TYING IN TWO-SIDED MARKETS WITH MULTI-HOMING*

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This paper analyzes the effects of tying on market competition and social welfare in two-sided markets when economic agents can engage in multi-homing by participating in multiple platforms to reap maximal network benefits. The model shows that tying induces more consumers to multi-home and makes platform-specific exclusive content available to more consumers, which is beneficial to content providers. As a result, tying can be welfare-enhancing if multi-homing is allowed, even in cases where its welfare impacts are negative in the absence of multi-homing. The analysis thus can have important implications for recent antitrust cases in industries where multi-homing is prevalent.

I. INTRODUCTION

This paper analyzes the effects of tying arrangements on market competition and social welfare in two-sided markets when consumers can engage in multi-homing; that is, consumers can participate in multiple platforms (or purchase multiple products) in order to reap maximal network benefits. The paper is partly motivated by the recent antitrust cases concerning Microsoft. In the European case, for instance, it has been alleged that the company’s tying practice of requiring Windows operating system users to accept its Windows Media Player software is anticompetitive and hurts digital media rivals such as RealNetworks. However, multi-homing is common in digital media systems. Many users have more than one media player and many content providers offer content in more than one format, which counteracts the tendency towards tipping and the lock-in effects in industries with network effects.

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1 On March 24, 2004, the European Union ruled that Microsoft was guilty of abusing the ‘near-monopoly’ of its Windows PC operating system and fined it a record 497 million euros ($613 million). The ruling was appealed, but upheld by the Court of First Instance on September 17, 2007.
To analyze the effects of tying in markets such as digital media, I adopt the framework of platform competition in two-sided markets. The defining characteristics of two-sided markets are indirect network effects or inter-group network externalities that arise through improved opportunities to trade with the other side of the market. In the digital media case, content providers and final consumers constitute the two sides that trade with each other. For instance, as more content is available in streaming media, the more valuable media player programs become, and vice versa. Other prominent examples of economic importance include auction sites such as eBay and Yahoo, where buyers and sellers interact to consummate a deal, credit card payment systems such as Visa and MasterCard where both merchants and consumers need to participate in the same system, video game platforms such as PlayStation, Xbox and GameCube where game developers and consumers constitute the two distinct sides, etc.2

I show that tying induces more consumers to multi-home and makes platform-specific exclusive content available to more consumers, which is also beneficial to content providers. As a result, tying can be welfare-enhancing if multi-homing is allowed, even in cases where its welfare impacts are negative in the absence of multi-homing. The analysis thus can have important implications for recent antitrust cases and provides a caution in applying the traditional theory of network effects and tipping to markets where multi-homing is prevalent.

The analysis in this paper builds on the burgeoning literature on competition in two-sided markets. More specifically, in two-sided markets the need for all sides of the market to get on board creates a so-called ‘chicken and egg’ problem (Caillaud and Jullien [2003]) in that members of each group are willing to participate in the market only if they expect many members from the other side to participate. The literature on two-sided markets is mainly concerned with the optimal pricing structure to coordinate the demands of distinct groups of customers.3

Amelio and Jullien [2007] are a notable exception in the analysis of tying in two-sided markets and are closest to my paper.4 They consider a situation in  

3 See Armstrong [2006] and Rochet and Tirole [2006]. More recently, the importance of studying antitrust issues in two-sided markets has been recognized by several authors. Evans [2003] and Wright [2003], for instance, provide a general discussion on antitrust policy in two-sided markets and call for caution in applying the traditional one-sided logic to two-sided markets in the antitrust arena. However, their discussion is mainly informal and does not deal with tying arrangements.  
4 Rochet and Tirole [2008] is another paper on tying in two-sided markets. It provides an economic analysis of the tying practice initiated by payments card associations Visa and MasterCard in which merchants who accepted their credit cards were forced also to accept their debit cards. Their model, however, is tailored to analyze the payment card industry and the recent antitrust suit involving Visa and MasterCard. In particular, the analysis focuses on tying by a non-profit association to reflect the status of credit card associations.
which platforms would like to set prices below zero on one side of the market to solve the demand coordination problem in two-sided markets, but are constrained to set non-negative prices. In the analysis of Amelio and Jullien, tying can serve as a mechanism to introduce implicit subsidies on one side of the market in order to solve the aforementioned coordination failure in two-sided markets. As a result, tying can raise participation on both sides and can benefit consumers in the case of monopoly platform. In a duopoly context, however, tying also has a strategic effect on competition. They show that the effects of tying on consumer surplus and social welfare depend on the extent of asymmetry in externalities between the two sides. Their paper and mine focus on different aspects of tying and can be viewed as complementary. For instance, they compare the effects of tying across different market structures (monopolistic vs. duopolistic), but they assume single-homing and do not analyze implications of multi-homing in two-sided markets.

This paper is also closely related to the literature on the ‘leverage theory’ of tying. According to the ‘leverage theory’ of tying, a two-product firm with monopoly power in one market can monopolize a second market using the leverage provided by its monopoly power in the first market. Carlton & Waldman [2002] are especially worth mentioning in relation to this paper. They investigate how the tying of complementary products can be used to preserve and create monopoly positions. Their analysis focuses on two mechanisms through which tying can be used in an anticompetitive way: entry costs and network externalities. In particular, their model with network externalities shows that the presence of network externalities for the complementary good can result in the strategic use of tying to deter entry into the primary market. The nature of network effects in their paper, however, is direct and thus does not explicitly account for the peculiarities of two-sided markets. In addition, none of these papers in the tying literature seriously take into consideration the possibility of multi-homing. Carlton and Waldman [2002], for instance, assume that, ‘if a consumer purchases a tied good consisting of one unit of the monopolist’s primary good and one unit of its complementary good, then the consumer cannot add a unit of the alternative producer’s complementary good to the system (italics added, p. 199).’ In other words, either they do not allow the possibility of multi-homing or multi-homing does not arise in equilibrium. Currently, formal economic analysis of tying that explicitly accounts for the possibility of

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5 See Whinston [1990] for a classical analysis of strategic tying. In Whinston’s model, inducing the exit of the rival firm is essential for the profitability of tying arrangements. Choi [1996, 2004] extended the analysis by investigating implications of tying for innovation incentives. He demonstrates that even in the absence of exit by the rival firm, bundling can be a profitable strategy via its long-term effects on competition through innovation.


7 For an explicit analysis of multi-homing in platform competition, see Carrillo and Tan [2006].
multi-homing is virtually non-existent. The analysis in the paper intends to fill this gap in the literature and can have important implications for recent antitrust cases in industries where multi-homing is prevalent.

The rest of this paper is organized as follows. In section II, I set up a model of two-sided markets with multi-homing on both sides of the market and derive the market equilibrium. In section III, I analyze the effects of tying arrangements on competition in two-sided markets with multi-homing and investigate its welfare implications. Concluding remarks follow.

II. THE MODEL OF TWO-SIDED MARKETS WITH MULTI-HOMING

In this section, I lay out a very simple model of two-sided markets and derive the market outcome in the absence of tying. The model is a variation of the framework developed by Armstrong [2006] and Rochet and Tirole [2003], but with an important departure. I modify the model to account for the possibility of multi-homing on both sides of the market. The analysis in this section will be used as a benchmark to investigate the effects of tying in two-sided platform markets in section III.

The model comprises three classes of agents. There are two distinct types of customer groups that interact with each other and intermediaries who provide platforms to enable these two customer groups to ‘meet’ each other. In the example of streaming multi-media players, the two customer groups can be described as content providers and consumers who download/stream multi-media content through the Internet. There are currently three major platform providers: RealNetworks, Microsoft and Apple. In my model, these software/platform providers can be considered the intermediaries who compete in two-sided platform businesses.

Let me assume that there are two intermediaries indexed by $i = A, B$. For concreteness, let me label the two customer groups as content providers and consumers (as in the streaming media industry). The two intermediaries compete for market share within each group. Let $p_i$ and $q_i$ denote intermediary $i$’s charge to content providers and consumers, respectively, where $i = A, B$. The intermediaries’ costs of serving each content provider and final consumer are given by $c$ and $d$, respectively. Finally, the number of content providers and consumers who participate in platform $i$ are denoted by $m_i$ and $n_i$, respectively.

Armstrong [2006] considers a similar model. He assumes that the consumer side of the market is characterized by exclusive intermediation, that is, final consumers participate in only one platform. More specifically, in his competitive bottleneck model that is applied to describe supermarket competition, consumers visit only one supermarket (‘single home’) while suppliers typically stock their products on the shelves of several supermarkets (‘multi-home’).
However, the assumption of exclusive intermediation on the consumer side can be at odds with the prevailing condition in many two-sided markets, such as the digital media and the payment card industries. In the digital media case, many users have more than one media player and many content providers offer content in more than one format. The payment card industry portrays a similar picture, with consumers carrying more than one payment card and merchants accepting multiple payment cards. I thus construct a model to explicitly analyze the possibility of multi-homing on both sides of the market.

II(i). Consumers

To reflect the market reality of the digital media market, I mainly focus on an equilibrium in which both content providers and consumers multi-home. To analyze the consumers’ choice of platform, I adopt the Hotelling model of product differentiation. I assume that two platforms, $A$ and $B$, are located at the end points of a line with length equal to 1. Consumers, whose size is normalized to 1, are uniformly distributed along the line. Each consumer’s utility of participating in a platform depends on the number of content providers on the same platform. More specifically, the availability of each additional content provider generates additional utility of $b$.

In contrast to the competitive bottleneck model of Armstrong [2006], consumers are allowed to multi-home. As a result, there are three choices for consumers, assuming that the market is covered. Consumers can choose to either single-home or multi-home. If they decide to single-home, they choose one of the two platforms to participate in (See Figure 1). If a consumer located at point $x$ participates in platform $A$ only, his utility is given by $u_A(q_A, x) = bm_A - q_A - tx$ while his utility from participating in platform $B$...
only is given by \( u_B(q_B, x) = bm_B - q_B - t(l - x) \), where \( t \) is a ‘transportation’ cost parameter. If the consumer decides to multi-home, his utility is given by 
\[
u_{AB}(q_A, q_B, x) = bm - q_A - tx - q_B - t(l - x),
\]
where \( m \) is the total amount of content available to consumers who multi-home. The relationship between \( m \) and \( m_i \) \((i = A, B)\) depends on the extent of duplicative content across the platforms. If there is no duplication across the platforms and all content is platform-specific, we have \( m = m_A + m_B \). If the extent of duplication is \( \delta (\leq \min[m_A, m_B]) \), we have \( m = m_A + m_B - \delta \).

II (ii). Content Providers

I assume that there is the same number of potential content providers, whose mass is normalized to 1, for each platform. Thus, the total measure of content potentially available for each format is also normalized to 1.\(^8\) As in the consumer side, each content provider gains additional utility (profit) of \( \pi \) from each consumer who has access to its content. The profit for content providers who create content on platform \( i \) is given by \( \pi n_i - p_i \) when the number of final consumers who participate in platform \( i \) is \( n_i \). A content provider is willing to create content for platform \( i \) if \( \pi n_i - p_i \geq 0 \).\(^9\)

If consumers were not allowed to multi-home, their sole concern would be the amount of content available for each platform. However, once multi-homing is allowed on the consumer side, we have to pay attention to the nature of content available as well as the amount of content. To see this, consider a symmetric equilibrium with the single-homing assumption where the same amount of content is available for each platform. Does this equilibrium persist if we allow multi-homing by consumers? The answer depends on the extent of content duplication across the platforms. Consumers do not have any incentive to multi-home, and the equilibrium with the single-homing assumption continues to be an equilibrium even if multi-homing is allowed on the consumer side, as long as the same content – not just the same amount – is provided across the platforms. However, if the content is different across the platforms, the previous equilibrium may not survive with the possibility of multi-homing on the consumer side.

In order to make the possibility of multi-homing on the consumer side play a role, I assume that there are two types of content available. One type

\(^8\) I assume away The fixed cost of creating content in this model since the amount of available content is fixed and the extent of entry by content providers is not an issue.

\(^9\) In the previous version of the paper, I also considered a model in which content providers were heterogeneous in their fixed costs of creating content, but with the assumption of single-homing on the consumer side. Introducing heterogeneity of content providers in this dimension in conjunction with multi-homing on both sides complicates the analysis significantly. For instance, the result we derive later that each platform’s optimal price for each side is independent of the other in an equilibrium where both sides multi-home may not hold. The result may also depend on the extent of economies of scale in the cost of porting the content for one platform to another.
of content is more suitable for one of the two platforms (formats) whereas the other type of content is suitable for both formats. To simplify the analysis, let me assume that when content is of the first type, that is, more suitable for one of the two formats, it is not economically feasible to encode in the other format. We have made the assumption that the total measure of content potentially available for each format is normalized to 1. Among them, the proportion of \( \lambda \) is of the first type and thus can be encoded only for a particular format whereas \( (1 - \lambda) \) can also be encoded in the other format. The existence of exclusive content available for each format creates incentives for consumers to multi-home. When the second type of content is encoded for both formats, content providers are said to multi-home.

One shortcoming of the model is that the amount of exclusive content is exogenously given. This assumption may be justified under some circumstances. For instance, we can imagine a scenario in which the two platforms are technically differentiated and some content is more appropriate for one particular type of technology. In the supermarket competition model of Armstrong [2006], we can envision a situation in which the two supermarkets are geographically separated. They carry both national brands and local products. If the local products unique to each region are difficult to transport to the supermarket located in the other region, they will play the role of exclusive content. More importantly, however, exclusive content can be endogenously created through the use of exclusive contracts. It is important to extend my model to allow for exclusive content that arises from exclusive contracts, but that is beyond the scope of the current paper.\(^{10}\)

\[\text{II(iii). Market Equilibrium in the Two-Sided Market with Multi-Homing}\]

I am interested in an equilibrium in which both content providers and consumers multi-home. Imagine a situation in which each platform has exclusive content of measure \( \lambda \) and nonexclusive content of \( (1 - \lambda) \) available. In other words, the nonexclusive content is available for both formats with the extent of content duplication \( \delta = 1 - \lambda \). Consider a consumer located closer to platform A who would thus choose to participate in platform A in a symmetric equilibrium if he chooses only one platform. Now I analyze the consumer's incentive to multi-home, that is, to participate in platform B in addition to A.

If a consumer located at point \( x \) participates in platform A, his utility is given by \( u_A(q_A, x) = bm_A - q_A - tx \). With the assumption that \( m_A = 1 \), I have \( u_A(q_A, x) = b - q_A - tx \). If the consumer multi-homes, his utility is given by \( u_{AB}(q_A, q_B, x) = bm - q_A - tx - q_B - t(1 - x) \), where \( m \) is the total amount of

\[\text{\(^{10}\) See Hagiu and Lee [2008] for an analysis of two-sided markets where exclusivity arises endogenously through contracts. However, they do not allow multi-homing on the consumer side.}\]
content available to consumers who multi-home. Since each platform has duplicative content of \( (1 - \lambda) \), I have \( m = 1 + \lambda \). As a result, the utility from multi-homing is given by \( u_{AB}(q_A, q_B, x) = b(1 + \lambda) - (q_A + q_B) - t \). The location of the consumer who is indifferent between single-homing on A and multi-homing is given by:

\[
x = 1 - \frac{\lambda b - q_B}{t}
\]

Similarly, the location of the consumer who is indifferent toward both single-homing on B and multi-homing is given by:

\[
y = \frac{\lambda b - q_A}{t}
\]

This implies that the number of consumers who single-home on platform \( i \) is as follows (see Figure 2).

\[
n_i = 1 - \frac{\lambda b - q_j}{t}, \text{ where } i = A, B \text{ and } j \neq i.
\]

The number of consumers who multi-home is given by

\[
n_M = y - x = \frac{2\lambda b - (q_A + q_B)}{t} - 1
\]

Let \( N_A \) and \( N_B \) denote the total number of consumers who participate in platform A and B, respectively. Then, we have

\[
N_A = y = n_A + n_M = \frac{\lambda b - q_A}{t},
\]

\[
N_B = 1 - x = n_B + n_M = \frac{\lambda b - q_B}{t}
\]

On the content provider side, the incentives to participate in each platform depend on the configuration of consumers on the other side of the market. Let me assume a situation in which the consumer market is covered and
some consumers multi-home, that is, \( N_A + N_B > 1 \) with \( n_M = N_A + N_B - 1 \) multi-homing consumers. Exclusive content for platform A will be provided if \( \pi N_A - p_A \geq 0 \). For nonexclusive content, the incentives to encode in format A depend on whether the same content is provided for the other format. If it is already provided for format B, the condition for a content provider to multi-home, that is, to encode in duplicative format A, is given by \( \pi n_A - p_A \geq 0 \). With multi-homing on the consumer side, \( N_A > n_A \). This implies that platform A can either charge \( \pi N_A \) and attract only \( \lambda \) exclusive content providers or charge \( \pi n_A \) and attract both exclusive and nonexclusive content providers.

Let me analyze platform A’s profit maximization problem assuming that it serves both exclusive and nonexclusive content providers with nonexclusive content providers multi-homing. Conditions for such behavior to constitute an equilibrium will be derived later. In such a case, we have \( n_A = 1 - \frac{\lambda b - q_B}{t} \). Notice that with consumers multi-homing, the number of consumers single-homing on A (\( n_A \)) depends only on the other platform’s price charged to consumers (\( q_B \)). Thus, the optimal price for platform A on the content provider side depends on \( q_B \) (under the configuration I consider), and it is given by

\[
p^*_A = \pi n_A = \pi \left( 1 - \frac{\lambda b - q_B}{t} \right)
\]

This implies that under the configuration in which both consumers and content providers multi-home, each platform’s optimal price for each side is independent of the other.\(^{11}\)

On the consumer side, platform A solves the following problem:

\[
Max_{q_A}(q_A - d)N_A = (q_A - d)\frac{\lambda b - q_A}{t}
\]

Thus, the optimal price on the consumer side is given by

\[
q^*_i = \frac{\lambda b + d}{2}, \ i = A, B
\]

The optimal price on the consumer side implies that \( N_A = N_B = \frac{\lambda b - d}{2t} \). For this to be consistent with consumer side multi-homing, we need \( N_A + N_B > 1 \), that is, \( \lambda b - d > t \), which I assume to hold:

\[A1. \ \lambda b - d > t\]

This condition means that for multi-homing to occur on the consumer side, the amount of exclusive content and the network benefits for consumers

\(^{11}\) If we assume fixed costs of creating content that differ across providers, this result may not hold. See footnote 9.
should be sufficiently high compared to the cost and ‘transportation’ parameters.

In addition, for the multi-homing postulated above to constitute an equilibrium, neither platform should have an incentive to deviate; that is, attracting both exclusive and nonexclusive content providers yields a higher payoff for platforms than attracting only exclusive content providers.\textsuperscript{12} I also note that in the case of digital media systems, the marginal costs of serving additional customers are small on both sides (i.e., $c \approx 0$, $d \approx 0$). For analytical simplicity and to reflect the reality of the digital media industry, I shall assume that $c = d = 0$ for the rest of the paper. With this additional assumption, the Appendix shows that the no deviation condition can be written as:

\begin{equation*}
A2. \quad \frac{\lambda[\lambda \pi + 2b(1 + \lambda)]}{4} \leq t
\end{equation*}

I assume that both $A1$ and $A2$ hold in the remainder of this paper. $A1$ says that for there to be multi-homing on the consumer side, $\lambda$ cannot be too small, whereas $A2$ says that for there to be multi-homing on the content provider side, $\lambda$ cannot be too large. For intermediate values of $\lambda$, multi-homing takes place on both sides.

\textit{Proposition 1.} If both $A1$ and $A2$ hold, that is, \( \frac{\lambda[\lambda \pi + 2b(1 + \lambda)]}{4} \leq t < \lambda b \), there is an equilibrium with both sides multi-homing.

A simple calculation on the bounds of the transport costs shows that the parameter space in which the multi-homing condition holds is non-empty if \( \frac{2(1-\lambda)}{\lambda} > \frac{p}{b} \). This implies that when the amount of exclusive content is large, sustaining a multi-homing equilibrium requires the ratio of the content provider side benefits of additional consumer ($\pi$) to the consumer side benefits of additional content ($b$) to be small.

\section*{III. AN ANALYSIS OF TYING IN TWO-SIDED MARKETS WITH MULTI-HOMING}

To analyze the effects of tying on competition in two-sided markets, I assume that intermediary $A$ is also a monopolist in a related market called $M$ with a unit production cost of $c_M$. More specifically, to reflect circumstances in the antitrust case against Microsoft concerning the tie-in of Media Player with the Windows operating system, assume that the good/service $M$ in the monopolized market (operating systems) is necessary for consumers to

\textsuperscript{12} I thank an anonymous referee for correcting an error in the previous version concerning this.
participate in the two-sided market (streaming multi-media) analyzed in this paper. All final consumers have valuation of $v (> c_M)$ for product $M$. It is assumed that entry into market $M$ is not feasible.\footnote{Firm A may have a patent or have an installed base that makes entry unprofitable in the presence of switching costs or network externalities (Farrell and Klemperer [2009]).}

I consider the following two-stage game. In the first stage, firm $A$ (the monopolistic supplier of product $M$) decides whether or not to tie the two products. A price game ensues in the second stage with the tying decision in the previous stage taken as given. The timing assumption reflects the fact that the tying decision through product design is a longer term decision that cannot be modified easily compared to the price decision. The outcomes are described below and depend on firm A’s tying decision in the first stage.

III(i). \textit{No Tying}

If the two products are not bundled, let me assume that consumers buy product $M$ prior to participating in the two-sided market since $M$ is essential for the latter activity. Due to the essentialness of product $M$, the monopolist can extract consumer surplus from participating in the two-sided market. The consumers who have the lowest surplus are the ones located in the middle segment of the line and multi-home. Let $u^*_{AB} = b(1 + \lambda) - (q_A^* + q_B^*) - t$ be the equilibrium surplus offered to multi-homing consumers in the two-sided market. With the assumption of $d = 0$, we have $u^*_{AB} = b - t$. The monopolist will then charge the price of $(v + b - t)$ for product $M$. In the two-sided market, the analysis in the previous section applies. This implies that the monopolist’s overall profit in market $M$ and the two-sided market is given by:

$$\Pi^*_M = [(v + b - t) - c_M] + \Pi^*_A$$

$$= [(v + b - t) - c_M] + \pi \left[ \frac{\pi (1 - \lambda b)}{2t} \right] + \frac{(\lambda b)^2}{4t} \tag{1}$$

III(ii). \textit{Tying}

Suppose that the monopolist bundles the two products and charges a price of $q_A$ for the bundled product on the consumer side.\footnote{Variables corresponding to tying are denoted with a tilde.} I assume that $v (> c_M)$ is sufficiently large that firm $A$ will price the bundled good so that every final consumer purchases it (see Figure 3).

Given that every consumer has $A$, I analyze incentives for consumers to multi-home, that is, to participate in platform $B$ in addition to $A$. Given that all consumers already have $A$, nonexclusive content providers have no incentive to encode the content in duplicate for format $B$. I thus consider an equilibrium in which all nonexclusive content is provided only for platform...
A. For multi-homing to take place under tying on the consumer side, it is necessary that exclusive content for platform B be provided. When there exists amount of exclusive content for platform B, the additional benefit of multi-homing for a consumer located at $x$ from platform B is given by $b\lambda - tx$. This implies that the number of multi-homing consumers is given by $\tilde{n}_M = \tilde{N}_B = \frac{\lambda b - \tilde{q}_B}{t}$, where $\tilde{q}_B$ is the price charged to consumers by platform B. The maximum price platform B can charge to content providers when $\tilde{n}_M = \tilde{N}_B$ consumers multi-home is $\tilde{p}_B^* = \pi \tilde{N}_B$. As a result, platform B’s profit maximization is given by:

$$\max_{\tilde{q}_B} \lambda (\pi \tilde{N}_B) + \tilde{q}_B \tilde{N}_B = \lambda \left( \pi \frac{\lambda b - \tilde{q}_B}{t} \right) + \tilde{q}_B \frac{\lambda b - \tilde{q}_B}{t}$$

The first order condition for the above problem yields

$$\tilde{q}_B^* = \frac{\lambda (b - \pi)}{2}$$

The number of consumers who participate in platform B, and thus multi-home, is given by

$$\tilde{N}_B^* = \tilde{n}_M^* = \frac{\lambda (b + \pi)}{2t}$$

Note that the number of consumers who have access to exclusive content for platform B increases. This can be seen from the comparison of $N_B = \frac{\lambda b}{2t}$ to $\tilde{N}_B = \frac{\lambda (b + \pi)}{2t}$. This is due to the fact that platform B charges a lower price on the consumer side to expand the reach of its exclusive content when platform A uses tying.  

15 In addition, non-exclusive content providers need to participate in only one platform with tying, rather than both, since every consumer on the other side participates in platform A. If there is a positive cost of serving content providers, such cost savings associated with
Proposition 2. When \( v \) is sufficiently large, platform A serves the whole consumer side market with tying. There is no need for duplication for non-exclusive content. As a result, platform B serves only exclusive content providers, whereas platform A serves both exclusive and non-exclusive content providers under tying. The number of multi-homing consumers increases with tying.

III(iii). Incentives to Tie

I now analyze the monopolist’s incentives to tie its monopolized product with participation in platform A for consumers. To derive the monopolist’s profit from tying, we need to derive the optimal bundled price \( \tilde{q}_A \) for the monopolist. With the assumption that \( v (>c_M) \) is sufficiently large, firm A will price the bundled good so that every final consumer purchases it. Note that the multi-homing consumers are the ones who have the lowest surplus from participating in the market. The multi-homing consumers’ net utility is given by \( v + b(1 + \lambda) - \tilde{q}_A^* - \frac{\lambda(b - \pi)}{2} - t \). Thus, the optimal bundle price for the monopolist is \( \tilde{q}_A^* = v + b(1 + \lambda) - \frac{\lambda(b - \pi)}{2} - t \). The monopolist can also charge \( \pi \) for each content provider. As a result, the monopolist’s profit from tying is:

\[
(2) \quad \tilde{\Pi}_M^* = v + b(1 + \lambda) - \frac{\lambda(b - \pi)}{2} - \frac{\lambda b \pi}{2} - t - c_M + \pi
\]

A comparison of equations (1) and (2) reveals that tying is profitable for the monopolist under A2.

\[
(3) \quad \tilde{\Pi}_M^* - \Pi_M^* = \frac{\lambda b}{2} + \frac{\lambda \pi}{2} + \frac{\lambda b \pi}{2t} - \frac{(\lambda b)^2}{4t} > 0
\]

It can also be easily verified that platform B’s profits decrease with tying by the monopolist. This is implied by Assumption 2, which guarantees that the platforms prefer to serve both exclusive and non-exclusive content providers.

Proposition 3. Tying is profitable for platform A, but decreases platform B’s profits.

non-duplication of content can be an additional source of welfare gain from tying. In this sense, tying induces more multi-homing on the consumer side but less multi-homing on the content provider side.
III(iv). Welfare Analysis

To explore the welfare implications of tying, I compare welfare under no tying and tying. Without tying, social welfare can be written as:

$$ W = (1 + n_M \lambda) b - \left[ \int_0^{1-N_B} tx dx + \int_0^{1-N_A} tx dx + n_M t \right] $$
$$ + \left[ \lambda (N_A + N_B) + (1 - \lambda) \right] \pi, $$

where $N_A = N_B = \frac{\lambda}{2} b$ and $n_M = \frac{\lambda}{2} b - 1$

By differentiating the welfare function with respect to $\lambda$, it can be easily verified that social welfare is increasing in $\lambda$ for the parameter space where multi-homing equilibrium exists.\(^{16}\)

In contrast, social welfare with tying can be written as:

$$ \tilde{W} = (1 + \tilde{n}_M \lambda) b - \left[ \int_0^{1-\tilde{n}_M} tx dx + \tilde{n}_M t \right] + \left[ \lambda (1 + \tilde{N}_B) + (1 - \lambda) \right] \pi, $$

where $\tilde{n}_M = \tilde{N}_B = \frac{\lambda (\pi + b)}{2t}$

Thus, the social welfare change due to tying can be written as:

$$ \Delta W = \tilde{W} - W = (\tilde{n}_M - n_M) [\lambda (\pi + b)] $$
$$ - \left\{ \left[ \int_0^{1-\tilde{n}_M} tx dx + \tilde{n}_M t \right] $$
$$ - \left[ \int_0^{1-N_B} tx dx + \int_0^{1-N_A} tx dx + n_M t \right] \right\} $$

Notice that $\tilde{n}_M - n_M = \frac{\lambda (\pi - b) + 2t}{2t} > 0$ by assumption A2, which implies that tying induces more consumers to multi-home and makes platform-specific exclusive content available to more consumers, which is also beneficial to content providers. The first term in equation (6) thus represents the net beneficial effects of wider availability of exclusive content due to tying. There are two channels. First, tying induces all consumers to have access to exclusive content for platform A. Second, the number of consumers who have access to exclusive content for platform B also increases, as noted earlier in Proposition 2. However, tying may increase overall ‘transportation costs,’ which is represented by the expressions in the curly brackets.

\(^{16}\) However, note that although welfare increases with $\lambda$, it becomes less likely that a multi-homing equilibrium exists due to the stringent requirement on the ratio of $\pi$ to $b$. 

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Nonetheless, the simple structure of the model yields an unambiguous answer concerning the welfare effects of tying. To see this, I manipulate equation (6) as

\[
\Delta W = \tilde{W} - W = (\tilde{n}_M - n_M)[\lambda (\pi + b) - t]
\]

\[
\text{(7)}
\]

\[
- \left\{ \int_0^{1-\tilde{n}_M} txdx - \left[ \int_0^{1-N_B} txdx + \int_0^{1-N_A} txdx \right] \right\}
\]

The first term in equation (7) is still positive by assumption A1. In addition, the expression in the curly bracket is negative since \(\tilde{n}_M = \frac{\lambda (b + \pi)}{2t} > \frac{\lambda b}{2t} = N_A = N_B\). Therefore, \(\Delta W = \tilde{W} - W > 0\); that is, tying is welfare-enhancing in this simple model.

However, we can also show that consumer welfare decreases with tying in our model. The main intuition is as follows. Multi-homing has an unintended effect of making consumers more homogeneous; as can be seen from \(u_{AB}(q_A, q_B, x) = bm - q_A - q_B - t\), the surplus from multi-homing is independent of the location of the consumer \(x\). This facilitates the monopolist’s extraction of consumer surplus. When the monopolist owns a good that is necessary for consumers to participate in the two-sided market, it is able to extract all consumer surpluses from multi-homing consumers. Since tying induces more consumers to multi-home, the consumer surplus is reduced as a result of tying. To see this more precisely, note that only single-homing consumers receive a positive surplus. As shown in the Appendix, the total consumer surplus without tying is given by

\[
CS = \left[ \int_0^{1-N_B} txdx + \int_0^{1-N_A} txdx \right]
\]

In contrast, with tying, the total consumer surplus is given by

\[
\tilde{CS} = \int_0^{1-\tilde{n}_M} txdx
\]

Since \(\tilde{n}_M = \tilde{N}_B > N_A = N_B\), I have \(CS > \tilde{CS}\).

**Proposition 4.** Tying decreases consumer surplus. However, it increases total social welfare.\(^{17}\)

To explore the role of multi-homing in the model, it is instructive to consider the welfare effects of tying in a situation where tying prevents

\(^{17}\)This implies that competition authorities’ optimal policy concerning tying in the two-sided markets can differ depending on whether they pursue consumer surplus maximization or total welfare maximization.
consumers from multi-homing.\footnote{This would be the case if the monopolist engages in technical tying so that it designs its product in a way such that a competitor’s product cannot interoperate with the tying product. My model suggests that such a practice can be anti-competitive.} Without multi-homing, all consumers will use the tied product only in the two-sided market. This implies that all content is provided for format A, and exclusive content for format B will no longer be available. In the Appendix I show that such tying where multi-homing is not allowed unambiguously reduces welfare. Furthermore, I show that the result on consumer surplus is reversed, and consumer surplus is higher under tying without multi-homing. These results are in sharp contrast to the results obtained with the assumption of multi-homing, and it highlights the importance of explicitly considering the role of multi-homing in the antitrust analysis of network industries.

IV. CONCLUDING REMARKS

I analyze the effects of tying arrangements on competition in markets with indirect network effects by using the framework of two-sided markets. In particular, I develop a model of platform competition that explicitly incorporates the possibility of multi-homing on both sides of the market: both content providers and final consumers are allowed to participate in both platforms.\footnote{In the previous version of this paper, I also considered a model in which only the content side is allowed to multi-home, with the consumer side of the market being characterized by exclusive intermediation. In this case, tying automatically leads to the foreclosure of competing products. Even so, the welfare implications of tying can be subtle and ambiguous. Tying reduces platform variety due to foreclosure. However, this effect is counterbalanced by two positive factors: a reduction in the duplication cost of content providers and an increase in the number of content providers who enter, since they now have access to a larger number of users on the consumer side. See Choi [2007] for more details.}

My analysis is motivated by the prevailing condition in the digital media market in which content providers encode in multiple formats and consumers use multiple media players. Multi-homing has the potential to counteract the tendency toward tipping and the lock-in effects in industries with network effects. As a result, tying does not automatically foreclose competing products especially when the rival platform has exclusive content. In fact, in my simple model, tying allows consumers who would not have bought the tied platform independently to access the exclusive content associated with it. In addition, tying induces more consumers to multi-home and as a result the total number of consumers who use the rival platform also increases. As a result, the total surplus increases with tying when multi-homing is allowed. To explore the role of multi-homing in the model, I also consider the welfare effects of tying in a situation where tying prevents consumers from multi-homing, and show that tying reduces welfare in the absence of multi-homing. Therefore, we need to be cautious...
when applying the traditional theory of network effects and tipping to two-sided markets. In particular, these contradictory results on social welfare highlight the importance of considering multi-homing in antitrust analysis of two-sided models. I conclude by mentioning a couple of avenues along which the current analysis can be extended.

First of all, I have assumed that there is an exogenous amount of exclusive content available for each format.\textsuperscript{20} This can be justified if the two platforms are technically differentiated, and some content is more appropriate for one particular type of technology. However, exclusive content can be endogenously created through the use of exclusive contracts. A recent paper by Doganoglu and Wright [2006] analyzes the ability of an incumbent to use exclusive contracts to deter entry by a more efficient entrant in a market characterized by network effects. They find that exclusive contracts can be anticompetitive if consumers can join only a single firm. With the possibility of multi-homing, however, they find that contracts that only require consumers to commit to purchase from the incumbent is not anticompetitive, unless they prevent consumers from also buying from the entrant. In my model, an interesting question would be if exclusive contracts can be used by \textit{non-tying} firms to create incentives for consumers to multi-home when the monopolist ties.\textsuperscript{21}

In addition, many network industries are in dynamic and technology-driven high-tech fields. Despite the central position that innovation occupies in the performance of such industries, the model in this paper has been mainly concerned with pricing implications of tying in network industries. One important extension in my model would be to analyze how the possibility of multi-homing shapes the incentives to innovate in network industries.

\textbf{APPENDIX}

\textit{Derivation of Condition A2}

When a firm, say platform A, deviates to a price to serve only the exclusive content providers by charging $\pi N_A$, its overall profit from both sides becomes

$$
\Pi_A = \hat{\lambda}(\pi N_A - c) + (q_A - d)N_A = \hat{\lambda}\left(\pi \frac{\lambda b - q_A}{t} - c\right) + (q_A - d)\frac{\lambda b - q_A}{t}
$$

Notice that when the platform does not induce multi-homing on the content provider side, the profit on the content provider side now depends on $N_A$, instead of $n_A$, which is a function of $q_A$. This implies that the optimal pricing decision on the consumer side is no

\textsuperscript{20} See also Hagiu [2006] who considers the possibility of seller multi-homing \textit{exogenously} given.

\textsuperscript{21} See also Armstrong and Wright [2007] for an analysis of exclusive contracts in two-sided markets where exclusive contracts are used as a device to foreclose the market and undermine the competitive bottleneck equilibrium.

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longer independent of the content provider side. The optimal consumer price for the deviating platform is given by

$$\hat{q}_A = \frac{\lambda(b - \pi) + d}{2}$$

The number of consumers who participate in platform A is given by

$$\hat{N}_A = \frac{\lambda(b + \pi) - d}{2t}$$

The optimal deviation payoff for platform A is thus given by

$$\hat{\Pi}_A = \lambda \left( \frac{\lambda(b + \pi) - d}{2t} - c \right) + \frac{\lambda(b - \pi) - d \lambda(b + \pi) - d}{2t}$$

In contrast, the profit in the proposed equilibrium with multi-homing on both sides is given by

$$\Pi_A = \pi \left( 1 - \frac{\lambda b - d}{2t} \right) - c + \frac{(\lambda b - d)^2}{4t}$$

Thus, the condition for the multi-homing equilibrium on both sides can be written as \( \Pi_A \geq \Pi_A \). With the assumption of \( c = d = 0 \), the condition above \( (\Pi_A \geq \Pi_A) \) can be rewritten as:

$$A2. \frac{\lambda \pi + 2b(1 + \lambda)}{4} \leq t$$

**Derivation of Consumer Surplus without Tying**

Without tying a consumer who is located at \( x \) and buys only from A obtains a surplus of \( u_A^*(x) = v + b - q_A^* - q_M^* - tx = t - \frac{\lambda b}{C_0} - tx \). The aggregate surplus of the consumers who buy only from A is given by \( \int_{0}^{1 - \hat{N}_A} u_A^*(x) dx \). Similarly, I can compute the surplus of a consumer buying only form B as \( u_B^*(x) = t - \frac{\lambda b}{C_0} - t(1 - x) \). The aggregate surplus of the consumers who buy only from B is given by \( \int_{\hat{N}_A}^{1} u_B^*(x) dx \). The aggregate surplus is thus given by \( \int_{0}^{1 - \hat{N}_A} u_A^*(x) dx + \int_{\hat{N}_A}^{1} u_B^*(x) dx = \int_{0}^{1 - \hat{N}_A} t x dx + \int_{\hat{N}_A}^{1} t x dx \).

**The Effects of Tying without Multi-Homing**

The welfare level under tying in the absence of multi-homing is given by

$$\bar{W}^{SH} = \pi + b - \int_{0}^{1} t x dx$$

Thus, I have

$$\Delta W = \bar{W}^{SH} - W = - (\pi + b) \lambda \left( \frac{\lambda b - t}{t} \right) + \frac{(\lambda b)^2}{4t} - \frac{t}{2}$$

$$< - (\pi + b) \lambda \left( \frac{\lambda b - t}{t} \right) + \frac{(\lambda b)^2}{4t} - \frac{t^2}{4t}$$

$$= - \frac{(\lambda b - t)}{4t} (4\lambda \pi + 3\lambda b - t) < 0$$
Thus, tying is unambiguously welfare-reducing if multi-homing is not allowed.

The result on consumer surplus is also reversed when multi-homing is not allowed. Without multi-homing, the bundled good price is set such that the final consumer located at $x = 1$ receives zero surplus. This implies that the total consumer surplus under tying is given by

$$CS^{SH} = \int_0^1 tx_0 dx > \left[ \int_0^{1-N_a} tx dx + \int_0^{1-N_1} tx dx \right] = CS$$

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