Management Science

Publication details, including instructions for authors and subscription information:
http://pubsonline.informs.org

Platform Competition with Multihoming on Both Sides: Subsidize or Not?

Yannis Bakos, Hanna Halaburda

MANAGEMENT SCIENCE
Articles in Advance, pp. 1–9
ISSN 0025-1909 (print), ISSN 1526-5501 (online)
http://pubsonline.informs.org/journal/mnsc

Platform Competition with Multihoming on Both Sides: Subsidize or Not?

Yannis Bakos,[a] **Hanna Halaburda**[a]

[a] Stern School of Business, New York University, New York, New York 10012

Contact: bakos@stern.nyu.edu, https://orcid.org/0000-0001-6778-6587 (YB); hhalaburda@gmail.com, https://orcid.org/0000-0002-2438-4972 (HH)

Received: December 23, 2019
Revised: February 11, 2020
Accepted: February 12, 2020
Published Online in Articles in Advance: July 27, 2020

https://doi.org/10.1287/mnsc.2020.3636

Abstract. A major result in the study of two-sided platforms is the strategic interdependence between the two sides of the same platform, leading to the implication that a platform can maximize its total profits by subsidizing one of its sides. We show that this result largely depends on assuming that at least one side of the market single-homes. As technology makes joining multiple platforms easier, we increasingly observe that participants on both sides of two-sided platforms multihome. The case of multihoming on both sides is mostly ignored in the literature on competition between two-sided platforms. We help to fill this gap by developing a model for platform competition in a differentiated setting (a Hotelling line), which is similar to other models in the literature but focuses on the case where at least some agents on each side multihome. We show that when both sides in a platform market multihome, the strategic interdependence between the two sides of the same platform will diminish or even disappear. Our analysis suggests that the common strategic advice to subsidize one side in order to maximize total profits may be limited or even incorrect when both sides multihome, which is an important caveat given the increasing prevalence of multihoming in platform markets.

History: Accepted by Joshua Gans, business strategy.
Funding: This work was supported by the NET Institute.
Supplemental Material: The online appendix is available at https://doi.org/10.1287/mnsc.2020.3636.

Keywords: multihoming • platforms • two-sided platforms • network effects • platform subsidies

1. Introduction

Platforms have been at the center of the recent economics and business literatures on technology-based markets because of their increasing economic importance and their distinctive economic characteristics that can lead to certain results important both for theory and for management practice. A major such result in the two-sided platform literature is that there is interdependence between the two sides served by the same platform, meaning that lowering the price on one side can make the platform more competitive on the other side (without lowering its price there).

The policy implication is that under certain conditions, such as asymmetric network effects or different demand elasticities on each side, a platform may maximize its total profits by subsidizing one side (Rochet and Tirole 2003, Armstrong 2006). In a typical example, it may be optimal for a payment platform such as PayPal to subsidize adoption by consumers in order to generate more merchant fees or for a content-distribution platform such as Adobe to offer Acrobat Reader to consumers at a zero or even a negative price in order to maximize its profits from the sale to content creators of the corresponding authoring tools.[1]

Although this interdependence between the two sides of a platform has led to a significant management literature and practitioner advice promoting cross-subsidization as a competitive strategy in platform markets, we show in this paper that this interdependence depends on the assumption that at least one side of the platform single-homes and is reduced or even disappears when both sides of the platform multihome. This is an important finding because although multihoming on both sides was uncommon in early platforms, such as operating systems, game consoles, or optical disc players, as technology makes joining multiple platforms easier, participants in both sides of two-sided platforms frequently multihome. This is common, for instance, in platforms that can be joined on either side by simply downloading an app, such as ride-sharing or food delivery. For platforms with multihoming on both sides, the interdependence result and cross-subsidization policy implications thus need to be qualified or changed.[2]

The literature on competition between two-sided platforms, going back to Armstrong (2006) and Rochet and Tirole (2006), mostly ignores this case of multihoming agents on both sides. Most analyses either consider single-homing by participants on both sides of a platform or allow multihoming by participants on one side while imposing single-homing on the other side. These models also typically assume full coverage on both sides; that is, that all agents participate on at least one platform.

The usual argument for not considering multihoming on both sides of the market is that if one side of the market fully multihomes, there is no benefit to allowing the other side of the market to also multihome, because all possible pairs of agents could already connect with each other (Armstrong 2006). This argument relies on the assumption that all agents on the multihoming side do multihome and that meeting the same agent for the second time on another platform does not bring any additional benefit. This assumption is limiting, however, if each side of the market only partially multihomes, in which case multihoming on both sides can generate new potential connections between the two sides of the market.

In this paper, we develop a model for platform competition in a differentiated setting (a Hotelling line), which is similar to the standard models in the literature. However, we focus on equilibria where only some agents on each side multihome. We show that in that case the strategic interdependence between the two sides of the same platform may be of lesser importance, or even not be present at all, in contrast to the models imposing single-homing on at least one side of the market. Thus, when multihoming is present on both sides of the market, the benefit of subsidizing one side is diminished or may not be present at all. This result is strongest when the market is fully covered and when connecting two agents who are already connected on a different platform does not create additional benefit.

Our results suggest that when both sides multihome, we need to be wary of overstating the importance of the interdependence between the two sides of a platform, even when it does exist, or we risk potentially offering inappropriate strategic advice.

2. Related Literature

Although most of the literature on competition between two-sided platforms assumes single-homing on at least one side, some papers allow for multihoming on both sides, typically in specialized settings. These papers differ from ours in that they address aspects of platform competition other than the effectiveness of subsidies, which is the focus of our paper.

An early example allowing multihoming on both sides is the work of Caillaud and Jullien (2003), who consider multihoming in a matching setting, where multihoming agents get additional chances at being matched, increasing the probability of successful matching. In another early paper, Doganoglu and Wright (2006) look at multihoming in a one-sided network market with two firms competing on a Hotelling line. They focus on the relation between multihoming and compatibility, exploring whether multihoming is a good substitute for compatibility, and specifically how the ability to multihome affects prices, firm profits, and firms' incentives to make the two networks compatible. They find that multihoming increases prices, firm profits, and social welfare, but it reduces firms' incentives to invest in compatibility. They illustrate how their setting and findings can be extended to two-sided networks; however, they consider only symmetric two-sided networks where firms charge identical prices on both sides and thus do not address potential cross-subsidization between the two sides.

Choi (2010) and Choi et al. (2017) focus on the profitability and optimality of tying (i.e., bundling) the content provided to consumers, modeling competition between two platforms that provide content to spatially differentiated consumers. Although the focus of their analysis is on tying, under certain parameters of their setting, the resulting equilibria involve multihoming on both sides of the market.

The papers by Ambrus et al. (2016) and Anderson et al. (2016) analyze platforms in media markets and study the effect of multihoming by advertisers and consumers on the provision of advertiser-supported content. Neither of these papers looks into the effectiveness of subsidies in maximizing profits. Athey et al. (2018) also model an advertising market where two publishers connect consumers with advertisers that value only the first impression to a given consumer. In their model, the publishers can subsidize consumers by investing in the quality of free content in order to increase engagement; this subsidization can be profitable because more engaged consumers allow publishers to charge higher prices to advertisers. When both consumers and advertisers multihome across publishers, the incentive to subsidize content quality is reduced as multihoming increases and disappears when all consumers multihome. The settings of these papers differ from ours (and the standard model of two-sided platform competition along a Hotelling line) because there are no network effects or spatial differentiation.

Belleflamme and Peitz (2019) study how competition between two-sided platforms is shaped by the possibility of multihoming. They do so by introducing multihoming on one side into a model where both sides initially single-home. Previous analysis (e.g., Armstrong 2006) suggests that if users on one side can multihome, platforms exert monopoly power on that side and compete on the single-homing side. Belleflamme and Peitz (2019) find that the result can go either way, possibly benefiting rather than hurting the multihoming side. They do not address multihoming on both sides, but they recognize the importance of studying platform competition when both sides multihome.

Jeitschko and Tremblay (2017) study entry and competition in a two-sided market where the homing decision is endogenized. Their setting differs from the canonical model of platform competition in that whereas one side (the "consumers") is spatially differentiated in terms of its realized network benefit from joining a platform, the other side (the "firms") realizes identical network benefits from either platform. They consider both a monopolist platform and a competitive setting with two platforms. They find a variety of equilibria, ranging from tipping, where one platform dominates, to competing platforms with a mix of multihoming and single-homing on both sides of the market. They characterize their cases in terms of social surplus and intensity of competition in the case of more than one platform and find that social surplus may be maximized under either monopoly or competition. They do not address the profitability of subsidies with or without multihoming in the settings with competing platforms.

Bryan and Gans (2018) model competition between two ridesharing platforms that can reduce the expected wait time of riders by hiring a certain number of idling drivers. They study the impact of different multihoming scenarios on market outcome, including the case where both riders and drivers multihome. They find that in their ridesharing setting, it may be optimal for firms to pay drivers for idling, thus reducing consumer wait times, and the incentive to do so disappears when both sides of the market multihome. Their model is specific to ridesharing, with spatial differentiation only on the rider side, and the drivers' wage exogenously determined.

Liu et al. (2019) offer an analysis of competition between two-sided platforms in which buyers and sellers can multihome, and platforms compete on transaction fees charged on both sides. They study outcomes with multihoming on both sides and find that the impact of increased platform competition depends on whether each side is allowed to multihome. They assume that platform adoption is costless and that consumers will join all platforms by default, and thus, in their model, there is no reason to subsidize platform adoption.

This emerging literature demonstrates the importance of considering equilibria in platform competition where both sides multihome. Given the centrality of the cross-subsidization result in the literature on platform competition, it is thus important to note that such cross-subsidization strategies are not profitable when both sides multihome.

3. Model Setup and Benchmarks

We consider a setting with two types of potential participants (sides), X and Y, which are spatially differentiated and uniformly distributed; specifically, $x \sim U[0,1]$ for side X, and $y \sim U[0,Y]$ for side Y. We allow Y to be smaller than, greater than, or equal to one. There is two-sided Hotelling competition between the two platforms, A and B, that are located at the ends of these segments, with A at zero on both sides and B, respectively, at one and Y. The platforms charge participation fees p_i, $i = A, B$, on side X and r_i on side Y and incur zero marginal cost in serving additional users.

A user located at x on side X (respectively, y on Y) receives utility from joining platform $i = A, B$:

$$\begin{aligned}
u(x;A) &= A_x + \alpha y_A - p_A - zx,\\
u(x;B) &= B_x + \alpha(Y - y_B) - p_B - z(1-x),\\
u(y;A) &= A_y + \beta x_A - r_A - qy,\\
u(y;B) &= B_y + \beta(1 - x_B) - r_B - q(Y - y),
\end{aligned} \tag{1}$$

where, for platform A, a mass of y_A agents participates on side Y, and a mass x_A agents participates on side X, whereas for platform B, a mass of $1 - x_B$ agents participates on side X, and a mass of $Y - y_B$ agents participates on side Y; α and β are the network effects of the other side on sides X and Y, respectively; A_x, B_x and A_y, B_y are the stand-alone values users on sides X and Y obtain from joining the respective platforms; and z and q are the respective transportation costs, that is, the loss of utility resulting from preference mismatch or setup costs. We assume that $qz > \alpha\beta$, that is, that network effects are weaker than transportation costs, which is a typical assumption in models of competition with network effects on a Hotelling line, because these models focus on the effects of differentiation. The utilities from multihoming will be specified separately within each iteration of the model because allowing for multihoming on one or both sides will affect these utilities.

In the rest of our analysis, we assume that both platforms offer the same stand-alone (intrinsic) value $A_x = B_x = \sigma_x$ and $A_y = B_y = \sigma_y$ because this significantly streamlines the exposition of the benchmark cases. This assumption does not affect our qualitative results and specifically the absence of subsidies under multihoming on both sides. We present formulas for the general case in the online appendix.

For instance, an application of this model to gaming platforms (e.g., Xbox versus PlayStation) would involve spatially differentiated preferences of consumers (e.g., based on user interface or previous experience with each platform) and game developers (e.g., based on each platform's development toolkits and the prior experience of application developers). If consumers were restricted to purchasing one of the two systems, then we would have single-homing on the consumer side. If developers could make their games available on one or both platforms, then we would be allowing multihoming on the developer side, the actual outcome depending on the setting parameters and the resulting equilibria.

Similarly, an application to ridesharing could have the two platforms adopt different levels of idleness for their drivers, as in Bryan and Gans (2018), which would affect the expected waiting time for consumers, with both drivers and consumers spatially differentiated based on their opportunity cost for idleness and waiting time, respectively. In this case, single-homing agents would consider only one ridesharing platform as drivers or consumers, whereas multihoming agents would consider both platforms and endogenously select to join one or both.

3.1. Single-Homing Benchmark

We begin by analyzing as a benchmark the case with full coverage and single-homing imposed on both sides, as is typical in the literature on platform competition. In this case, $x_A = x_B = \tilde{x}$ such that $u(\tilde{x}; A) = u(\tilde{x}; B)$ and, similarly, $y_A = y_B = \tilde{y}$. The platforms set their prices (p_A, r_A) and (p_B, r_B) to maximize their profits $\Pi_A = p_A\tilde{x} + r_A\tilde{y}$ and $\Pi_B = p_B(1-\tilde{x}) + r_B(Y-\tilde{y})$, resulting in the equilibrium familiar in the literature[3] with prices $p_A^S = p_B^S = z - Y\beta$ and $r_A^S = r_B^S = qY - \alpha$ and allocations $\tilde{x}^S = \frac{1}{2}$ and $\tilde{y}^S = \frac{Y}{2}$. Superscript S denotes equilibrium values in environments with single-homing imposed on both sides.

Platforms find it optimal to subsidize one side when $Y\beta > z$ or when $\alpha > qY$ (which is possible without violating $qz > \alpha\beta$).

Illustrative Example. For instance, consider a setting with parameters $\alpha = 0.6$, $\beta = 1.5$, $z = 1.4$, $q = 1.6$, $\sigma_x = \sigma_y = 1.6$, $Y = 1$, and single-homing imposed on both sides. At equilibrium, the profit-maximizing prices are $p_A^S = p_B^S = -0.1$ and $r_A^S = r_B^S = 1$, yielding $\tilde{x}^S = \tilde{y}^S = \frac{1}{2}$ and $\Pi_A^S = \Pi_B^S = 0.45$. This example illustrates how subsidizing users on one side can be optimal in an environment where both sides single-home.

3.1. Benchmark with Multihoming on One Side Only

We now examine the second benchmark, with single-homing imposed on side X, multihoming allowed on side Y, and full coverage of both sides. As before, $\tilde{x}$ is characterized by $u(\tilde{x}, A) = u(\tilde{x}, B)$. A user y on side Y that multihomes obtains utility $u(y; A\&B) = 2\sigma_x + \beta - r_A - r_B - qY = u(y; A) + u(y; B)$. It is preferable for that user to join both platforms when both $u(y; A) > 0$ and $u(y; B) > 0$. Therefore, all users $y < y_A$ join platform A, where y_A is characterized by $u(y_A; A) = 0$. All users $y > y_B$ join platform B, where y_B is characterized by $u(y_B; B) = 0$. Users $y \in (y_B, y_A)$ multihome.

At equilibrium,[4] the platforms set the following profit-maximizing prices, where superscript M denotes equilibrium values with multihoming allowed on side Y and single-homing imposed on side X:

$$p_A^M = p_B^M = \frac{4(qz - \alpha\beta) + \beta(\alpha - \beta) - 2\beta\sigma_y}{4q},$$

$$r_A^M = r_B^M = \frac{2\sigma_y - \alpha + \beta}{4}.$$

For certain parameter values, these prices are negative for one side.

Illustrative Example, Continued. For instance, consider the parameter values in our illustrative example from Section 3.1, with single-homing imposed on side X, whereas side Y can multihome. At equilibrium, the profit-maximizing prices are $p_A^M = p_B^M = -0.12$ and $r_A^M = r_B^M = 1.025$, yielding $\tilde{x} = \frac{1}{2}$, $y_A^M = 0.83$, $y_B^M = 0.17$, and $\Pi_A^M = \Pi_B^M = 0.79$. For these parameter values, when multihoming is allowed on side Y, it is optimal to subsidize users on the single-homing side X even more than before, resulting in increased platform profits.

4. Allowing for Multihoming on Both Sides

We now allow for multihoming on both sides of a platform. For instance, in the case of ridesharing platforms, a driver may participate in both Uber and Lyft, and a passenger may consider offerings from both Uber and Lyft in selecting a ride. Similarly, some consumers may own both Windows and MacOS computers, whereas developers often create applications for both operating systems.

4.1. Utility When Multihoming

We first characterize the utilities agents get when multihoming, $u(x; A\&B)$ and $u(y; A\&B)$, when multihoming occurs on both sides X and Y. On the X side, market coverage is given by x_A for platform A and $1 - x_B$ for platform B, with multihoming occurring when $x_A > x_B$ and multihoming on both sides occurring when both $x_A > x_B$ and $y_A > y_B$. Thus, when multihoming occurs, the market is fully covered, and the marginal agents x_A, x_B, y_A, and y_B multihome.[5] In such a case, a multihoming agent from side X may meet certain agents from side Y on both platforms because agents from side Y are multihoming as well, and vice versa. Note that this situation is unique to the case of multihoming on both sides. For instance, when multihoming is allowed only on one side, the multihoming agent meets distinct agents on the other side on each platform, and his or her multihoming utility is simply equal to the sum of the utilities from joining each platform.

When two agents meet on both platforms, they may realize no additional benefit from the second meeting—there is no "double counting" of the network benefit. At the other extreme, the benefit received on each platform could be additive—there would be double counting of the network benefit. In the intermediate case, meeting for the second time may yield a partial additional network benefit, having partial double counting of the network benefit. The same possibilities arise for the stand-alone (intrinsic) benefit of the two platforms under multihoming.

For the base case of our analysis, we assume double counting of the stand-alone intrinsic values but no double counting of the network effect from overlapping agents.[6] Even though X-side users may meet some Y-side users on both platforms, they receive the network benefit only once. When multihoming, the agents pay for participation on both platforms, p_A and p_B, and also incur the mismatch or setup cost twice, $zx + z(1-x) = z$. Thus, joining both platforms when $y_A \geq y_B$ yields

$$u(x; A\&B) = 2\sigma_x + \alpha Y - p_A - p_B - z.$$

We similarly obtain $u(y; A\&B)$.

4.2. Decision to Participate in Both Platforms

An agent multihomes when multihoming yields a higher utility than joining only platform A, only platform B, or not joining either of the platforms. The utility of an agent joining A only is given by $u(x; A)$, as in (1). If A were the only platform in the market, users $x < \bar{x}_A$ would prefer to join A, whereas users $x > \bar{x}_A$ would prefer not to join it, where $\bar{x}_A$ is characterized by $u(\bar{x}_A; A) = 0$; that is,

$$\bar{x}_A = \frac{\sigma_x + \alpha y_A - p_A}{z}. \tag{2}$$

That is, $\bar{x}_A$ would be the X-side market captured by platform A if it were the only platform (see Figure 1(a)).

Similarly, if B were the only platform in the market, all users $x > \bar{x}_B$ would prefer to join B, whereas $x < \bar{x}_B$ would not join (see Figure 1(b)), where

$$\bar{x}_B = 1 - \frac{\sigma_x + \alpha(Y - y_B) - p_B}{z}.$$

When $\bar{x}_A > \bar{x}_B$, there is potential for multihoming on side X. Note, however, that if there is multihoming on both sides, there will be fewer than $\bar{x}_A$ joining platform A. This is because marginal agents will consider joining A while they already participate in B. In such a case, user x's utility from joining A in addition to B is given by

$$u(x; A|B) = u(x; A\&B) - u(x; B). \tag{3}$$

If there is multihoming on side Y, this incremental utility $u(x; A|B)$ is smaller than $u(x; A)$ because user x has already met on platform B some of the Y-side agents that he or she is now meeting on platform A. This means that some agents who might have joined A if no other platform had been available will not join A as the second platform; that is, for some x, $u(x; A|B) < 0 < u(x; A)$. Thus, the actual market captured by platform A in the case of multihoming on both sides is smaller than $\bar{x}_A$.

To characterize the size of the market captured by platform A in the case of multihoming on both sides, we need to identify the marginal user $\hat{x}_A$ for whom joining platform A in addition to platform B brings no additional benefit, that is, who is indifferent between joining A in addition to B and staying with B only. For X-side users of platform B, the attractiveness of platform A is determined by its Y-side agents that are not already available on platform B, that is, the number of *exclusive* Y-side agents it offers access to, rather than the overall Y-side agents that have joined.

Formally, the marginal user $\hat{x}_A$ is characterized by $u(\hat{x}_A; A|B) = 0$, which, by (3), is equivalent to $u(\hat{x}_A; A\&B) = u(\hat{x}_A; B)$; that is,

$$\hat{x}_A = \frac{\sigma_x + \alpha y_B - p_A}{z}. \tag{4}$$

All users $x < \hat{x}_A$ will strictly prefer to join platform A, even if they also join platform B. Thus, in the case of multihoming on both sides, platform A captures a market of size $\hat{x}_A$ on side X.

Two observations follow from comparing Equations (2) and (4): First, because $y_A > y_B$, $\hat{x}_A < \bar{x}_A$; that is, the actual market captured by platform A in the case of multihoming on both sides is smaller than $\bar{x}_A$, consistent with the preceding discussion (see Figure 2).

Figure 1. (Color online) Market Coverage if Platform A or Platform B Would Be the Only Platform in the Market

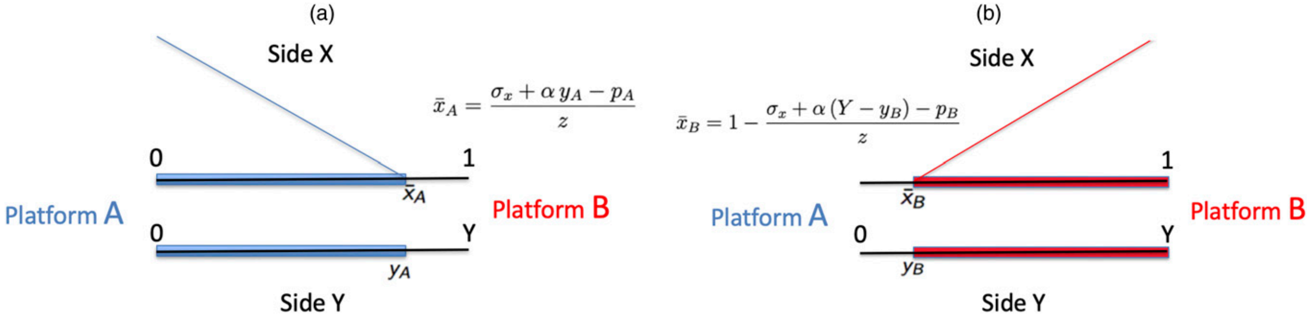
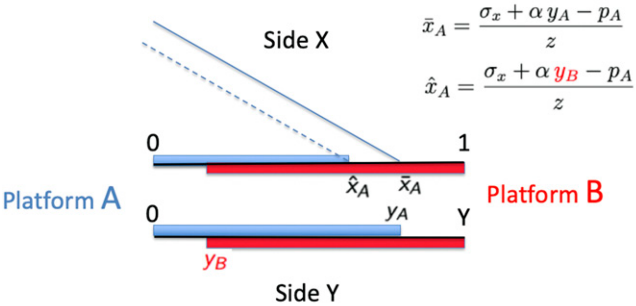


Figure 2. (Color online) Market Coverage of Platform A When Multihoming on Both Sides Occurs, $\hat{x}_A$



Second, there is no dependence of $\hat{x}_A$ on y_A. The threshold $\bar{x}_A$ depends on y_A, that is, the number of opposite-side agents available on the same platform A, which, in turn, depends on the Y-side pricing of platform A. However, $\hat{x}_A$ depends on y_B, which depends on the Y-side pricing of *the other* platform.

When multihoming takes place on both sides, platform A cannot make itself more appealing to agents on side X by increasing the number of Y agents it attracts. In fact, the attractiveness of platform A to agents on side X depends inversely on side Y agents attracted by the other platform; this is because y_B represents the number of side-Y agents that are *exclusive* to platform A. As platform B becomes more attractive to side-Y agents, the number of such agents joining A exclusively decreases—even if A can increase its overall coverage on side Y. This lowers the attractiveness of joining A for the marginal side-X agent because the marginal side-X agent is deciding whether to join A in addition to B, not whether to join either A or no platform at all, and the marginal agent on side X already has access to these side-Y agents on platform B.

We can already see the intuition for our main result. To make sure that it holds in full equilibrium, we next characterize the equilibrium.

4.3. Equilibria with Partial Multihoming on Both Sides

We call *partial multihoming* a situation where some agents on both sides multihome, whereas others single-home. Partial multihoming on both sides occurs at equilibrium when $0 < \hat{x}_B < \hat{x}_A < 1$ and $0 < \hat{y}_B < \hat{y}_A < 1$ (see Figure 3), where[7]

$$\hat{x}_A = \frac{\sigma_x + \alpha\hat{y}_B - p_A}{z},$$
$$\hat{x}_B = 1 - \frac{\sigma_x + \alpha(Y - \hat{y}_A) - p_B}{z},$$
$$\hat{y}_A = \frac{\sigma_y + \beta\hat{x}_B - r_A}{q},$$
$$\hat{y}_B = Y - \frac{\sigma_y + \beta(1 - \hat{x}_A) - r_B}{q}. \tag{5}$$

Lemma 1. *If both sides multihome and there is no double counting of the network benefits from meeting the same other-side agent on both platforms, there is no interdependence of prices on the two sides of the same platform when maximizing profit; that is, the profit-maximizing p_i^* does not depend on r_i^*.*

Proof. From (5), we can see that in equilibrium, there is interaction between $\hat{x}_A$ and $\hat{y}_B$ (and therefore between p_A and r_B), but not between $\hat{x}_A$ and $\hat{y}_A$; that is, there is no strategic interaction between pricing on the two sides of the same platform. Formally, it follows from first-order conditions (FOCs) for profit maximization: r_i does not enter the FOC for maximizing the profit of platform i with respect to p_i, and vice versa. □

Interdependence of prices on the two sides of the same platform is the driver of subsidies in platform pricing; without it, there is no incentive to subsidize one side because according to Lemma 1 and (5), this will not affect the optimal price and quantity on the other side and thus will not be profitable.

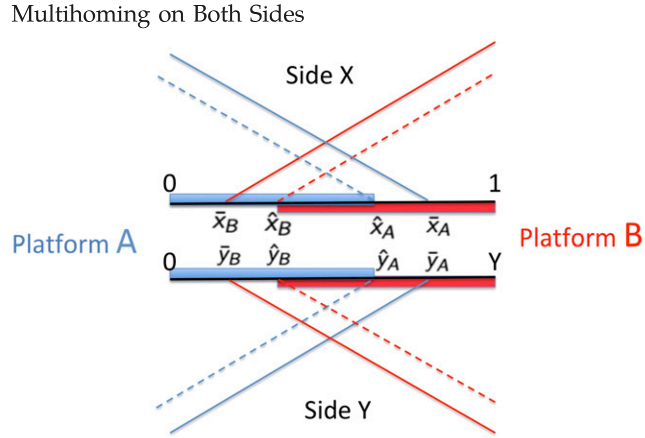
The pure strategy equilibrium with partial multihoming on both sides is characterized by

$$\hat{x}_A^{MM} = \frac{q[(2qz - \alpha\beta)(\sigma_x + \alpha Y) - \alpha z(\sigma_y + \beta)]}{(qz - \alpha\beta)(4qz - \alpha\beta)},$$
$$\hat{x}_B^{MM} = \frac{(2qz - \alpha\beta)^2 - (2qz - \alpha\beta)q(\sigma_x + Y\alpha) + \alpha qz\sigma_y}{(qz - \alpha\beta)(4qz - \alpha\beta)},$$
$$\hat{y}_A^{MM} = \frac{z[(2qz - \alpha\beta)(\sigma_y + \beta) - \beta q(\sigma_x + Y\alpha)]}{(qz - \alpha\beta)(4qz - \alpha\beta)},$$
$$\hat{y}_B^{MM} = \frac{Y(2qz - \alpha\beta)^2 - (2qz - \alpha\beta)z(\sigma_y + \beta) + \beta qz\sigma_x}{(qz - \alpha\beta)(4qz - \alpha\beta)} \tag{6}$$

and

$$p_A^{MM} = p_B^{MM} = \frac{(2qz - \alpha\beta)(\sigma_x + Y\alpha) - \alpha z(\sigma_y + \beta)}{4qz - \alpha\beta},$$
$$r_A^{MM} = r_B^{MM} = \frac{(2qz - \alpha\beta)(\sigma_y + \beta) - \beta q(\sigma_x + Y\alpha)}{4qz - \alpha\beta}.$$

Figure 3. (Color online) Participation Decision with Multihoming on Both Sides



We use superscript MM to denote equilibrium values in environments with multihoming allowed on both sides.

Proposition 1. *For the range of parameters described by Conditions* (a)–(f) *below, there exists a pure strategy equilibrium with partial multihoming on both sides:*

i. $zq(4zq+\sigma_y\alpha) > q(Y\alpha+\sigma_x)(2qz-\alpha\beta)+\alpha\beta(4qz-\alpha\beta)$;

ii. $q(\sigma_x + Y\alpha)(2qz - \alpha\beta) < (qz - \alpha\beta)(4qz - \alpha\beta) + \alpha qz(\sigma_y + \beta)$;

iii. $zq(4zq + 2\sigma_y\alpha + \alpha\beta) < 2q(2qz - \alpha\beta)(\sigma_x + Y\alpha) + \alpha\beta(4qz - \alpha\beta)$;

iv. $Y(2qz-\alpha\beta)^2 + qz\beta\sigma_x > z(\sigma_y+\beta)(2qz-\alpha\beta)$;

v. $z(\sigma_y + \beta)(2qz - \alpha\beta) < (qz - \alpha\beta)(4qz - \alpha\beta) + \beta zq (\sigma_x + Y\alpha)$; *and*

vi. $Y(2qz-\alpha\beta)^2+\beta zq(2\sigma_x+Y\alpha)<2z(2qz-\alpha\beta)(\sigma_y+\beta)$.

Proof. Suppose that parameters satisfy conditions (a)–(f). The region of parameters satisfying these conditions is nonempty because, for instance, the parameter values in our illustrating example from Sections 3.1 and 3.2 satisfy all these conditions. As shown in the online appendix, these conditions guarantee an equilibrium with positive profits for the platforms and weakly positive utility for the marginal agents. Directly from conditions (a)–(f), it follows that $\hat{x}_A^{MM}$, $\hat{x}_B^{MM}$, $\hat{y}_A^{MM}$, and $\hat{y}_B^{MM}$ calculated according to (6) are such that $0 < \hat{x}_B^{MM} < \hat{x}_A^{MM} < 1$ and $0 < \hat{y}_B^{MM} < \hat{y}_A^{MM} < 1$. Conditions $\hat{x}_B^{MM} < \hat{x}_A^{MM}$ and $\hat{y}_B^{MM} < \hat{y}_A^{MM}$ indicate multihoming on both sides. And because all four thresholds are strictly between zero and one, the multihoming is partial. □

Proposition 2. *In an equilibrium with partial multihoming on both sides, there are no subsidies; that is,* p_A^{MM}, r_A^{MM}, p_B^{MM}, *and* r_B^{MM} *are strictly positive.*

Proof. Consider parameters for which conditions (a)–(f) in Proposition 1 are satisfied. Because the conditions imply that $0 < \hat{x}_B^{MM} < \hat{x}_A^{MM} < 1$ and $0 < \hat{y}_B^{MM} < \hat{y}_A^{MM} < 1$, they must also imply that $\hat{x}_A^{MM} > 0$, $\hat{x}_B^{MM} < 1$, $\hat{y}_A^{MM} > 0$, and $\hat{y}_B^{MM} < 1$. Direct algebraic manipulations reveal that $\hat{x}_A^{MM} > 0 \iff p_A^{MM} > 0$, $\hat{y}_A^{MM} > 0 \iff r_A^{MM} > 0$, $\hat{x}_B^{MM} < 1 \iff p_B^{MM} > 0$, and $\hat{y}_B^{MM} < 1 \iff r_B^{MM} > 0$. □

Note that for other parameter values, different pure strategy equilibria are possible. For instance, equilibria may arise where the market on one or both sides is not fully covered or where single-homing arises endogenously.

Illustrative Example, Continued. Once again considering the parameter values in the illustrative example from Sections 3.1 and 3.2, if multihoming is allowed on both sides, users will chose to multihome because the profit-maximizing prices are $p_A^{MM} = p_B^{MM} = 0.65$ and $r_A^{MM} = r_B^{MM} = 0.72$, yielding $\hat{x}_A^{MM} = 0.78$, $\hat{x}_B^{MM} = 0.22$, $\hat{y}_A^{MM} = 0.75$, $\hat{y}_B^{MM} = 0.25$, and $\Pi_A^{MM} = \Pi_B^{MM} = 1.06$. Compared with the preceding settings with single-homing imposed on at least one side, prices are positive on both sides (i.e., there is no subsidy of one side).

5. Discussion and Extensions

Our analysis of platform competition with multihoming on both sides assumes that participants that overlap on multiple platforms do not derive additional benefit from being able to meet on more than one platform, which we described as having no double counting of the corresponding network effects. Under this assumption, we showed that at equilibrium, there is no interdependence between pricing decisions on the two sides by the same platform. This is a striking result when compared with the benchmarks of single-homing on at least one side, where such an interdependence has been a central result in the literature.

As we noted in Section 4, there are many possibilities for how the utility of these overlapping multihomers is specified. In some markets, the platforms may be differentiated enough to provide additional functionality; for instance, seeing the same listing on Airbnb and HomeAway may offer incremental value to the prospective renter from accessing more photographs, property information, and additional reviews. Similarly, being exposed to the same prospective renter on both platforms may be valuable for a property because of an additional chance to make an impression or the ability to appeal when the consumer is planning business as well as vacation travel. This can be captured by extending our analysis to allow partial double counting of the network effects in the utility of multihomers so that meeting the same agent on the second platform yields some incremental network benefit above the network benefit from meeting him or her on the first platform.

The utility of a multihoming agent x on side X with $y_A - y_B$ agents multihoming on side Y can thus be specified as

$$u(x; A\&B, \omega) = A_x + B_x + \alpha\big[Y + \omega\big(y_A - y_B\big)\big] - p_A - p_B - z,$$

where $\omega \in [0,1]$ is the degree of double counting the network effect. For $\omega = 0$, there is no double counting, as in our preceding analysis. When $\omega = 1$, $u(x; A\&B) = u(x, A) + u(x, B)$; that is, the X-side agent gets a fully additive benefit from meeting a Y agent on both platforms. This means that the two platforms provide different benefits, and thus they are not competing with each other.

By accounting for ω in the analysis from Section 4, we get

$$\hat{x}_A(\omega) = \frac{\sigma_x + \alpha\big[\omega y_A + (1-\omega)y_B\big] - p_A}{z},$$

with similar results for side Y; ω thus determines the interdependence between the price platform A sets on side Y and how attractive it is to agents on side X. If there is some incremental network benefit of meeting the same other-side agent on both networks (i.e., double counting the network effect from agents common to the two platforms), the strength of the interdependence between the prices charged on the two sides by the same platform is determined by the strength of this incremental benefit. For small values of ω, this interdependence is correspondingly small, and the price set by platform B on side Y is much more important to determining $\hat{x}_A$, platform A's market coverage on the X side, than its own price on side Y, thus reducing A's incentives to subsidize Y.

In our main analysis, we assumed a market that needs to be fully covered for multihoming to occur. This assumption allowed for a clearer presentation of our result. Spatially differentiated models of two-sided platforms in the literature sometimes add "hinterland" areas of consumers located beyond rather than between the platform locations, thus providing an alternative to positioning the platforms at the ends of the Hotelling segment—see, for instance, Hagiu and Halaburda (2014). These hinterlands are typically noncompetitive in the sense that at equilibrium, they are always served by the proximate platform. In our setting, they would correspond to $x < 0$ and $x > 1$ on the X side and $y < 0$ and $y > Y$ on the Y side. In the case of multihoming on both sides, hinterlands that are not fully covered at equilibrium can reintroduce an interdependence between the prices a platform charges on the two sides and thus possibly create an incentive to subsidize one of these sides. This is because the subsidy could attract new participants from the platform's hinterland, if this hinterland is not fully covered, and these new participants would increase the platform's attractiveness to the other side. However, similar to the case of partial double counting of network effects, this interdependence between the sides would be weaker because it would affect only part of the market that the platform covers. Thus, a potential subsidy would bring lower benefits to the platform, which would weaken the incentive to subsidize one side.

Our analysis of the setting with multihoming on both sides established that although under platform competition the interdependence between the two sides plays a key role in environments with single-homing on at least one side, this interdependence is of lesser importance, and may disappear completely, when the platforms are competing in an environment where multihoming on both sides is possible. In the absence of this interdependence, it is never optimal for the platforms to subsidize one side. This interdependence can be reintroduced when the benefit of meeting the same other-side participant on both platforms is at least partially additive or when the market is not fully covered despite multihoming. However, the presence of multihoming on both sides makes this interdependence weaker and therefore the benefits from subsidizing smaller or nonexistent.

6. Conclusion

In this paper, we analyze platform competition when agents multihome on both sides. This is an increasingly important case as technology makes joining multiple platforms easier and, as a result, participants on both sides of two-sided platforms increasingly multihome. This case of multihoming on both sides has been mostly ignored in the literature, including the work establishing the central result in platform competition for the pricing interdependence between the two sides of the market, which implies that it may be optimal for a platform to subsidize one side.

We develop a model for platform competition in a differentiated setting (a Hotelling line), which is similar to other models in the literature but focuses on the case where at least some agents on each side multihome. Once we allow for multihoming on both sides, it is important to specify the utility of the multihoming users who meet multihoming users on the other side—that is, they meet each other twice on the two platforms. Do they obtain the benefit of interaction twice or only once?

In the base model, we analyze the case where participants meeting on both platforms obtain the benefit only once (no double counting). It is reasonable to assume, for instance, that in online retailing, there is little incremental value in having a potential buyer see a seller's product listing on eBay once that same listing has already been seen by that buyer on Amazon Marketplace. For this specification, we show that

- under certain conditions, equilibria exist with multihoming on both sides;
- when we have multihoming on both sides, the interdependence between the two sides plays out differently than under single-homing; specifically, there is no interdependence between the two sides of the same platform; and
- optimal pricing for a platform on one side depends on the prices of the other platform only, and thus it is never optimal to subsidize the other side (no divide-and-conquer strategy).

These results differ from most of the two-sided platform literature, where interdependence between the two sides served by the same platform is a major result leading to the implication that a platform will often maximize its total profits by subsidizing one side. Thus, the common strategic advice to subsidize one side in order to maximize total profits may be limited or even incorrect when both sides multihome, which can be significant given the increasing prevalence of multihoming.

Although we start with the assumption that meeting the same agent on both platforms brings no incremental benefit compared with meeting on one platform, we also discuss a more general formulation, where the agents can gain a partial benefit from meeting each other the second time. In this case, the interdependence is present again. However, the degree of interdependence strongly depends on the size of the benefit from the second meeting. If the incremental benefit is small, the interdependence is also weak, and pricing of the other platform is a much more important factor in determining a platform's optimal price than its own pricing on the other side. If, by contrast, meeting again on the second platform is almost as valuable as meeting for the first time, the strong interdependence between the two sides of the same platform reappears, and the conventional platform pricing strategy advice may apply.

Acknowledgments

The authors thank Bernard Caillaud, Martin Peitz, Bill Rogerson, Yossi Spiegel, Sebastian Steffen, Larry White, and attendees at the 2017 Asia-Pacific Industrial Organization Society Conference, the 2018 Toulouse Digital Economics Conference, the 2018 Workshop on Information Systems and Economics, the 2019 Platforms Symposium at Boston University, the 2019 NET Institute Conference, the 2019 Theory Industrial Organization Theory Conference at the University of California, Berkeley, and seminars at New York University and the Massachusetts Institute of Technology for helpful comments and discussions. They also thank the department editor, Joshua Gans, and the anonymous review team for their insightful comments and suggestions that greatly helped to improve this paper.

Endnotes

[1] Both the business and economics literatures recognize that subsidies are common in platform businesses (Eisenmann et al. 2006, Rochet and Tirole 2006). A number of papers specifically study the role of subsidies in platform competition, under the name of *divide-and-conquer pricing* (Caillaud and Jullien 2003, Jullien 2011).

[2] Interestingly, these platforms frequently take strategic actions to discourage multihoming, for example, in the case of ridesharing loyalty rewards or nonlinear pricing such as up-front fees and lower marginal costs on the consumer side and attempts to lock in drivers, for example, with vehicle financing or insurance programs that restrict participation in other platforms.

[3] For this equilibrium to hold, the utilities of the indifferent users on sides X and Y need to be positive (to ensure full coverage), which is the case if $2\sigma_x > 3z - Y(\alpha + 2\beta)$ and $2\sigma_y > 3qY - (2\alpha + \beta)$. Also, platform profits must be nonnegative, which is the case as long as $3z - Y(\alpha + 2\beta) > 0$ and $3qY - (2\alpha + \beta) > 0$.

[4] This equilibrium exists when $2\sigma_y + \alpha + \beta > 2qY$ and $2(\alpha + \beta)\sigma_y + 4q\sigma_x > 6(qz - \alpha\beta) - (\alpha - \beta)^2$.

[5] This is a property of the Hotelling model with platforms A and B located at the ends of the Hotelling line. In Section 5, we discuss how our results change if the platforms are not located at the ends of the Hotelling line and multihoming may occur without full coverage.

[6] Double counting the stand-alone values keeps the setting comparable to the benchmark case of multihoming on one side. We later comment on how double counting and partial double counting of network effects affect our results.

[7] Formulas in (5) are obtained using derivations similar to those leading to (4).

References

Ambrus A, Calvano E, Reisinger M (2016) Either or both competition: A "two-sided" theory of advertising with overlapping viewerships. *Amer. Econom. J. Microeconom.* 8(3):189–222.

Anderson SP, Foros O, Kind HJ (2016) Competition for advertisers and for viewers in media markets. *Econom. J.* 128(608): 34–54.

Armstrong M (2006) Competition in two-sided markets. *RAND J. Econom.* 37(3):668–691.

Athey S, Calvano E, Gans JS (2018) The impact of consumer multihoming on advertising markets and media competition. *Management Sci.* 64(4):1574–1590.

Belleflamme P, Peitz M (2019) Platform competition: Who benefits from multi-homing. *Internat. J. Indust. Organ.* 64:1–26.

Bryan KA, Gans JS (2018) A theory of multi-homing in rideshare competition. NBER Working Paper No. 24806, National Bureau of Economic Research, Cambridge, MA.

Caillaud B, Jullien B (2003) Chicken & egg: Competition among intermediation service providers. *RAND J. Econom.* 34(2): 309–328.

Choi JP (2010) Tying in two-sided markets with multi-homing. *J. Indust. Econom.* 58(3):606–627.

Choi JP, Jullien B, LeFouili Y (2017) Tying in two-sided markets with multi-homing: Corrigendum and comment. *J. Indust. Econom.* 65(4):872–886.

Doganoglu T, Wright J (2006) Multihoming and compatibility. *Internat. J. Indust. Organ.* 24(1):45–67.

Eisenmann T, Parker G, Van Alstyne MW (2006) Strategies for two-sided markets. *Harvard Bus. Rev.* 84(10):92–10.

Hagiu A, Halaburda H (2014) Information and two-sided platform profits. *Internat. J. Indust. Organ.* 34(May):25–35.

Jeitschko TD, Tremblay MJ (2017) Platform competition with endogenous homing. Working paper, Michigan State University, East Lansing.

Jullien B (2011) Competition in multi-sided markets: Divide and conquer. *Amer. Econom. J. Microeconom.* 3(4):186–219.

Liu C, Teh TH, Wright J, Zhou J (2019) Multi-homing and oligopolistic platform competition. Working paper, National University of Singapore, Singapore.

Rochet JC, Tirole J (2003) Platform competition in two-sided markets. *J. Eur. Econom. Assoc.* 1(4):990–1029.

Rochet JC, Tirole J (2006) Two-sided markets: A progress report. *RAND J. Econom.* 37(3):645–667.