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

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

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Abstract

As the costs of joining platforms decrease, we often see participants in both sides of two-sided platforms to multihome, a case 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 Hoteling 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 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, compared to models that assume single-homing on at least one side of the market.

The implication is that when multihoming may be present on both sides of the market, the benefit of subsidizing one side (typically the one with higher price elasticity) is diminished or may not be present at all. This outcome differs 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 policy implication that a platform will often maximize its total profits by subsidizing one side, typically the one with more elastic demand. Our analysis shows 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 can be significant given the increasing prevalence of multihoming.

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

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1 Introduction

The literature on competition between two-sided platforms, going back to Armstrong (2006) and Rochet and Tirole (2006), mostly ignores the 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 of the platform while they impose single homing on the other side. These models also typically assume full coverage on both sides, i.e. that all agents participate on at least one platform.

The argument in favor of 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; as all possible pairs of agents could already connect with each other. This assumption is limiting, however, if each side of the market only partially multihomes, in which case multihoming on the other side does generate new potential interactions between agents on the two sides of the market. It is also limiting if the platforms are differentiated, in which case two agents meeting on one platform would create different surplus than the same agents meeting on a different platform.

A major 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 a platform may maximize its total profits by subsidizing one side, a typical example being that it may be optimal for a content distribution platform like 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.

In this paper we develop a model for platform competition in a differentiated setting (a Hoteling line), which is similar to other models in the literature. However we focus on the case where at least some agents on each side multihome, and 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, compared to models that assume single-homing on at least one side of the market. The implication is that when multihoming may be present on both sides of the market, the benefit of subsidizing one side (typically the one with higher price elasticity) is diminished or may not be present at all.

Our results suggest that we need to be wary of overstating the importance of the interdependence even when it does exist, or we risk missing the important drivers of the market equilibrium, and give wrong strategic advice. This is a significant departure from the two-sided platform literature, which identifies interdependence between the two sides served by the same platform, and has policy implications about a platform's ability to maximize total profits by subsidizing one side.

2 Related Literature

While most of the literature on competition between two-sided platforms assumes single homing on at least one side, some papers allow for multi-homing on both sides, typically in specialized settings. An early example is 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.

Choi (2010) and Choi, Jullien and LeFouili (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; while the focus of their analysis is on tying, under certain parameters of their setting the resulting equilibria involve multi-homing on both sides of the market. Ambrus, Calvano and Reisinger (2016) and Anderson, Foros and Kind (2016) also 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 feasibility of subsidies by the platforms in terms of the conditions necessary to make such subsidies profitable.

Belleflamme and Peitz (2017) study how competition between two-sided platforms is shaped by the possibility of multihoming and contrast single homing on both sides of a market with multihoming on one side. 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 singlehoming side. Bellaflamme and Peltz 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 multi home.

Jeitschko and Tremblay (2017) study entry and competition in a two-sided market where the two sides of the market (firms and consumers) are heterogeneous and the homing decision is endogenized. They consider a monopolist platform as well as 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 multi-homing and single-homing on both sides of the market. Cross-subsidization only takes place in the monopoly case, and thus they do not address the profitability of subsidies in a setting with competing platforms.

Liuy 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, but they assume such multihoming will take place rather than derive it endogenously.

This emerging literature provides an increasing solid theoretical foundation for the importance of equilibria in platform competition that are characterized by multi-homing on both sides. Given the centrality of the cross-subsidization result in the literature on platform competition, it is thus important to note our results that such cross-subsidization strategies are not profitable when both sides multihome,

3 Model

We consider a setting with two types of potential participants (sides), X and Y, which are specially differentiated along segments $[0, 1]$ and $[0, Y]$ respectively. There is two-sided Hoteling competition between the two platforms, A and B that are located at the ends of these segments, with A at 0 in both sides and B respectively at 1 and Y. Specifically, the setting is characterized by:

– two-sided Hoteling competition

– side X, $x \sim U[0, 1]$

– side Y, $y \sim U[0, Y]$, $Y \gtreqless 1$

– two platforms, A and B, located at 0 and 1 (Y)

– platforms charge p_i, $i = A, B$ on side X and r_i on side Y

– user located at x on side X (resp. y on Y) receives following 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 y_A etc is the number of agents on side Y that participate in platform A.

– A_x, A_y — stand-alone values of platform A for X and Y users

– α, β — "network effect" of the other side on side X and Y

– z, q — "transportation cost": loss of utility due to preference mis-match, or set-up costs

The setup of this model is shown in Figure 1. An application of this model to gaming platforms (e.g., Xbox vs 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 prior experience of application developers), with multihoming consumers purchasing both platforms, and multihoming developers making their games available on both platforms.

Similarly, an application to ride sharing could have the two platforms adopt different levels of idleness for their drivers, 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, along the lines of Bryan and Gans (2018). In this case, single homing agents would only consider one ride sharing platform as drivers or consumers, while multihoming agents would consider both platforms and endogenously select to join one or both.

4 Single-homing benchmark

We begin by analyzing as a benchmark the case with full coverage and single-homing, as is typical in most of the literature on platform competition.

– imposing single-homing and full coverage: $x_A = x_B = \tilde{x}$ s.t. $u(\tilde{x}; A) = u(\tilde{x}; B)$ and $y_A = y_B = \tilde{y}$

$$\tilde{x} = \frac{z + A_x - B_x + 2\alpha\tilde{y} - \alpha Y - p_A + p_B}{2z}$$

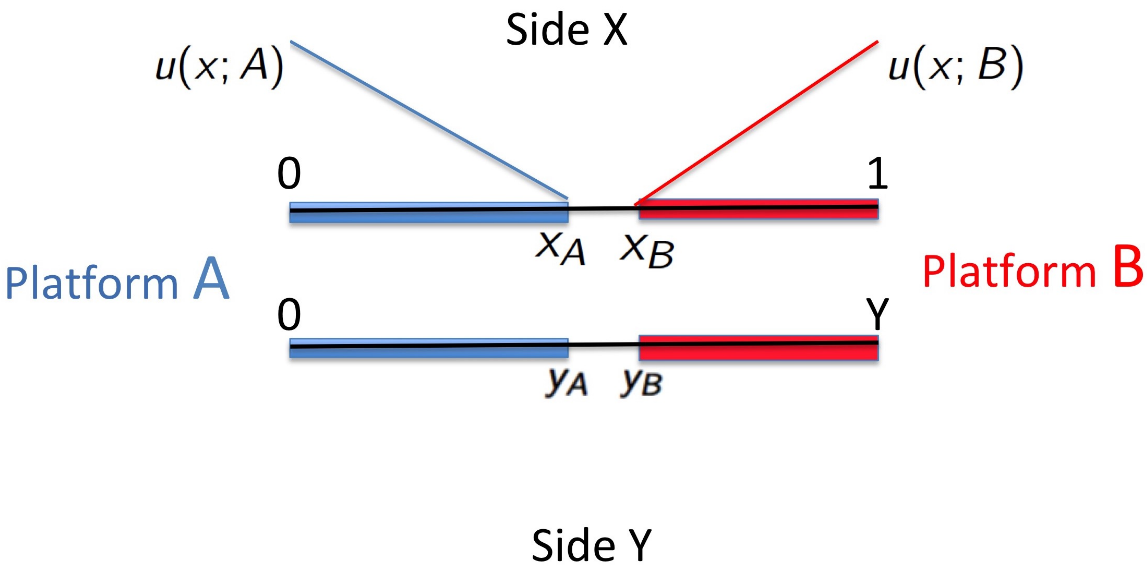


Figure 1: Setup

$$\tilde{y} = \frac{qY + A_y - B_y + 2\beta\tilde{x} - \beta - r_A + r_B}{2q}$$

– $\tilde{x}$ depends on p_A, p_B and r_A, r_B

– interdependence for each platform between its prices on the two sides

5 Allowing for multihoming on both sides

We now allow for multihoming on both sides of a platform.

Utility when multihoming. We first characterize the utilities agents get when multihoming, $u(x; A\&B)$ and $u(y; A\&B)$.

The market coverage of platform A is given by x_A, and $1 - x_B$ is the market coverage of platform B. Multihoming on side X occurs when $x_A > x_B$. Multihoming on both sides occurs when $x_A > x_B$ and $y_A > y_B$. In such a case, an x agent who is multihoming may meet the same y agents on both platforms, as y agents are multihoming as well; and vice versa.

There are many possibilities for the functional form of $u(x; A\&B)$ and $u(y; A\&B)$. When two agents meet on two different platforms, they could receive the network benefit twice (once on each platform). We call that case "double-counting" of the network effects from the overlapping agents. At the other extreme, the agents may get the benefit only from meeting once, and no additional benefit from meeting again — "no double counting." In the intermediate case, meeting for the second time may yield partial additional network advantage — "partial double counting." Similarly we need to consider the benefit from intrinsic values of the two platforms when an agent is multihoming.

For the base case of our analysis, we assume double counting of intrinsic values, but no double counting of the network effect from overlapping agents. Even though X side users may meet some Y side users on both platforms, they only get the network benefit once. Therefore, joining both platforms when $y_A \geq y_B$ yields

$$u(x; A\&B) = A_x + B_x + \alpha Y - p_A - p_B - z$$

Utility of an agent joining A only, without having joined the other platform, is given by $u(x; A)$. Note that

$$u(x; A\&B) < u(x; A) + u(x; B) \text{ if } y_A > y_B$$

Similarly for $u(y; A\&B)$.

Decision to participate in both platforms. An agent will multihome when multihoming yields higher utility than joining only platform A, only platform B, or not joining either of the platforms.

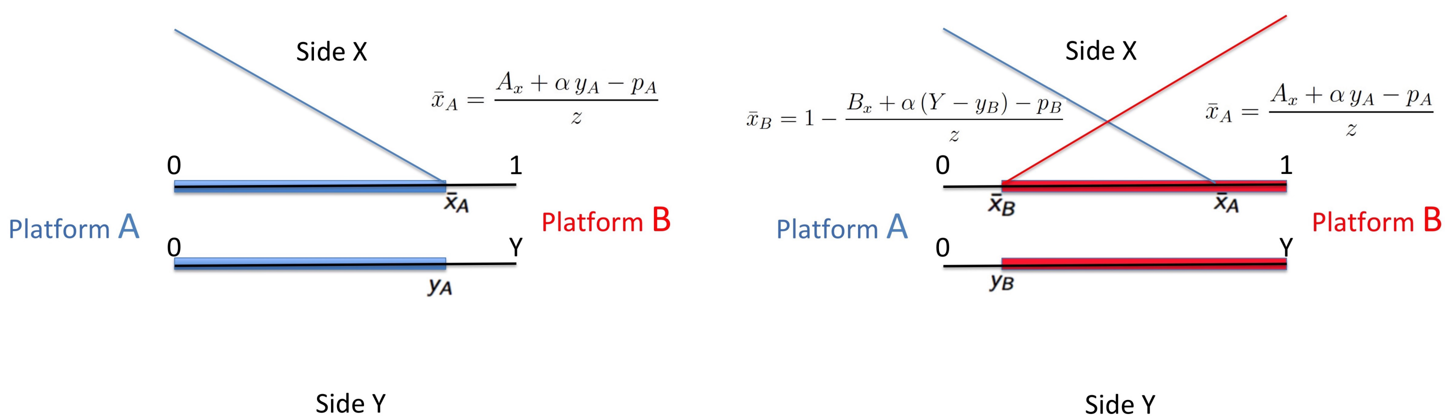
Utility of an agent joining A without having joined the other platform is given by $u(x; A)$ as in (1). Therefore, the agent indifferent between joining platform A only and not joining any platform at all, $\bar{x}_A$, is characterized by $u(\bar{x}_A; A) = 0$, i.e.,

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

Users $x < \bar{x}_A$ would prefer to join A while users $x > \bar{x}_A$ would prefer not to join at all (see Figure 2a). I.e., $\bar{x}_A$ would be the market captured by platform A if it was the only platform.

Similarly, given only the choice of platform B or no platform, all users $x > \bar{x}_B$ would prefer to join B, while $x < \bar{x}_B$ would not join (see Figure 2b), where

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



(a) (b)

Figure 2

With multihoming, 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

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

Note that if there is multihoming on side Y, this incremental utility $u(x; A|B)$ must be less than $u(x; A)$.[1] That means that some agents who might have joined A if no other platform was available, would not have joined A as the second platform. I.e., 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 agent who is indifferent between joining A in addition to B, and just staying with B only. This agent, denoted by $\hat{x}_A$, is characterized by $u(\hat{x}_A; A|B) = 0 \iff u(\hat{x}_A; A\&B) = u(\hat{x}_A; B)$.

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

In the case of multihoming on both sides, platform A captures market of size $\hat{x}_A$ on side X. It is straightforward to note that since $y_A > y_B$, then $\hat{x}_A < \bar{x}_A$.

Notice the difference between formulas (2) and (4). The threshold $\bar{x}_A$ depends on the number of opposite-side agents available on the same platform, y_A. That is, it depends on pricing decision of the same platform A. But $\hat{x}_A$ depends on y_B, which depends on the pricing decision of *the other* platform.

Interestingly, 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 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 of 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

[1] Another thing to note is that (3) is valid no matter what we take for $u(x; A\&B)$, i.e., whether we double count intrinsic values and the network effect from overlapping platform members.

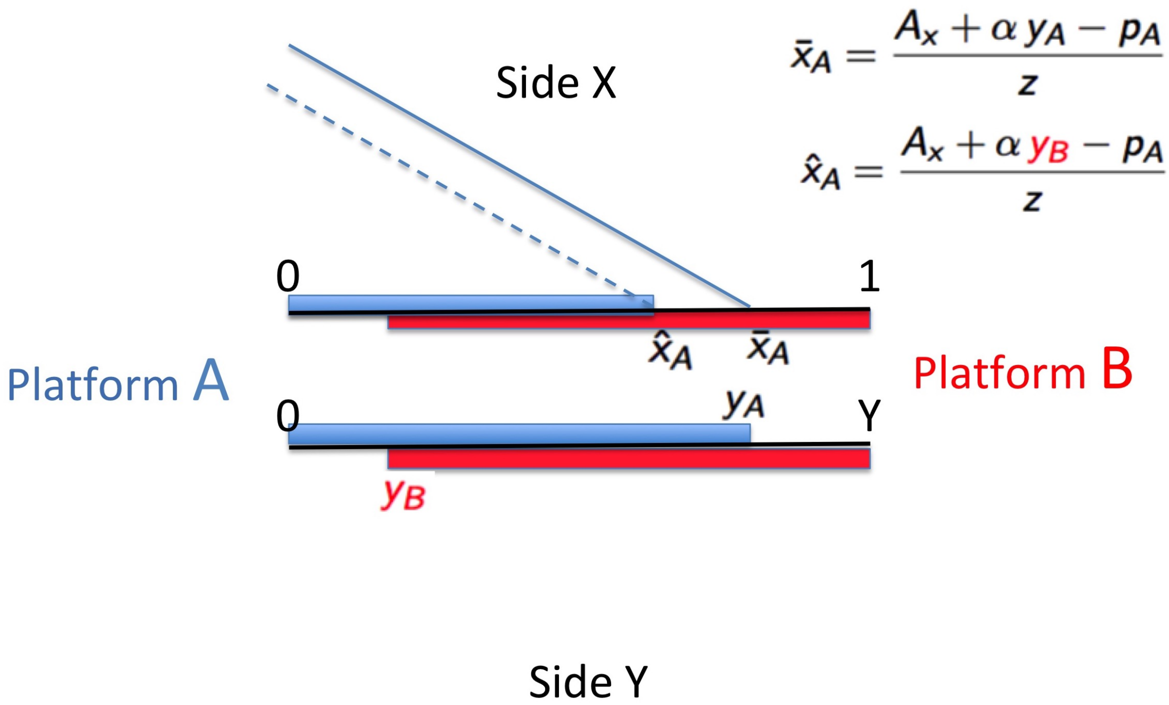


Figure 3: Market coverage of platform A when multihoming on both sides occurs, $\hat{x}_A$

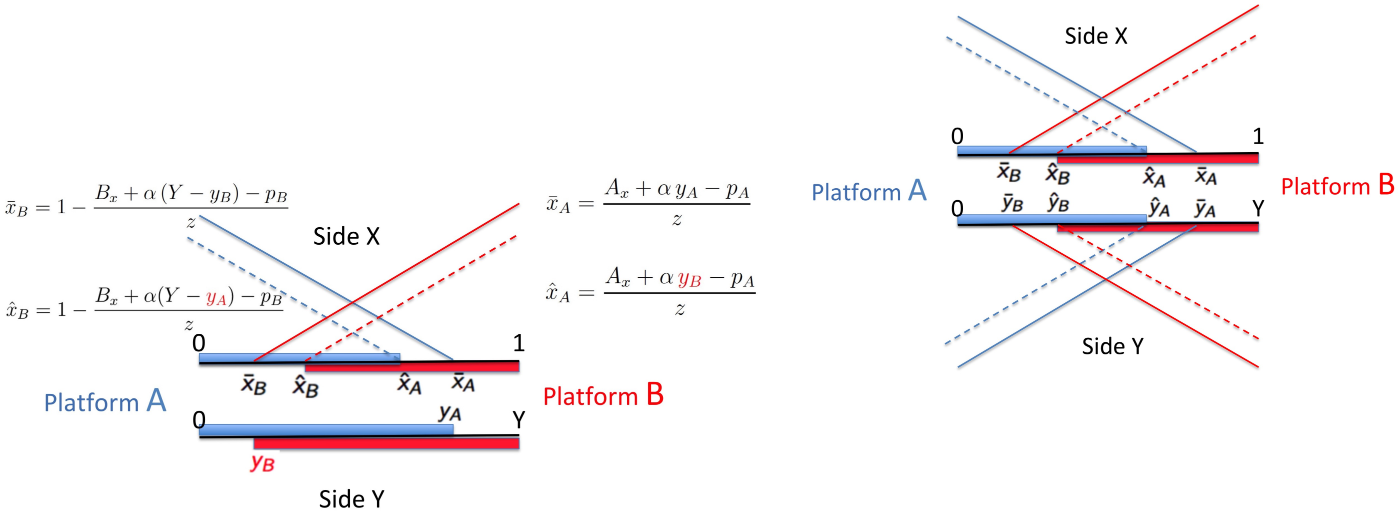
the marginal side X agent already has access to these side Y agents on platform B.

More formally, the profit maximizing $\bar{x}_A^*$ depends on p_A and r_A, the two prices set by platform A. The profit maximizing $\hat{x}_A^*$, however, depends on p_A and r_B, but not on r_A. Thus $\hat{x}_A^*$, which is the relevant profit maximizing price on side X, does not depend on the price set by platform A on the Y side.

6 Equilibria with multihoming on both sides

The focus of our analysis in this section is to characterize equilibria where agents on both sides multihome, and especially equilibria where only some agents on both sides multihome, while others singlehome. We call it *partial multi-homing*.

Partial multihoming on both sides occurs in equilibrium when $\hat{x}_A > \hat{x}_B$ and $\hat{y}_A > \hat{y}_B$.



(a) (b)

Figure 4: Participation decision with multihoming on both sides

Note also that in such a case: $x_A = \hat{x}_A$, $x_B = \hat{x}_B$, $y_A = \hat{y}_A$ and $y_B = \hat{y}_B$. Using the derivation of the previous section, we obtain

$$\begin{aligned}
\hat{x}_A &= \frac{A_x + \alpha \hat{y}_B - p_A}{z} \\
\hat{x}_B &= 1 - \frac{B_x + \alpha(Y - \hat{y}_A) - p_B}{z} \\
\hat{y}_A &= \frac{A_y + \beta \hat{x}_B - r_A}{q} \\
\hat{y}_B &= Y - \frac{B_y + \beta(1 - \hat{x}_A) - r_B}{q}
\end{aligned} \tag{5}$$

Note the 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.

Proposition 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 sane platform when maximizing profit. I.e., the profit* *maximizing p_i^* does not depend on r_i^*.*

Proof. This follows directly from FOC for profit maximization. Technically, r_i does not enter the FOC for maximizing profit with respect to p_i.

Corollary 1 *In the environment described in Proposition 1, it is never profitable for a platform to subsidize one side of the market, i.e., charge a negative price.*

The strategic interaction between $\hat{x}_A$ and $\hat{y}_B$ is fueled by the strength of the network effects). When network effects are strong, i.e., $\alpha\beta > q\,z$, then no pure strategy equilibrium with partial multihoming exists. However, there may exist equilibria with multihoming on both sides where thresholds are outside of the interval, even for strong network effects.

In the rest of the proposal we focus on the case where network effects are weaker than transportation costs, i.e., $\alpha\beta < q\,z$.

For $\alpha\beta < q\,z$, equilibrium with partial multihoming on both sides is characterized by

$$\hat{x}_A^* = \frac{q(A_x(2qz-\alpha\beta)-\alpha(B_y z-2qYz+z\beta+Y\alpha\beta))}{(qz-\alpha\beta)(4qz-\alpha\beta)}$$
$$\hat{y}_A^* = \frac{z(A_y(2qz-\alpha\beta)-\beta(B_x q-2qz+qY\alpha+\alpha\beta))}{(qz-\alpha\beta)(4qz-\alpha\beta)}$$
$$\hat{x}_B^* = \frac{2q^2z(2z-Y\alpha)+\alpha^2\beta^2+B_x q(-2qz+\alpha\beta)+q\alpha(A_y z-4z\beta+Y\alpha\beta)}{(qz-\alpha\beta)(4qz-\alpha\beta)}$$
$$\hat{y}_B^* = \frac{4q^2Yz^2+qz(A_x-2z-4Y\alpha)\beta+\alpha(z+Y\alpha)\beta^2+B_y z(-2qz+\alpha\beta)}{(qz-\alpha\beta)(4qz-\alpha\beta)}$$

And

$$
\begin{aligned}
p_A^* &= -\frac{A_x(-2qz+\alpha\beta)+\alpha(B_y z-2qYz+z\beta+Y\alpha\beta}{4qz-\alpha\beta} \\
r_A^* &= -\frac{A_y(-2qz+\alpha\beta)+\beta(B_x q-2qz+qY\alpha+\alpha\beta)}{4qz-\alpha\beta} \\
p_B^* &= \frac{(B_x(2qz-\alpha\beta)-\alpha(A_y z-2qYz+z\beta+Y\alpha\beta)}{4qz-\alpha\beta} \\
r_B^* &= \frac{B_y(2qz-\alpha\beta)-\beta(A_x q-2qz+qY\alpha+\alpha\beta)}{4qz-\alpha\beta}
\end{aligned}
$$

Proposition 2 *For an appropriate range of parameters, there exists a pure strategy equilibrium with multihoming on both sides .*

Proof. For now, we prove the existence by providing a set of parameters for which such an equilibrium exists. We plan to derive soon an analytical formulation for the applicable range of parameters.

Consider the following parameter values: $\alpha = \beta = 0.1$; $q = z = 0.2$; $A_x = A_y = B_x = B_y = 0.26$; $Y = 1$. These values result in the following pure strategy equilibrium: $p_A = r_A = p_B = r_B = 0.12; x_A = y_A = 0.8; x_B = y_B = 0.2$ and profits $\pi_A = \pi_B = 0.192$. ■

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 singlehoming arises endogenously.

7 Meeting the same agent on additional platforms yields incremental network benefit

So far, we have assumed that participants that overlap on multiple networks do not derive additional benefit from being able to meet on more than one platform; in other words there is no double counting of overlapping network members and no double counting of the corresponding network effects. Under this assumption, we have arrived at equilibrium conditions (5), which indicate that there is no interdependence between pricing decisions on the two sides by the same platform. It is a striking result, especially when compared with the single homing benchmark.

As we have noted in Section 5, there are many possibilities for how utility of multihomers is specified. Different specifications may be more suitable for different markets.

In this section, we generalize the analysis, by allowing partial double counting of the network effects in the utility of multihomers. That is, meeting the same agent on the second platform yields some incremental network benefit above the network benefit from meeting him on the first platform. As we will see, when the partial double counting is allowed, the interdependence in pricing of two sides by the same platform is present again. However, the strength of this interaction directly depends on the size of the double-counting. With very little double-counting, the interdependence is negligibly small.

Our aim in this analysis is to point out that while the interdependence plays primary role in environments with assumed single-homing, the interdependence is of lesser importance, and may disappear completely, when the platforms are competing in an environment where multihoming on both sides is possible.

Set up of the generalized problem. The measure of the multihoming agents on side Y is $y_A - y_B$. The utility of a multihoming agent x is

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

where $\omega \in [0, 1]$ is the size of the double-counting. For $\omega = 0$, there is no double counting. In the special case of $\omega = 1$, $u(x; A\&B, \omega = 1) = u(x, A) + u(x, B)$. That is, the agent gets full double benefit from meeting a Y agent twice on the two platforms. In a way, it means that the two platforms provide different benefits, and there isn't much competition between them.

Now, even with ω, formula (3) is still valid

$$u(x; A|B, \omega) = u(x; A\&B, \omega) - u(x; B) = A_x + \alpha[\omega y_A + (1 - \omega)y_B] - p_A - z\,x\,.$$

And thus

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

Based on the discussion at the end of Section 5, ω measures the interdependence between the price platform A sets on side Y, and how attractive it is to agents on side X. This interdependence ranges with the value of ω, and for small ω is close to negligible. With small ω, the price set by the other platform on side Y is much more important to determining $\hat{x}_A$.

Note also that for $\omega = 1$, $\hat{x}_A(\omega = 1) = \bar{x}_A$, while for $\omega < 1$, $\hat{x}_A(\omega) < \bar{x}_A$.

Proposition 3 *If there is some incremental network benefit of meeting the same other-side agent on both networks ("double counting" of common agents), the strength of the interdependence between the prices charged on the two sides by the same platform is determined by the strength of the above double counting.*

8 Conclusion

In this paper we analyze platform competition when agents multihome on both sides. This is an increasingly important case, as the cost of joining platforms is often low, and as a result participants in both sides of two-sided platforms increasingly multi home. 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 often it is optimal for a platform to subsidize one side.

We develop a model for platform competition in a differentiated setting (a Hoteling 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 what is 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 in 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 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
- 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 policy implication that a platform will often maximize its total profits by subsidizing one side, typically the one with more elastic demand. 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.

While we start with the assumption that meeting the same agent on both platforms brings no incremental benefit compared to meeting on one platform, we also extend our analysis to a more general formulation, where the agents can gain 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 partial benefit is very small, the interdependence is also negligible and pricing of the other platform is a much more important factor in determining a platform's optimal price. If, on the other hand, meeting again on the second platform conveys significant additional benefit, the interdependence between the two sides of the same platform reappears, and the conventional pricing strategy advice applies once again.

In conclusion, we need to be wary of overstating the importance of the interdependence even when it does exist, or we risk missing the important drivers of the market equilibrium, and give wrong strategic advice.

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