\)).
The strategic effect on the developer side is:

$$\frac{\partial \tilde{\Pi}_1}{\partial \tilde{p}^D_{A_2}} \frac{d\tilde{p}^D_{A_2}}{d\delta} = -(\tilde{P}_1 + \beta \tilde{p}^D_{A_1}) \frac{\partial \tilde{n}_1}{\partial \tilde{p}^D_{A_2}} \frac{\beta - \alpha}{2\Phi} < 0.$$  

Under bundling, platform $A_2$ lowers its developer price because it becomes less valuable to developers; price competition is intensified on the developer side. In Fig. 1, dotted lines depict the speed of $\Pi_1$ increasing in $\delta$ under separate selling, which is 1; the solid curves depict the speed of $\Pi_1$ increasing in $\delta$ under bundling. When $t < t < \frac{\beta^2}{4} + \frac{3\alpha\beta}{4}$ (Fig. 1a), $\Pi_1$ increases at a speed that is faster than $\tilde{n}_1$: Either the speed is faster than 1, or the speed is slower than 1 but faster than $\tilde{n}_1$. In other words, either bundling is profitable for any value of $\delta$, or it is profitable only when $\delta$ is of significant value. When $t > \frac{\beta^2}{4} + \frac{3\alpha\beta}{4}$ (Fig. 1b), $\Pi_1$ increases in $\delta$ at a speed that is strictly slower than $\tilde{n}_1$. As a result, bundling cannot be profitable for firm 1.

As the value of $\delta$ increases (i.e., $\delta \geq \delta^* = \frac{\Phi}{2}$), platform $A_2$’s market share decreases down to zero and eventually lead to its foreclosure in the market. Sufficient vertical differentiation in market $B$ allows firm 1 to commit to a large discount on the $(A_1, B_1)$ bundle so that even the consumer who has the most intense preference for the rival platform would consume the bundle.
4.2. Bundling strategy

Let \( t_1 = \frac{5\alpha^2}{24} + \frac{7\alpha\beta}{12} + \frac{5\beta^2}{24}, \) \( t_2 = \frac{3\alpha^2}{16} + \frac{5\alpha\beta}{8} + \frac{3\beta^2}{16} \) and \( \delta_1 = \frac{\Phi(16t-3\alpha^2-10\alpha\beta-3\beta^2)}{8t-\alpha^2-6\alpha\beta-\beta^2} \).

The following proposition characterizes firm 1’s bundling strategy in stage 1, given that firm 2 sells the two products separately.

**Proposition 1.** Consider the baseline model in which consumers are homogeneous with respect to valuation of products \( B_i \). Given that firm 2 does not introduce bundling, firm 1’s bundling strategy is characterized as follows:

When \( \delta < \delta^* = \frac{\Phi}{2} \), firm 1’s bundling practice is detrimental to firm 2, but it does not lead to foreclosure of firm 2. (i) For \( \frac{t}{2} < t \leq t_2 \), bundling is profitable for firm 1 regardless of the value of \( \delta \). (ii) For \( t_2 < t < t_1 \), bundling is profitable for firm 1 when \( \delta \geq \delta_1 \). (iii) Bundling reduces firm 1’s profit otherwise.

When \( \delta \geq \delta^* \), firm 1’s bundling practice leads to foreclosure of firm 2, and it is profitable for \( \frac{t}{2} < t \leq t_1 \).

The set of parameters upon which bundling emerges as a profitable strategy in equilibrium is depicted by the gray area in Fig. 2. Proposition 1 states that, without leading to foreclosure of firm 2, profitable bundling is possible for firm 1 in cases where platforms implement cross subsidies from the high-externality side (developers) to the low-externality side (consumers). To generate sufficient additional profit on the developer side, bundling should be able to steal sufficient consumer demand from the rival platform and expand developer demand sufficiently. Either consumer preferences for platforms are weak, so that bundling stimulates sufficient consumer demand even with a small discount on the bundle price, or the level of vertical differentiation in market \( B \) is high, so that firm 1 commits to a large discount on \( \tilde{P}_1 \) when the preferences get more intense. Therefore, when consumer preferences for platforms are very weak (\( t < t \leq t_2 \)), bundling is profitable for firm 1 regardless of the value of \( \delta \). When consumer preferences for platforms get more intense (\( t_2 < t < t_1 \)), firm 1 has to offer a larger discount on \( \tilde{P}_1 \) in order to stimulate sufficient consumer demand. In other words, the level of vertical differentiation needs to be high.

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Note that \( t_2 < t_1 \) holds.
enough ($\delta \geq \delta_1$). When consumer preferences for platforms get very intense ($t \geq t_1$), it is impossible for firm 1 to stimulate sufficient consumer demand for bundling to be profitable. Bundling is detrimental to firm 2, as it lowers participation on both sides of platform $A2$ and reduces price on the developer side. When bundling leads to foreclose of firm 2, bundling can only be profitable when the platforms are not very differentiated, so that firm 1 does not need to compensate consumers too much for their distaste for platform $A1$.

Fig. 2: Firm 1’s bundling strategy

Note that if firm 1 practices tying, it also sells $B1$ on a stand-alone basis, consumers can choose a system that close to their ideal. Thus, tying makes no difference from untying. This result contradicts Amelio and Jullien (2012) due to the absence of non-negative price constraint.

4.3. Welfare analysis

Let us now consider how firm 1’s bundling practice affects welfare. Bundling affects consumer welfare through the bundle price, application variety and the distance between a consumer’s ideal component in each market and the one he or she chooses.
Proposition 2. Consider the baseline model in which consumers are homogeneous with respect to valuation of product $B_i$. Firm 1’s unilateral bundling improves consumer welfare.

The consumers who purchase the $(A_1, B_1)$ bundle are affected positively due to a lower bundle price and more application variety. However, for those who no longer consume their preferred platform, there is a loss for such mismatch. Bundling is welfare-reducing for the consumers who assemble the alternative system: they receive less subsidy for adopting platform $A_2$, have access to less applications. The positive effects dominate. Indeed, the more vertical differentiation in market $B$, the larger the increment on consumer surplus due to bundling. When bundling leads to foreclosure of firm 2, all consumers enjoy a lower bundle price and more application variety although the aggregate transportation cost is even higher.

Now we turn to how bundling affects social welfare. Let $\delta_2 = \frac{2\alpha^2}{20t-10\alpha\beta-\beta^2-\alpha^2}$ and $t_3 = \frac{3(\alpha+\beta)^2}{4}$. The following proposition characterizes the impact of firm 1’s unilateral bundling on social welfare.

Proposition 3. Consider the baseline model in which consumers are homogeneous with respect to valuation of product $B_i$. Firm 1’s unilateral bundling is socially beneficial if $\frac{t}{t_3} < t \leq t_3$ and $\delta \geq \delta_2$. When bundling leads to foreclosure of firm 2 (i.e., $\delta \geq \delta^* = \frac{\Phi}{2}$), bundling is socially beneficial if $\frac{t}{t_3} < t \leq t_3$. Bundling reduces social welfare otherwise.

There are two channels through which firm 1’s unilateral bundling positively affects social welfare. First, it enhances participation on both sides of platform $A_1$, thus higher utility from indirect network effects. Second, it reduces the mass of developers who multihome, and hence the cost of multihoming. However, bundling also leads to three sources of inefficiency. First, two-sided users of platform $A_2$ suffer utility loss because of lower participation on the two sides. Second, some consumers end up buying the platform that is further from their ideal. Thirdly, the consumers who do not adopt the $(A_1, B_1)$ bundle have to use the inferior $B_2$. Proposition 3 states that, for bundling to
be socially beneficial, there has to sufficient vertical differentiation in market $B$ and the platforms cannot be too differentiated. A high level of vertical differentiation in market $B$ allows firm 1 stimulate sufficient consumer demand. Consequently, it leads to a significant welfare gain from the indirect network effects and a significant reduction in the cost of multihoming on the developer side. A high consumer demand for the $(A1, B1)$ bundle also indicates a small welfare loss due to a low consumer demand for the inferior product $B2$.

Note that when bundling leads to foreclosure of firm 2, the indirect network effects can be fully internalized as all users in market $A$ interact on platform $A1$ and the cost of multihoming on the developer side does not occur. However, half of the consumers are using a platform that is further from their ideal.

Bundling usually considered anti-competitive, consequently welfare-harming to consumers. We have emphasized the potential benefits of bundling when there are indirect network effects at play. However, it is important to note that the benefits of bundling largely stem from the utility gain from indirect network effects as bundling raises participation on both sides of platform $A1$. The positive feed-back loop between the two sides can amplify the effectiveness of bundling in stimulating demands, and makes the rival platform even more vulnerable. Consequently, bundling can limit consumers’ choices. Thus, it is important for the society to find the right balance between coordinating two-sided demands efficiently and increasing choice for consumers.

4.4. Retaliatory bundling

Now we consider the subgame of unilateral bundling by firm 2. Assume that in stage 1, firm 2 decides to bundle while firm 1 decides to sell the products separately. Let $\tilde{P}_2$ and $\tilde{n}_2$ denote the price and demand of the $(A2, B2)$ bundle respectively. A consumer located at $x$ is indifferent towards assembling a system that consists of firm 1’s two products and the $(A2, B2)$ bundle if

$$v + \alpha \tilde{n}_A^D - \tilde{p}_A^C - tx + z - \tilde{p}_{B1} = v + \alpha \tilde{n}_A^D - \tilde{P}_2 - t(1-x) + z - \delta,$$
which is equivalent to the Eq. 1. Consumers’ utility from market $B$ has no effect on the demand of platforms even if firm 2 introduces the bundle. Thus, given that firm 1 decides not to bundle in stage 1, firm 2 cannot commit to a more aggressive pricing strategy by bundling the platform with an inferior complementary product.

Then we consider the subgame of bilateral bundling. Suppose that both firms decide to sell bundles in stage 1. A consumer located at $x$ is indifferent towards the two bundles if

$$v + \alpha \tilde{n}_{A1}^D - \tilde{P}_1 - tx + z = v + \alpha \tilde{n}_{A2}^D - \tilde{P}_2 - t(1 - x) + z - \delta,$$

which is equivalent to the Eq. 2. Thus, we confirm that firm 2 cannot commit to a more aggressive pricing strategy through bundling, and firm 1’s bundling strategy holds regardless of firm 2’s bundling decision in stage 1.

**Proposition 4.** When $t < t_2$ or when $t_2 < t < t_1$ and $\delta \geq \delta_1$, (bundling, no bundling) is the Nash equilibrium. Otherwise, (no bundling, no bundling) is the Nash equilibrium.

When two-product firms compete in a platform market and a complementary good market, bundling gives the firm that owns the superior complementary goods a competitive advantage when facing a horizontally differentiated rival in the platform market. It explains why a firm (e.g. Samsung) that owns an inferior complementary good may not want to build an exclusive system by bundling the platform with the inferior product. Our results provide a theory to make sense of the observations from the mobile application store market.

5. **Robustness check**

In this section, we check the robustness of our insights obtained from the baseline model.
5.1. Extension to independent goods

Now we modify our model to study the bundling decision of a two-sided platform and an independent good. We show that firm 1’s bundling strategy can also be applied when the two components of the bundle are independent products.

Assume that the two markets are independent for consumers in the sense that the utility that each consumer derives from participating in one market is independent of whether he or she participates in the other market. Assume that market A remains the same as described before in the baseline model. Firm 1 is a monopoly in market B. Consumers are homogeneous with respect to the willingness to pay for product B, which is $u_B = z$. Under separate selling, the equilibrium of market A is the same as that of the baseline model. In market B, all consumers purchase product B at price $p_B = z$. If firm 1 decides to bundle, a consumer buys either the $(A_1, B)$ bundle or platform $A_2$.

Let $\bar{P}_1$ denote the price for the $(A_1, B)$ bundle, the implicit price of access to platform $A_1$ is $\bar{p}^C_{A1} = \bar{P}_1 - z$. A consumer located at $x$ is indifferent towards the $(A_1, B)$ bundle and platform $A_2$ if

$$v + \alpha n^D_{A1} - \bar{P}_1 - tx + z = v + \alpha n^D_{A2} - \bar{p}^C_{A2} - t(1 - x).$$

which is very similar to the Eq. 2. Thus, we confirm that firm 1 can commit to a more aggressive pricing strategy by bundling a platform with an independent good as it faces competition in the platform market. The effectiveness of the bundling practice depends on consumers’ willingness to pay for the independent good.

5.2. Economies of scope

The analysis in this paper is carried out under the assumption that there are no economies of scope in multihoming for developers. This assumption works

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$^{12}$Our insights does not change if we assume that firm 1 has a superior product and firm 2 has a inferior product in market B. Both product compete in price and consumers are homogeneous with respect to the valuation of product $Bi$. 
in favor of profitable pure bundling. Some may argue that the cost of adapting an existing application to a different platform is smaller than that of developing a new application from scratch. To see how changing this assumption affects the firm’s bundling strategy, first consider the case where the listing cost is incurred only once if a developer joins two active platforms. Developers effectively choose between multihoming and not participating. Therefore, they care only about the sum of consumer demand and not its distribution between the two platforms. Consumers face the same set of applications on both platforms. The market expansion effect induced by a consumer price cut on one platform is fully captured by both platforms. The firm needs to commit to a substantially larger discount on the implicit platform price to increase consumer demand so that bundling can be profitable, because the bundling platform cannot offer more application variety. We then consider the case where a proportion of the listing cost is incurred again if a developer joins a second platform. If the firm commits to a lower implicit platform price, some of the benefits of market expansion on the developer side are obtained by the rival platform. Consequently, the firm has less incentive to cut platform price through bundling.

6. Conclusion

Inspired by the casual observations from the mobile application store market, this paper examines the bundling strategy of two-product firms that bundles a complementary good with a platform as they compete in both markets. We model horizontal differentiation in the platform market and vertical differentiation in the complementary good market. Bundling works as a commitment device: It allows the firm that owns the superior complementary good to commit to a lower bundle price to consumers. Bundling stimulates consumer demand and consequently expands demand on the developer side in the platform market.

Our paper carries an important message for policymakers. Bundling is usually considered to be anti-competitive, consequently detrimental to consumer
welfare. We demonstrate that when one of the markets involved is two-sided, bundling can improve consumer welfare largely because of better internalization of the indirect network effects. However, the positive feed-back loop between the two sides amplifies the effectiveness of bundling in stimulating demands, and makes the rival platform even more vulnerable. Consequently, bundling can limit consumers’ choices. Thus, we suggest that competition authorities should scrutinize in detail of bundling practice by involving two-sided markets, and find the right balance between coordinating two-sided demands efficiently and increasing choice for consumers.

In our model, we assumed that the level of vertical differentiation is exogenously determined, and we find that it plays a crucial role in firms’ bundling decisions. However, firm can determine the quality of their products in real world. Interesting future work might endogenize the level of vertical differentiation and analyze a model in which firms should determine the quality of the complementary goods and their bundling strategy.

Appendix A  Proofs of propositions in text

Proof of Proposition 1

Let \( t_1 = \frac{5\alpha^2}{24} + \frac{7\alpha \beta}{12} + \frac{5\beta^2}{24} \), \( t_2 = \frac{3\alpha^2}{16} + \frac{5\alpha \beta}{8} + \frac{3\beta^2}{16} \) and \( \delta_1 = \frac{\Phi(16t-3\alpha^2-10\alpha \beta-3\beta^2)}{8t-\alpha^2-6\alpha \beta-\beta^2} \).

First consider when the interior equilibrium prevails under bundling (i.e., \( \delta < \delta^* = \frac{\Phi}{2} \)). Bundling leads to a change in firm 1’s profit:

\[
\Delta \Pi_1 = -\frac{\delta}{4} \left[ \frac{16t-3\alpha^2-10\alpha \beta-3\beta^2}{\Phi} - \frac{(8t-\alpha^2-6\alpha \beta-\beta^2)\delta}{\Phi^2} \right].
\]

For bundling to be profitable for firm 1, we must have:

\[
\delta \geq \frac{(16t-3\alpha^2-10\alpha \beta-3\beta^2)\Phi}{8t-\alpha^2-6\alpha \beta-\beta^2} = \delta_1.
\]

Notice that when \( t < t \leq t_2 \), \( \delta_1 \leq 0 \), so \( \delta > \delta_1 \) must satisfy; when \( t > t_2 \), \( \delta \geq \delta_1 > 0 \). Additionally, when the interior equilibrium prevails under
bundling, $\delta < \frac{\Phi}{2}$ needs to be satisfied, which gives

$$\frac{(16t - 3\alpha^2 - 10\alpha\beta - 3\beta^2)\Phi}{8t - \alpha^2 - 6\alpha\beta - \beta^2} < \frac{\Phi}{2}. $$

When $t < t < t_1$, the condition $\frac{(16t - 3\alpha^2 - 10\alpha\beta - 3\beta^2)\Phi}{8t - \alpha^2 - 6\alpha\beta - \beta^2} < \frac{\Phi}{2}$ holds. Hence, firm 1’s bundling strategy in the interior equilibrium can be characterized as follows: when $t < t_2 < t < t_1$, bundling is profitable for firm 1 if $\delta \geq \delta_1$.

Bundling leads to a change in platform $B$’s profit:

$$\Delta \Pi_2 = \frac{8t - \alpha^2 - 6\alpha\beta - \beta^2}{16} \left[ \frac{(\Phi - 2\delta)^2}{\Phi^2} - 1 \right].$$

Note that $\text{sign}(\Delta \Pi_2) = \text{sign} \left[ \frac{(\Phi - 2\delta)^2}{\Phi^2} - 1 \right] = \text{sign}(\delta - \Phi)$. Hence, $\Delta \Pi_2 < 0$ when the interior equilibrium prevails under bundling.

Then consider the corner solution in which bundling leads to the foreclosure of firm 2 (i.e., $\delta \geq \delta^* = \frac{\Phi}{2}$).

Bundling leads to a change in firm 1’s profit:

$$\Delta \Pi_1 = -\frac{3t}{2} + \frac{5\alpha^2}{16} + \frac{7\alpha\beta}{8} + \frac{5\beta^2}{16}.$$

For bundling to be profitable for firm 1, we must have:

$$t \leq \frac{5\alpha^2}{24} + \frac{7\alpha\beta}{12} + \frac{5\beta^2}{24} = t_1,$$

so that: When $t < t \leq t_1$, $\Delta \Pi_1 \geq 0$; when $t > t_1$, $\Delta \Pi_1 < 0$. 
Proof of Proposition 2

Let $W_C$ denote the consumer surplus. Under separate selling:

$$W_C = \int_0^{n_{A1}^*} (v + \alpha n_{A1}^* - tx - p_{A1}^*) dx + \int_{1-n_{A2}^*}^1 [v + \alpha n_{A2}^* - t(1-x) - p_{A2}^*] dx + (z - \delta)$$

$$= v - \frac{5t}{4} + \alpha^2 + \frac{\beta^2}{4} + \alpha \beta + z - \delta.$$

We consider that $\delta < \delta^*$ so that firm 1 cannot foreclose the platform market.

In the equilibrium, bundling leads to a change in consumer welfare $\Delta W_C = \frac{\delta}{2} + \frac{\delta^2}{4t} > 0.$

Proof of Proposition 3

Let $W_T$ denote the total surplus. Under separate selling:

$$W_T = \int_0^{n_{A1}^*} (v + \alpha n_{A1}^* - tx - p_{A1}^*) dx + \int_{1-n_{A2}^*}^1 [v + \alpha n_{A2}^* - t(1-x) - p_{A2}^*] dx + z - \delta$$

$$+ \int_0^{n_{A1}^*} (\beta n_{A1}^* - p_{A1}^* - y) dy + \int_{n_{A2}^*}^{n_{A2}^*} (\beta n_{A2}^* - p_{A2}^* - y) dy + \Pi_1^* + \Pi_2^*$$

$$= v - \frac{t}{4} + \frac{3(\alpha + \beta)^2}{16} + z.$$

First we consider whether bundling is socially beneficial when the interior equilibrium prevails. Let $\delta_2 = \frac{2\Phi^2}{20t-10\alpha\beta - \beta^2 - \alpha^2}$ and $t_3 = \frac{3(\alpha + \beta)^2}{4}.$

$$\Delta W_T = -\frac{\delta [2\Phi^2 - \delta (20t - 10\alpha \beta - \beta^2 - \alpha^2)]}{4\Phi^2}.$$  

For bundling to be socially beneficial, we must have $2\Phi^2 - \delta (20t - 10\alpha \beta - \beta^2 - \alpha^2) \leq 0.$ Note that $20t - 10\alpha \beta - \beta^2 - \alpha^2 > 0$ for all $t > t_2,$ and $\Delta W_T \geq 0$ when $\delta \geq \frac{2\Phi^2}{20t-10\alpha\beta - \beta^2 - \alpha^2} = \delta_2.$ Additionally, when the interior equilibrium prevails under bundling, $\delta < \frac{\Phi^2}{2}$ needs to be satisfied. Hence, bundling is socially beneficial when $t < t_3$ and $\delta \geq \delta_2.$

Then we consider whether bundling is socially beneficial when the tipping
equilibrium prevails. The total surplus under bundling in the tipping equilibrium is:

\[
\tilde{W}_T = \int_0^{\tilde{n}_1^*} (v + \alpha \tilde{n}_1^{D_1^*} - tx - \tilde{P}_1^* + z)dx + \int_0^{\tilde{n}_2^{D_2^*}} (\beta \tilde{n}_1^* - \tilde{P}_1^{D_1} - y)dy + \tilde{\Pi}_1^* \\
= v - \frac{t}{2} + \frac{3\alpha^2}{8} + \frac{3\alpha\beta}{4} + \frac{3\beta^2}{8} + z.
\]

Bundling leads to a change in social welfare: \(\Delta W_T = -\frac{t}{4} + \frac{3\alpha^2}{16} + \frac{3\alpha\beta}{8} + \frac{3\beta^2}{16}\).
Therefore, when \(t < \frac{3\alpha^2}{4} + \frac{3\alpha\beta}{2} + \frac{3\beta^2}{4}\), bundling is socially desirable; when \(t > \frac{3\alpha^2}{4} + \frac{3\alpha\beta}{2} + \frac{3\beta^2}{4}\), it is not socially desirable.

References


