Exclusive Dealing in Asymmetric Platform Competition

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Abstract

This paper studies exclusive dealing by asymmetric platforms on sellers who have heterogeneous preferences between the two platforms. Exclusivity may arise because it softens price competition by either or both platforms. As a result, exclusivity can be introduced by the strong platform alone, the weak platform alone, or both. In each case, exclusivity appears only when the initiator's service is marginally valuable to sellers. Platform asymmetry facilitates the weak platform's adoption of exclusivity and hinders the strong platform's. When few sellers would have multihomed anyway, only the strong platform will introduce exclusivity, which benefits society, buyers, and sellers as a whole. When only the weak platform introduces exclusivity, by contrast, welfare and sellers are both hurt.

Keywords: Asymmetric platform competition, multihoming, singlehoming, exclusive dealing, welfare, regulation policy

JEL code: D43, L12, L13, L14, L42

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1 Introduction

A platform provides a marketplace for buyers and sellers to interact. In many industries, multiple platforms coexist, and one way for a platform to compete is to forbid its sellers from operating on rival platforms. For example, Chinese e-commerce giant Alibaba does not allow its sellers to sell on its major competitor, JD.com.[1] In the US, UK, and Canada, the large peer-to-peer carsharing platform Turo prohibits its car hosts from listing the same vehicle on rivalrous platforms.[2] In South Korea, Google Play makes exclusive deals with app developers, thwarting the largest local app marketplace One Store.[3] Competing food delivery platforms, such as Foodpanda and Deliveroo in Singapore and Hong Kong, and Meituan and Ele.me in China, impose mutually exclusive deals on their restaurants.[4] Ride-hailing start-up Grab recruited taxis and drivers in Singapore on the condition that they stay away from the more established platform, Uber.[5]

In these examples, platforms compete with asymmetric strength, and exclusivity can be introduced by the strong platform or the weak platform or both. The practice has recently raised concerns from regulators. In a number of countries, the antitrust authorities have investigated platforms' exclusive dealing and have come to different conclusions and regulations.[6]

The competitive behavior and divergent regulation policy call for further studies of exclusive dealing on platforms. In particular, what drives a platform to introduce exclusivity? How do asymmetric platforms differ in their incentives? What are the welfare consequences? Does the welfare consequence depend on which platform introduces exclusivity?

To study these questions, we build a model of platform competition with user heterogeneity in their platform preferences (Armstrong, 2006; Bakos and Halaburda, 2020). Two platforms differ in their intrinsic values and compete with uniform membership fees on sellers.[7] Each platform independently decides whether to forbid its sellers from transacting on the rival plat-

[1] https://www.reuters.com/article/us-jd-com-alibaba-idUSKCN0SS17820151103

[2] Canadian Competition Bureau's investigation of Turo's exclusivity policy can be found at https://www.competitionbureau.gc.ca/eic/site/cb-bc.nsf/eng/04668.html.

[3] https://www.wsj.com/articles/south-korea-fines-google-32-million-for-squeezing-out-local-rival-37dc76c9

[4] The report on food delivery platforms' exclusive dealing in Singapore can be found at https://www.todayonline.com/singapore/concerns-over-exclusive-deals-between-delivery-services-and-eateries. The report on Hong Kong Competition Commission's investigation of food delivery platforms' exclusivity can be found at https://www.scmp.com/news/hong-kong/society/article/3164987/hong-kong-antitrust-watchdog-investigates-foodpanda. Meituan has been fined nearly 1 billion dollars by China's regulators for its exclusivity arrangements with restaurants: https://www.wsj.com/articles/chinas-antitrust-regulator-planning-to-fine-meituan-about-1-billion-11628238951.

[5] https://www.todayonline.com/singapore/grab-signs-exclusive-partnership-smrt-build-largest-car-fleet-singapore

[6] The Competition Commission of Singapore believes that food delivery platforms' exclusive deals in Singapore are motivated by the vibrant competition for market shares and should not be a concern as long as the market is competitive (https://www.cccs.gov.sg/media-and-consultation/newsroom/media-releases/investigation-of-online-food-delivery-industry). The Competition Bureau of Canada, the South Korean FTC, and China's antitrust authority believe that a platform's dominance leads to exclusivity, which further strengthens the platform's market power and hurts its weak rivals. The Competition Commission in Hong Kong believes that exclusivity by food delivery platforms may weaken competition and hurt consumers (https://www.compcomm.hk/en/media/press/files/PR_Online_Delivery_Platform_EN.pdf).

[7] The buyer membership fee is assumed to be zero in the main model for simplicity. Consumers rarely pay to join a platform in industries that we have in mind in this study, such as e-commerce, food delivery, and ride-hailing. In the extension of Section 5.1, we show that introducing an endogenous buyer membership fee does not change any major result.

form, a practice referred to as exclusivity. If at least one platform enforces exclusivity, no seller can multihome, and exclusivity prevails in equilibrium. We focus on the parameter space where some sellers indeed multihome when no platform enforces exclusivity.

In the benchmark multihoming subgame, sellers with strong preferences singlehome, and sellers with weak preferences multihome. The equilibrium characteristics are shaped by the two platforms' intrinsic values (i.e., the inherent attractiveness) to sellers, referred to as platform *strength*. In particular, the total number of multihoming sellers is determined by the two platforms' *joint strength*, whereas the distribution of all sellers between the two platforms, regardless of single- or multi-homing, is determined by the two platforms' relative strengths, referred to as the *strength asymmetry*. Fixing the joint strength, as the asymmetry rises, the seller base expands on the strong platform and declines on the weak platform.

A platform enforces exclusivity if and only if its profit rises, where the profit comes entirely from the total membership fee collected from sellers who transact on the platform. There may be two cases in which exclusivity may arise in equilibrium, and they are driven by different forces. In the first case, there are many multihoming sellers to begin with, and exclusivity causes both platforms to lose sellers. Then a platform may find exclusivity profitable only if it can raise sellers' membership fee. Compared to the multihoming equilibrium, exclusivity affects the equilibrium level of the membership fee through two opposite forces. On the one hand, a platform tends to compete more aggressively (i.e., to lower the membership fee) given that it now loses sellers. On the other hand, a platform may also tend to compete less aggressively (i.e., to raise the membership fee). In multihoming, a seller considers whether to join a platform; under exclusivity, a seller considers which platform to join. This makes a seller's platform preference much more relevant in its homing choice. Because some marginal sellers strongly prefer the rival platform, a lower fee becomes less effective for a platform to recruit sellers. That's the reason why a platform may compete less aggressively (Chen and Riordan, 2008; Belleflamme and Peitz, 2019). If the second effect dominates so that exclusivity mitigates the two platforms' price competition, then it may be profitable for one or even both platforms to introduce exclusivity.

In this model, sellers have different preferences between the two platforms despite unanimous ranking of their intrinsic values: Some sellers prefer this platform, and some prefer that platform. Such heterogeneity plays an important role in the logic explained above. On the one hand, because some sellers strongly prefer the rival platform, it is increasingly costly for a platform to expand its seller base through exclusivity. On the other hand, exclusivity makes a seller's platform preference more relevant: The seller has to choose between the two platforms rather than between joining and not joining a given platform. This softens the platforms' price competition. The two forces have opposite effects on a platform's exclusivity incentives, which in turn implies that exclusivity may not always be preferred by a platform despite the cross-side network effect and, when exclusivity is indeed implemented, it can be driven mainly by the price effect (i.e., it forces sellers to pay a higher membership fee) rather than the quantity effect (i.e., it forces most sellers to abandon the rival platform).

So much for the first case of exclusivity. In the second case, there are few multihoming sellers to begin with, and exclusivity can be a profitable strategy for the strong platform (but not the weak platform) because it alters the nature of the two platforms' price competition. Given that few sellers would have multihomed anyway, when exclusivity is in force, each platform loses a relatively small number of sellers. As a result, the weak platform responds to the strong platform's lower price by *raising* its own price, whereas under multihoming equilibrium, the weak platform responds by *lowering* its own price. In other words, exclusivity turns the two platforms' price competition from strategic complements into strategic substitutes. This allows the strong platform to price aggressively, which will increase its seller base by not only keeping all the multihoming sellers, but also by obtaining some sellers who originally singlehome on the weak platform.

Through these two mechanisms, a particular combination of the two platforms' strengths may lead to exclusivity by none, either or both platforms. Win-win is possible (i.e., both platforms enforce exclusivity) because of the mitigation of platform competition. It is also possible for the weak platform alone to introduce exclusivity. Given its smaller size of inframarginal sellers, the platform is less constrained than its stronger rival in platform competition, which allows the weak platform to compete aggressively and to lose few sellers.[8] Finally, exclusivity may be introduced by the strong platform alone because it softens the rival platform's competition and allows the strong platform to attract more sellers, taking advantage of the expanded network effects. In general, a lower joint strength tends to favor exclusivity by the strong platform, while a higher joint strength tends to favor the exclusivity of the weak platform. A greater strength asymmetry between the platforms is conducive to the weak platform's exclusivity adoption and works against adoption by the strong platform.

Consumer surplus and social welfare can be improved by exclusivity. This happens when the joint strength is small so that exclusivity allows most sellers and buyers to coordinate onto the strong platform, generating strong cross-side network effect that may benefit not only buyers and total welfare but also sellers as a whole. Although a platform's strength is not directly observable, it can be inferred from the identity of exclusivity enforcers, providing a helpful guide to public policy. In particular, welfare rises only when exclusivity is introduced by the strong platform alone, never rises if introduced by the weak platform alone, and rarely

[8]When competing for marginal sellers under exclusivity, the strong platform does not necessarily enjoy any advantage over its weaker rival because platform differentiation and asymmetry imply that some marginal sellers prefer the weak platform.

rises if both platforms do it.

Platform asymmetry shapes exclusivity. In turn, exclusivity reshapes the relative power between the two platforms in terms of market shares or profits. If a platform is the only initiator, its exclusivity favors itself at the expense of its rival. Therefore, the two platforms will become less asymmetric if exclusivity is enforced by the weak platform alone, and more asymmetric if it is enforced by the strong platform alone. If both platforms introduce exclusivity, the balance can go either way.

Some papers have examined platforms' incentives for exclusive dealing with sellers. Armstrong and Wright (2007) consider a setting where sellers are homogeneous in their platform preferences and therefore they all multihome. With exclusivity, a platform can attract all sellers and can generate a strong network effect, which allows the platform to raise the fee on buyers. Our study intentionally shuts down the channel of such a seesaw pricing mechanism. Instead, we show that even when it is increasingly costly for a platform to lure most sellers due to seller heterogeneity, exclusivity can still be profitable because it can mitigate platform competition. Belleflamme and Peitz (2019) find that symmetric platforms impose exclusivity if their services are not very valuable to sellers. Our framework admits symmetric platforms as a special case and focuses on asymmetric platforms' different incentives in enforcing exclusivity. We show how the welfare consequence depends crucially on the identity of the enforcer and how exclusivity reshapes the two platforms' relative power, which can be a useful guide for antitrust policy.[9] Unlike these two papers and a new contribution to the literature, we also highlight how exclusivity can convert platforms' competitive prices from strategic complements to strategic substitutes.

Some studies have focused on a powerful seller's incentive to singlehome. Such a seller faces the following tradeoff (Hagiu and Lee, 2011; Weeds, 2016; Carroni et al., 2023). Multihoming intensifies platform competition for buyers and lowers the rent the seller can extract from a platform; singlehoming strengthens the homing platform's competitive advantage and the extractable rent for the seller, but foregoes the opportunity to reach additional buyers. In Ishihara and Oki (2021), a monopolistic content provider decides the proportion of exclusive and nonexclusive content between two platforms. Exclusive contents encourage buyers to multihome, which intensifies platform competition for these contents and increases the content provider's bargaining power against the platforms. In these papers, exclusivity can be profitable *for a seller* because it encourages platform competition for the seller and thus increases the seller's share of the total surplus. In our paper, by contrast, exclusivity can be profitable *for a platform* because it mitigates platform competition.

[9]Shekhar (2021) allows a platform to charge different prices depending on a seller's homing choice, and shows that such a strategy appears in equilibrium (but does not necessarily benefit the initiator) when there are many sellers who singlehome or multihome. Unlike our paper, his focus is on differential pricing rather than forced singlehoming.

In traditional industrial organization studies, exclusive dealing has been studied without cross-side network effects.[10] Exclusivity may impact welfare by changing relationship-specific investments and effort (Segal and Whinston, 2000a; De Meza and Selvaggi, 2007) or by facilitating entry (Lee, 2013). It may also serve as a rent-extraction device or employ buyers' coordination failure to deter entry (Aghion and Bolton, 1987; Rasmusen et al., 1991; Bernheim and Whinston, 1998; Segal and Whinston, 2000b).[11] In our setting, the cross-side network effect plays a central role. Exclusivity would never have appeared in equilibrium without such an effect because it always intensifies platform competition and hurts both platforms.

The remainder of the paper is organized as follows. After setting up the model in Section 2 and analyzing the benchmark subgame of allowing multihome in Section 3, we establish the equilibrium of exclusivity in Section 4 and discuss its conditions and various impacts, including those on welfare. Section 5 provides several extensions, such as endogenous buyer membership fee, personalized pricing with exclusivity, platform investment, and noncompulsory exclusivity. Finally, Section 6 concludes.

2 Model setup

A unit mass of sellers and buyers are uniformly distributed on their respective Hotelling lines between two ends, $[0, 1]$. Two platforms, referred to as $i \in \{1, 2\}$, are located at the two endpoints, with platform one at zero and platform two at one. If a seller joins platform $i \in \{1, 2\}$, his profit from the platform is:

$$\pi_i = v_i + \beta b_i - t_0 x_i - p_i,$$

where v_i is the intrinsic value of joining platform i, b_i is the number of buyers who patronize i, $\beta > 0$ measures the buyer-to-seller cross-side network effect, t_0 is the unit transportation cost for sellers and therefore captures the degree of platform differentiation in the eyes of sellers, x_i is the distance from the seller's location to platform i (with $x_2 = 1 - x_1$), and p_i is the seller membership fee charged by platform i. If the seller multihomes by joining both platforms, then his profit is a simple summation of the profit earned from each platform:

$$\pi_m = \pi_1 + \pi_2.$$

If a buyer singlehomes at platform $i \in \{1, 2\}$, she obtains a utility of

$$u_i = \alpha s_i - k y_i - f_i$$

[10]Doganoglu and Wright (2010) show that when the industry has traditional network effects, the incumbent can use a cheap introductory offer to sign some consumers exclusively and can exploit the subsequent consumers. As a result, the incumbent increases profits and deters entrants. Their study does not involve exclusive dealing on a platform.

[11]Rey and Tirole (2007) and Whinston et al. (2006) provide overviews of the literature.

where s_i is the number of sellers at platform i, α measures the seller-to-buyer cross-side network effect, k is the unit transportation cost for buyers and hence measures the degree of platform differentiation in the eyes of buyers, y_i is the distance from the buyer's location to platform i (with $y_2 = 1 - y_1$), and f_i is the buyer membership fee charged by platform i. If a buyer multihomes, her utility is the sum of utilities from both platforms with a discount:

$$u_m = u_1 + u_2 - \gamma s_m$$

where $s_m \equiv \max\{0, s_1 + s_2 - 1\}$ is the measure of multihoming sellers and $\gamma \in [0, \alpha]$ captures buyers' discounts for meeting multihoming sellers for a second time. For simplicity, the model ignores buyers' intrinsic value from the platform, which does not affect the main results.

Several features of the model are worth discussion. The model directly specifies a seller's profit and a buyer's utility in joining a platform. By abstracting away from any explicit modeling of the transaction between buyers and sellers, we are better able to focus on platform choice (of exclusivity) rather than seller or buyer choices (of product market transaction). Such abstraction is common in platform studies (Rochet and Tirole, 2003, 2006; Armstrong, 2006) and does not imply that buyers pay zero to sellers. In fact, the payment must be positive as is captured by the term βb_i in a seller's profit expression.

The parameter v_i captures a platform's intrinsic value to sellers, also known in the literature as intrinsic benefit, stand-alone benefit or stand-alone value. Other than providing a virtual market for sellers and buyers to meet, a platform provides many necessary and valuable services to sellers such as platform infrastructure, platform branding, data analytics, quality assurance, payment convenience, target advertising, delivery and other logistics services. For example, Alibaba offers sellers digital store decorations, marketing suggestions, consumer targeting services, and microloans. Meituan offers restaurants digital menus and streamlines their online and offline food order systems. Grab provides insurance and car maintenance services to drivers. This kind of intrinsic value is independent of seller preferences for platforms (i.e., a seller's location on the Hotelling line) as well as the number of buyers on a platform (i.e., the magnitude of the cross-side network effect) (Armstrong and Wright, 2007; Belleflamme and Peitz, 2019; Bakos and Halaburda, 2020). In our model, platform asymmetry is reflected in their intrinsic values, and we assume without any loss of generality that platform one provides a more valuable service than platform two: $v_1 \geq v_2$. In what follows, v_i refers to platform i's *strength*.

Sellers are heterogeneous in their platform preferences as captured by their different locations on the Hotelling line. Ditto for buyers. This reflects the fact that some sellers may prefer one platform over the other for individualistic reasons other than the platform strength (which is the same for all sellers), which can be particularly relevant for businesses that involve both online and offline elements such as food delivery or ride hailing.

We assume that a multihoming buyer incurs some utility discount when encountering a multihoming seller for a second time. This is because having a second chance to conduct a transaction is less valuable. Such a discount is needed for studying exclusivity on the seller side. If it is absent, the two platforms are not competing at all when multihoming is allowed, and neither platform will enforce exclusivity, which would have introduced platform competition and reduced both platforms' profits.[12] If sellers also discount the profits of meeting multihoming buyers, we can show that the main results do not change qualitatively. This is not surprising, as the discounts are about duplicative transactions, which involve multihoming on both sides, so a one-sided formulation of the discounts is enough to capture the effect.

In our model, a seller's payment to a platform takes the form of membership fee, which may include an entry fee for accessing the platform and service charges for necessary platform-specific software and investments.[13] The seller profit expression implies that all sellers pay the same amount of membership fee, an assumption that will be relaxed in an extension. In addition to the membership fee, a seller may also pay a platform through commissions that are linked to each particular transaction. Such commissions, however, are incorporated in the endogenous membership fee in our model. This is because buyers and sellers are homogeneous in product transaction on a platform (they are heterogeneous only in terms of platform preferences), which means that all sellers on a platform sell the same quantity and at the same price, so their commissions, if any, are identical, and there is no need to modify our formulation of the seller profit.

In the main model, we make three assumptions to simplify the analysis and to highlight the critical mechanisms.

Assumption 1. $f_1 = f_2 = 0$.

Assumption 2. $\alpha = \beta = k = 1$.

Assumption 3. $t_0 > \frac{\alpha\beta}{k} = 1$, *and* $\gamma \leq \frac{\alpha}{2} = \frac{1}{2}$.

Assumption 1 says that buyers can join a platform for free, which is indeed the case in many industries, including e-commerce, food delivery, and ride-hailing. Later, we relax this assumption in an extension and show that our main results remain the same. Assumption 2 is made mainly to simplify the nonessential parameters. A seller's homing decision is affected by the cross-side network effects (as captured by α and β) and platform differentiation (as captured

[12]Buyers' multihoming discount is very common in the literature, for example Ambrus et al. (2016), Jeitschko and Tremblay (2020), Bakos and Halaburda (2020), and Saruta (2021). Like us, Belleflamme and Peitz (2019) and Shekhar (2021) also assume away sellers' multihoming discount for simplicity.

[13]Membership fees can be substantial in real life. For example, Alibaba's retail platform, Tmall, charges a seller ten thousand to one million RMB annually for the software services necessary for doing business on the platform.

by t_0 and k), or more precisely by the relative strengths of t_0k, $\alpha\beta$, $\frac{\alpha}{k}$, and $\frac{\beta}{t_0}$ (Armstrong, 2006; Armstrong and Wright, 2007; Belleflamme and Peitz, 2019; Bakos and Halaburda, 2020). By normalizing α, β, k and sufficiently varying t_0, we can generate all the forces needed. In Section 5 of the online appendix, we show why reintroducing a general buyer-to-seller network effect β does not change our main results qualitatively. For Assumption 3, the first part says that the platform differentiation effect is stronger than cross-side network effects, a typical assumption in models of platform competition on a Hotelling line. The second part says that the buyers' multihoming discount is not too severe. It allows some buyers to multihome, consistent with real business. Moreover, this assumption does not cause our analysis to lose any generality. In the special case of $\gamma = \frac{\alpha}{2}$, all buyers singlehome and γ become irrelevant in the equilibrium, which is also the exact equilibrium outcome for $\gamma > \frac{\alpha}{2}$.

Suppose each platform can force its sellers to singlehome, a policy referred to as *exclusivity*.[14] The game proceeds as follows. In stage one, the two platforms simultaneously decide whether or not to enforce exclusivity. If at least one platform adopts exclusivity, then a seller can choose at most one platform; if neither platform adopts exclusivity, a seller can multihome. In stage two, the two platforms simultaneously announce their membership fees for sellers p_i, $i \in \{1, 2\}$. In the final stage, sellers and buyers simultaneously choose which platform(s) to join. In the following analysis, we adopt the subgame in which no platform enforces exclusivity as the benchmark.

3 Benchmark: The multihoming equilibrium

As the benchmark, we first analyze the subgame when neither platform enforces exclusivity, and hence, sellers can multihome. Given $\pi_m = \pi_1 + \pi_2$, a seller's decision to join a platform is independent of his decision to join the other platform: he joins platform i if and only if $\pi_i \geq 0$. Therefore, platform i's marginal seller is determined by $\pi_i = 0$, implying that its total number of sellers is

$$s_i = \frac{v_i + b_i - p_i}{t_0}. \tag{1}$$

We focus on an equilibrium where $s_1 + s_2 > 1$ with $s_1 \in (0, 1)$ and $s_2 \in (0, 1)$, referred to as a *multihoming equilibrium*. Figure 1(a) shows the sellers' distribution on the two platforms.

For buyers, given $u_m = u_1 + u_2 - \gamma s_m$, a buyer chooses to singlehome at platform i if and only if $u_i \geq \max\{u_j, u_m, 0\}$, and to multihome if and only if $u_m \geq \max\{u_i, u_j, 0\}$. As shown in Figure 1(b), platform one's marginal buyer is the one who is indifferent between joining platform two in addition to platform one and staying with platform two only. In other words, the marginal

[14] Exclusivity is enforced as a compulsory policy in several antitrust cases, including JD.com vs. Alibaba, Ele.me vs. Meituan, Canadian Competition Bureau vs. Turo, and Shanghai Administration for Market Regulation vs. Sherpa's.

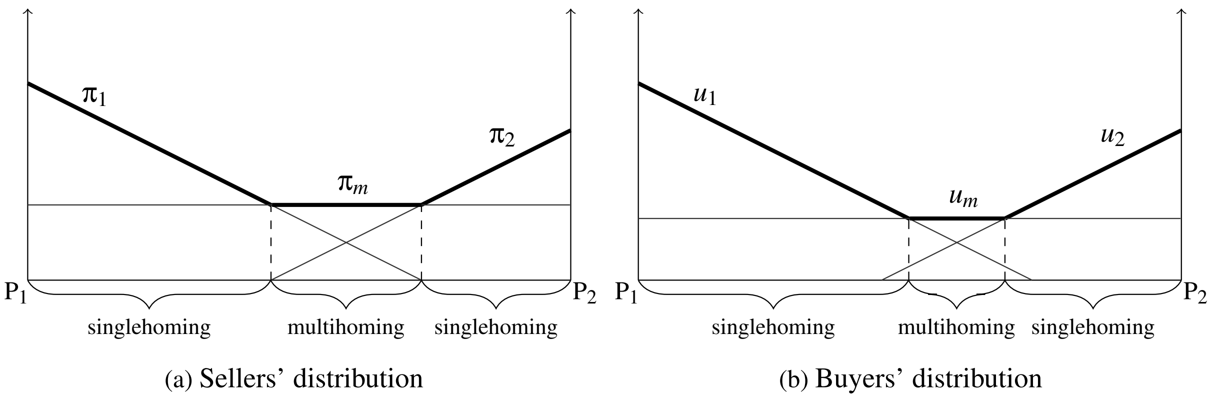


Figure 1: Seller and buyer distribution in the multihoming equilibrium

buyer is found from $u_m = u_2$. Similarly, platform two's marginal buyer is found from $u_m = u_1$. We have platform i's amount of buyer is

$$b_i = s_i - \gamma(s_i + s_j - 1). \tag{2}$$

Note that not every buyer multihomes even though joining a platform is free of charge. This is because of platform differentiation: A buyer incurs some loss of utility (in the form of transportation cost) when doing transactions on a non-ideal platform.

Since $s_i \in (0, 1)$, we have $b_i \in (0, 1)$, and the number of multihoming buyers $b_1 + b_2 - 1 = (1 - 2\gamma)(s_1 + s_2 - 1)$. Under Assumption 3, $s_1 + s_2 > 1$ implies $b_1 + b_2 \geq 1$, with equality only when $\gamma = 1/2$.

The seller and buyer homing choices (given p_1 and p_2) are solved simultaneously from equations (1) and (2). It is convenient to use the following parameters:

$$t \equiv t_0 - \frac{\alpha\beta}{k} = t_0 - 1 > 0 \text{ and } \theta \equiv \frac{\gamma}{t + \gamma} \in (0, 1). \tag{3}$$

The parameter t represents platform differentiation relative to the cross-side network effect. A smaller t indicates a (relatively) stronger cross-side network effect. The parameter θ represents buyers' multihoming discount relative to t. Given the two platforms' prices, the amount of sellers at platform i is $s_i = \frac{(v_i - p_i) - \theta(v_j - p_j) + t\theta}{t(1+\theta)}$. Each platform's profit is $\Pi_i = p_i s_i$. The equilibrium prices are

$$p_i^m = \frac{(2 - \theta^2)v_i - \theta v_j}{4 - \theta^2} + \frac{t\theta}{2 - \theta},$$

where the superscript m indicates multihoming equilibrium. Notice that platform i's price p_i^m positively relates to its strength v_i and negatively relates to the rival platform's strength v_j, implying two platforms engage in price competition for sellers. However, competition disappears when γ (and hence θ) equals zero. In the equilibrium, $s_i^m = p_i^m/(t(1+\theta))$ sellers choose platform i. Apparently, $s_1^m \geq s_2^m$, with equality if and only if $v_1 = v_2$. Platform i's profit in the multihoming equilibrium is

$$\Pi_i^m = \frac{(p_i^m)^2}{t(1+\theta)}. \tag{4}$$

Define

$$v \equiv v_1 + v_2, \quad \text{and} \quad \mu \equiv \frac{v_1}{v_1 + v_2}, \tag{5}$$

where v is the two platforms' *joint strength*, and μ measures their *strength asymmetry* with $\mu \in \left[\frac{1}{2}, 1\right)$. In the multihoming equilibrium, the measure of multihoming sellers is $s_m \equiv s_1^m + s_2^m - 1 = \frac{(1-\theta)[v-t(2+\theta)]}{t(1+\theta)(2-\theta)}$. The measure depends only on the joint strength but not the strength asymmetry. Platform one always has more singlehoming sellers than platform two, with equality only when $\mu = \frac{1}{2}$. As the strength asymmetry μ increases, the number of singlehoming sellers increases at platform one and decreases at platform two. In other words, the segment of multihoming sellers in Figure 1(a) shifts closer to platform two.

Lemma 1. *In the multihoming equilibrium,*

(i) the number of multihoming sellers increases with the joint strength and is independent of the strength asymmetry;

(ii) fixing the joint strength, a greater strength asymmetry increases the number of sellers at platform one and decreases it at platform two.

The intuition of Lemma 1 is as follows. A larger joint strength implies a higher intrinsic value from at least one platform, which means that the platform holds more sellers. As a result, multihoming sellers expand. Fixing the joint strength, higher strength asymmetry implies a larger v_1 and a smaller v_2, making platform one attract more sellers and platform two attract fewer sellers. The multihoming sellers are therefore located far from platform one and close to platform two. Lemma 1 relates the nonobservable joint strength and strength asymmetry to the observable measure of multihoming and singlehoming sellers.

Finally, for this to be a proper multihoming equilibrium, the joint strength should be neither too large nor too small:[15]

$$v > \underline{v} \equiv t(2+\theta), \tag{6}$$

$$v < \overline{v} \equiv \frac{2t(2+\theta)}{\theta + d(4-\theta^2) + [(2-\theta) - d(4-\theta^2)]\mu}, \tag{7}$$

where $d \equiv \frac{\sqrt{1-\theta^2}-1}{\theta} < 0$. When v is smaller than $\underline{v}$, no seller multihomes. When v is larger than $\overline{v}$, platform two has very few singlehoming sellers and uses mixed strategies in pricing. A joint

[15] Section A.1 in the Appendix sketches the proof of multihoming equilibrium. The detailed equilibrium analysis is contained in Section 1 of the Online Appendix.

strength satisfying (6) and (7) allows us to focus on pure-strategy multihoming equilibrium. The equilibrium is unique given our assumption that platform differentiation is stronger than the cross-side network effect. Also note that the two platforms' prices are strategic complements.

Figure 2 shows $\underline{v}$ and $\overline{v}$ in the space of μ and v, given any pair of t and θ. The lower bound $\underline{v}$ is independent of the strength distribution μ, while the upper bound $\overline{v}$ is decreasing in μ.[16]

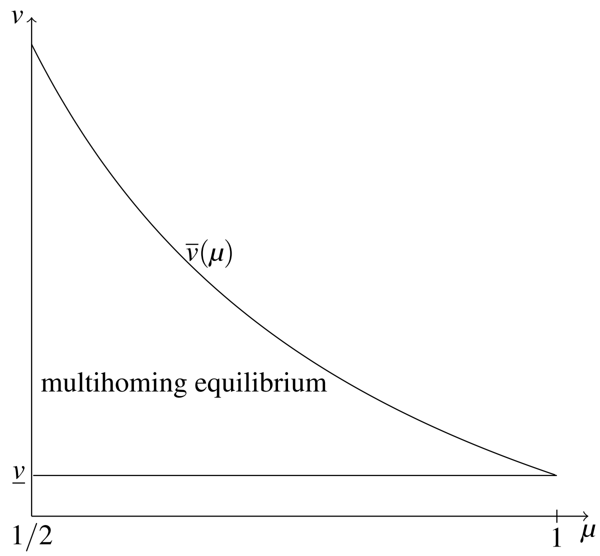


Figure 2: The region of multihoming equilibrium

4 Equilibrium exclusivity

This section starts with the subgame analysis in which at least one platform adopts exclusivity on sellers. We focus on the parameter space where (6) and (7) are satisfied.

Under exclusivity, anticipating buyers' homing decisions, seller x singlehomes at platform i if and only if $\pi_i \geq \max\{\pi_j, 0\}$. Platform i's marginal seller is determined by $\pi_i = \pi_j$, which leads to

$$s_1 = \frac{1}{2} + \frac{(v_1 + b_1 - p_1) - (v_2 + b_2 - p_2)}{2t_0}, \quad s_2 = \frac{1}{2} + \frac{(v_2 + b_2 - p_2) - (v_1 + b_1 - p_1)}{2t_0}. \tag{8}$$

Under exclusivity, a seller joins platform i only when this platform brings a higher profit than platform j. In the benchmark of no exclusivity, a seller joins platform i whenever this platform brings a nonnegative profit. In other words, exclusivity changes a seller's outside option. The difference in a seller's decision rule manifests in how s_i is determined in (1) and (8).

Buyers are not prohibited from multihoming. Buyer y's utility from singlehoming is either $u_1 = s_1 - y$ or $u_2 = s_2 - (1 - y)$. Since no seller can multihome under exclusivity, the buyer's

[16]To see why the curve $\overline{v}(\mu)$ in Figure 2 is downward sloping, note that platform two uses pure-strategy pricing in equilibrium when the number of its singlehoming sellers is above some threshold. If μ is larger, v has to be smaller to ensure that platform two does have some singlehoming sellers.

utility from multihoming is $u_m = u_1 + u_2 - \gamma s_m = u_1 + u_2$. Therefore, under exclusivity, a buyer's decision to join a platform is independent of her decision to join the other platform: she joins platform i if and only if $u_i \geq 0$. As a result, buyers $y \leq s_1$ join platform one and buyers $y \geq 1 - s_2$ join platform two, which leads to $b_i = s_i$.[17]

Within the parameter space satisfying (6) and (7), the exclusivity equilibrium may take two forms. In the first case (i.e., $3t < v < \bar{v}$), the equilibrium is unique, and the seller who is indifferent between the two platforms obtains positive profit in the equilibrium. In the second case (i.e., $\underline{v} < v < 3t$), there are multiple equilibria, and the indifferent seller always obtains zero profit in the equilibrium. For equilibrium selection, we follow the literature (Caillaud and Jullien, 2001, 2003; Halaburda and Yehezkel, 2016, 2019) by focusing on an equilibrium where the strong platform prices most aggressively and the weak platform prices least aggressively.

Basically, the two platforms' prices are strategic complements in the first case, and they are strategic substitutes in the second case. In the first case, there are relatively more multihoming sellers to begin with, so each platform loses a substantial number of sellers under exclusivity. This makes the weak platform compete more aggressively—it *lowers* its own price in response to the rival platform's lower price. In the second case, by contrast, because the number of multihoming sellers is small, each platform loses few sellers. This induces the weak platform to compete less aggressively in the sense that when its rival lowers the price, it responds by *raising* its own price.[18]

The equilibrium expressions of the two cases are shown in Table 1, where the superscript e indicates exclusivity. Despite the different expressions, the equilibrium prices, market shares, and profits change continuously between the two cases.

Table 1: Equilibrium under exclusivity

	p_1^e	p_2^e	s_1^e	s_2^e	Π_1^e	Π_2^e
if $3t < v < \bar{v}$	$t + \frac{v_1 - v_2}{3}$	$t + \frac{v_2 - v_1}{3}$	$\frac{1}{2} + \frac{v_1 - v_2}{6t}$	$\frac{1}{2} + \frac{v_2 - v_1}{6t}$	$\frac{[3t+(2\mu-1)v]^2}{18t}$	$\frac{[3t-(2\mu-1)v]^2}{18t}$
if $\underline{v} < v < 3t$	$v_1 + \frac{v_2}{3} - t$	$\frac{2v_2}{3}$	$1 - \frac{v_2}{3t}$	$\frac{v_2}{3t}$	$\frac{[(2\mu+1)v-3t][-(1-\mu)v+3t]}{9t}$	$\frac{2(1-\mu)^2 v^2}{9t}$

Note: In the equilibrium, $b_i^e = s_i^e$ holds.

4.1 Equilibrium exclusivity and platform profits

Platform i enforces exclusivity if and only if it obtains a higher profit under exclusivity, i.e., $\Pi_i^e > \Pi_i^m$. In other words, we compare a platform's profit under exclusivity (in Table 1) with its

[17]Buyers do not multihome in the equilibrium, even though they are not prohibited from doing so. This result is driven by assumptions 1 and 2 and the fact that buyers do not enjoy intrinsic value from joining a platform. If we assume platforms provide positive intrinsic value to buyers, some buyers multihome under exclusivity, but our main results do not change.

[18]Mathematically, equilibrium prices in the second case satisfy $p_1^e + p_2^e = v - t$, so they move in opposing directions. Of course, the logic also applies to the strong platform—if the weak platform prices very aggressively, the strong platform retreats. That is why we have multiple equilibria.

profit in the multihoming equilibrium to determine the condition of equilibrium exclusivity.

Platform one enforces exclusivity if and only if[19]

$$v < v_s^e \tag{9}$$

where the subscript s indicates the strong platform. The cutoff v_s^e is shown in Figure 3(a). Condition (9) says that the strong platform enforces exclusivity when the two platforms' joint strength v is not too large. Platform two enforces exclusivity if and only if

$$\underline{v}_w^e < v < \overline{v}_w^e, \tag{10}$$

where the subscript w indicates the weak platform.[20] Condition (10) says that the weak platform enforces exclusivity when the joint strength v is neither very large nor very small. Figure 3(b) shows the cutoffs.

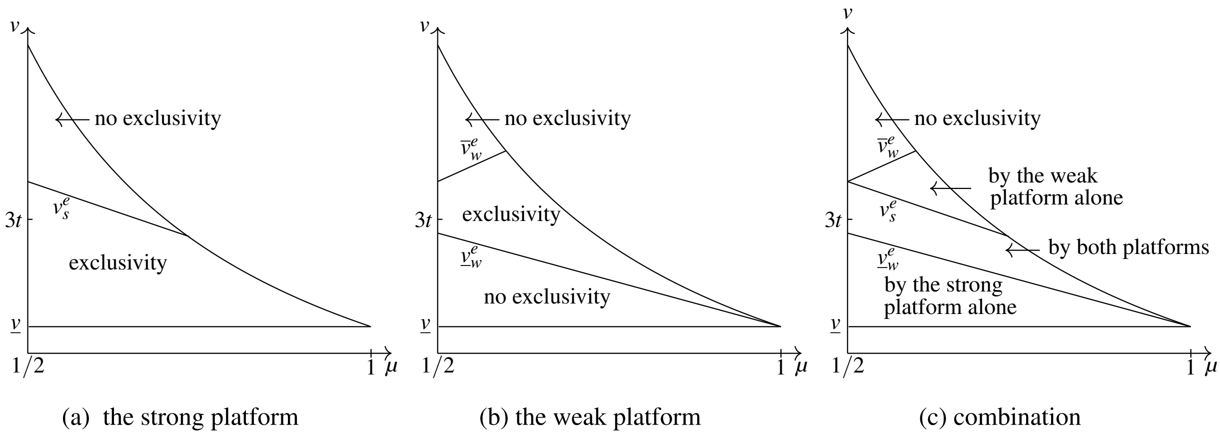


Figure 3: Equilibrium exclusivity

Proposition 1. *Exclusivity is enforced*

(i) if and only if the platforms' joint strength is not too large;

(ii) by the strong platform when the joint strength is below a threshold;

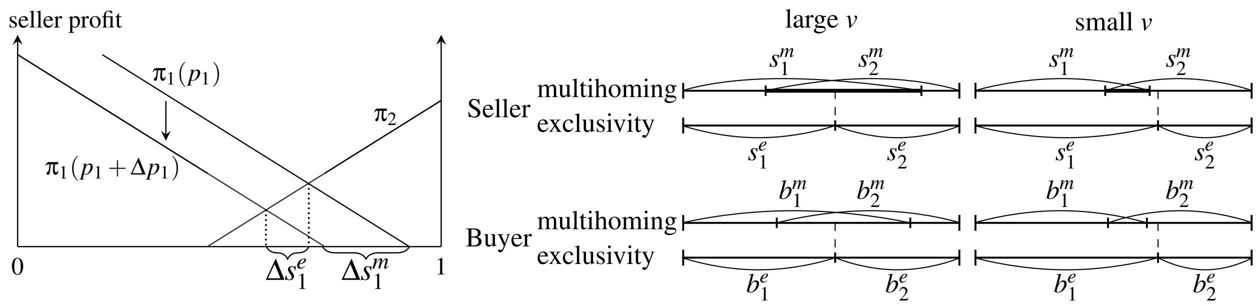
(iii) by the weak platform when the joint strength is moderate.

A platform's profit equals the number of sellers multiplied by the equilibrium membership fee levied on these sellers, so exclusivity may raise a platform's profit by raising either variable. For the membership fee, exclusivity brings two opposite effects. On the one hand, exclusivity reduces a platform's seller base because multihoming sellers must turn to singlehome,

[19]Detailed expressions of v_s^e and other subsequent cutoffs can be found in the appendix.

[20]The upper boundary $v < \overline{v}_w^e$ is established from $\Pi_2^e > \Pi_2^m$, in which Π_2^e is the equilibrium of $3t < v < \overline{v}$ in Table 1. The lower boundary $\underline{v}_w^e < v$ comes from $\Pi_2^e > \Pi_2^m$, in which Π_2^e is the equilibrium of $\underline{v} < v < 3t$ in Table 1.

motivating each platform to compete more aggressively. On the other hand, sellers become less sensitive to a platform's price under exclusivity. Now, a seller compares its profit from a platform with the profit from the rival platform rather than with zero as in the multihoming equilibrium. If platform one increases its membership fee by Δp_1 (Figure 4(a)), the platform loses Δs_1^m sellers in the multihoming equilibrium, but only Δs_1^e sellers under exclusivity. This motivates the platform to compete less aggressively (Chen and Riordan, 2008; Belleflamme and Peitz, 2019).[21] By affecting the number of multihoming sellers in the multihoming equilibrium and hence the potential seller loss under exclusivity, the joint strength impacts which effect dominates.



(a) seller price sensitivity (b) distribution of sellers and buyers with/without exclusivity

Figure 4: The price sensitivity effect and the market demand change

If the joint strength is large (Proposition 1(i)), many sellers were multihoming, and exclusivity makes each platform compete aggressively to retain sellers and causes them to lose a substantial number of sellers; there is no way for either platform to gain. The "large v" column of Figure 4(b) shows this case. Despite potential gains from a greater network effect, exclusivity is unable to concentrate most sellers (and buyers) onto a single platform because of platform differentiation and seller heterogeneity in their platform preferences: It becomes increasingly difficult for a platform to recruit more sellers, who strongly prefer the rival platform. For this reason, joint strength cannot be very large if either platform is to enforce exclusivity.

If the joint strength is small, exclusivity turns the two platforms' prices from strategic complements into strategic substitutes, so that the strong platform prices more aggressively, while the weak platform prices less aggressively. In equilibrium, the strong platform recruits all multihoming sellers and some sellers that used to singlehome at the weak platform. This benefits the strong platform and hurts the weak platform. For this reason, there is a lower bound of the joint strength for the weak platform's exclusivity (Proposition 1(iii)), but no such bound exists for the strong platform's exclusivity (result (ii)).

Because each platform's strength v_i contributes to the joint strength v, the following corol-

[21] Mathematically, a platform's marginal revenue is $s_i(p_i) + p_i s_i'(p_i)$, which leads to $p_i = -\frac{s_i(p_i)}{s_i'(p_i)}$. On impact (i.e., evaluating at the original p under multihoming), exclusivity reduces both $s_i(p_i)$ (the demand curve shifts inward) and $s_i'(p_i)$ (the demand curve becomes steeper). A smaller $s_i(p_i)$ tends to make a platform lower its price, and a smaller $s_i'(p_i)$ tends to make a platform raise its price.

lary is obvious:

Corollary 1. *A very strong platform never enforces exclusivity with uniform pricing, regardless of the strength asymmetry.*

The strength asymmetry μ has opposite impacts on the exclusivity choices of the strong and the weak platforms. As shown in Figure 3(a), the cutoff v_s^e decreases in μ. That is, fixing the joint strength, the strong platform is less likely to enforce exclusivity when the two platforms become more asymmetric. In contrast, as shown in Figure 3(b), the weak platform's upper boundary $\overline{v}_w^e$ increases in μ, and the lower boundary $\underline{v}_w^e$ decreases in μ, meaning that the weak platform is more likely to enforce exclusivity when the two platforms are more asymmetric.

Proposition 2. *As the two platforms become more asymmetric, the strong platform is less likely to enforce exclusivity, and the weak platform is more likely to enforce exclusivity.*

Proposition 2 is driven by the two platforms' asymmetric incentives in price competition. In both multihoming and exclusivity, a platform's lower price helps recruit marginal sellers but cannibalizes inframarginal sellers. Fixing the joint strength, as the strength asymmetry μ increases, the number of sellers in the multihoming equilibrium rises at platform one and drops at platform two (Lemma 1(ii)). Moving from multihoming to exclusivity, both platforms tend to lose sellers, but the loss (in terms of seller percentage) is relatively much more significant for the weak platform than for the strong platform. This means that the former competes more fiercely than the latter; therefore, a larger asymmetry is conducive to the weak platform's adoption of exclusivity and hinders the strong platform's.

For the same reason, a larger joint strength favors exclusivity by the weak platform rather than by the strong platform, in the sense that the weak platform's upper boundary, $\overline{v}_w^e$, is always above the strong platform's, v_s^e (see Figure 3(c)).

The model setting allows us to link a platform's exclusivity incentive into the two platforms' profitability under the policy. In particular, a platform always benefits from its exclusivity but may benefit or suffer from the exclusivity enforced by the rival. We have the following corollary.

Corollary 2. *Conditional on equilibrium exclusivity,*

(i) the win-win outcome arises when the joint strength is moderate;

(ii) as the joint strength increases, it is less likely for the strong platform to benefit from exclusivity and more likely for the weak platform to benefit;

(iii) as the strength asymmetry increases, it is less likely for the strong platform to benefit from exclusivity and more likely for the weak platform to benefit.

Therefore, equilibrium exclusivity can result in a lose-win and a win-win for the two platforms but never a lose-lose. So it is impossible to have a prisoners' dilemma.

4.2 The impact of the cross-side network effect on exclusivity

Figure 3 is drawn for a particular strength of cross-side network effect, which is captured by the parameter $t \equiv t_0 - \frac{\alpha\beta}{k}$. In particular, it shows a situation where the cross-side network effect is strong relative to platform differentiation (i.e., $t < \frac{3+\sqrt{17}}{2}\gamma$). When the network effect becomes weaker (i.e., t increases given $t > \frac{3+\sqrt{17}}{2}\gamma$), equilibrium exclusivity becomes less likely, as the strong platform's cutoff v_s^e shifts closer to $\underline{v}$, and the weak platform's cutoffs $\overline{v}_w^e$ and $\underline{v}_w^e$ shift to the right. When the network effect is very weak ($t > 8\gamma$), the weak platform never enforces exclusivity.

If the buyer-to-seller network effect is zero (i.e., $\beta = 0$),[22] a seller's decision to join a platform in a multihoming equilibrium depends only on that platform's fee level but not its rival's. This means the two platforms are not competing, each earning a monopoly profit. In that case, exclusivity forces the two platforms to compete, and neither can earn a profit that is greater than its monopoly profit. No platform has any incentive to enforce exclusivity. Therefore, the existence of cross-side network effects is a necessary condition for exclusivity appearing in equilibrium.

Proposition 3. *A buyer-to-seller network effect (i.e., a positive β) is necessary for equilibrium exclusivity. When the network effect weakens relative to platform differentiation (i.e., t increases), exclusivity is*

(i) less likely to appear in equilibrium;

(ii) enforced only by the strong platform if the network effect is sufficiently weak.

4.3 Exclusivity reshapes the platform asymmetry

Exclusivity changes the two platforms' relative power in terms of market shares, which can be measured by the gap between their seller amount ($s_1 - s_2$) or the buyer amount ($b_1 - b_2$). The strong platform becomes stronger under equilibrium exclusivity, i.e., $s_1^e - s_2^e > s_1^m - s_2^m$ or $b_1^e - b_2^e > b_1^m - b_2^m$, whenever[23]

$$\mu < \tilde{\mu} \equiv \frac{3t(\theta+2) - (2\theta+1)v}{2(1-\theta)v}. \tag{11}$$

The curve $\tilde{\mu}$ is downward sloping in the space of μ and v and lies between curves v_s^e and $\underline{v}_w^e$. The condition (11) implies that two platforms become more unbalanced in market shares under equilibrium exclusivity when their initial strength asymmetry is small, and less unbalanced when their initial strength asymmetry is large. When platforms' relative power is measured by

[22] In our model, the seller-to-buyer network effect (i.e., α) cannot be zero; otherwise, buyers do not join any platform, as the network effect is the only benefit they derive.

[23] The inequality $b_1^e - b_2^e > b_1^m - b_2^m$ requires the same condition as $s_1^e - s_2^e > s_1^m - s_2^m$ because $b_i^e = s_i^e$ and $b_i^m = s_i^m - \gamma s_m$.

their profit gap, $\Pi_1 - \Pi_2$, a similar condition exists for the strong platform to become stronger under equilibrium exclusivity.

Basically, a platform gains if it introduces exclusivity. As a result, the two platforms become less asymmetric in market shares and profit gap when only the weak platform enforces exclusivity, and become more asymmetric when only the strong platform enforces exclusivity. In the win-win outcome, the asymmetry can go either way.

Moreover, in equilibrium exclusivity, the strong platform never forecloses the weak rival by attracting all sellers and buyers, regardless of the strength asymmetry. With uniform pricing, the strong platform has to balance the benefit of winning more sellers (hence more buyers) and the cost of cannibalizing inframarginal sellers. Competing aggressively to win all sellers is too costly for the strong platform. Therefore, platforms continue to compete even after they introduce exclusivity.

Proposition 4. *Exclusivity makes the two platforms:*

(i) more asymmetric when only the strong platform enforces exclusivity;

(ii) less asymmetric when only the weak platform enforces exclusivity;

(iii) more asymmetric in the win-win outcome when the joint strength and strength asymmetry are small.

(iv) No platform is foreclosed (i.e., losing all sellers and buyers).

4.4 Welfare and seller profits

We now study the impacts of equilibrium exclusivity on consumer surplus, sellers' total profits, and social welfare. When multihoming is allowed, buyers on $[0, 1 - b_2^m]$ singlehome at platform one, buyers on $[1 - b_2^m, b_1^m]$ multihome, and buyers on $[b_1^m, 1]$ singlehome at platform two. The total consumer surplus is

$$CS^m = \int_0^{1-b_2^m} (s_1^m - y)dy + \int_{1-b_2^m}^{b_1^m} (1-\gamma)(s_1^m + s_2^m - 1)dy + \int_{b_1^m}^{1} (s_2^m - (1-y))dy. \tag{12}$$

Under exclusivity, buyers on $[0, b_1^e]$ singlehome at platform one and buyers on $[1 - b_2^e, 1]$ singlehome at platform two. The total consumer surplus is

$$CS^e = \int_0^{b_1^e} (s_1^e - y)dy + \int_{1-b_2^e}^{1} (s_2^e - (1-y))dy. \tag{13}$$

Consumer surplus in (12) and (13) consists of cross-side network effects and transportation costs. Both are changed by exclusivity. As shown in Figure 4(b), multihoming buyers save transportation costs under exclusivity by switching to singlehome; most singlehoming buyers do not experience any change in transportation costs as they do not change their homing decisions. Therefore, transportation costs are unlikely to negatively impact welfare under exclusivity. When v is relatively large, each platform loses many sellers and hence experiences a substantial drop in network effects, hurting consumer surplus. For exclusivity to enhance consumer surplus, a necessary condition is that the network effect is strengthened at the strong platform, which happens when v is small so that the strong platform increases its seller base. Formally, equilibrium exclusivity enhances consumer surplus if and only if

$$v < v^e_{cs}, \tag{14}$$

in which v^e_{cs} is a function of μ, t, and θ. Figure 5 shows the curve of v^e_{cs}.

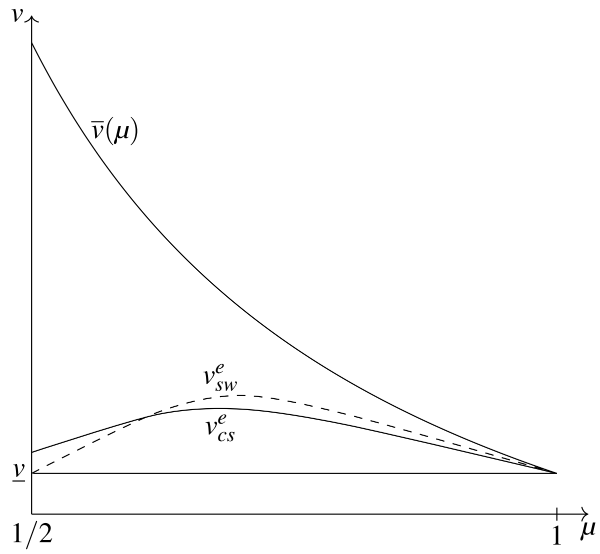


Figure 5: The impacts of equilibrium exclusivity on welfare

Equilibrium exclusivity enhances social welfare if and only if $v < v^e_{sw}$. The curve v^e_{sw} is shown in Figure 5. This intuition is similar to what is behind (14). In order for exclusivity to increase social welfare, the network effect at the strong platform must be enhanced.

Sellers' total profits are

$$\pi^i = \int_0^{s_1^i} (v_1 + b_1^i - t_0 x - p_1^i)dx + \int_{1-s_2^i}^1 (v_2 + b_2^i - t_0(1-x) - p_2^i)dx, \ i \in \{m, e\}. \tag{15}$$

We find that exclusivity increases sellers' total profit (i.e., $\pi^e > \pi^m$) if and only if $v < v^e_\pi$. The curve of v^e_π is similar to the curve v^e_{cs} in Figure 5. As shown in Figure 4(b), when the joint strength is large, many sellers and buyers multihome originally. Sellers' loss from giving up a second home is significant. In addition, a large joint strength v (slightly below $\overline{v}^e_w$ in Figure

3(c) such that exclusivity appears in equilibrium) also mitigates platforms' price competition so that sellers have to pay a higher fee under exclusivity.

Proposition 5. *Exclusivity increases consumer surplus, sellers' total profits, and social welfare when the joint strength is small.*

According to Proposition 5, benign exclusivity (for consumers, sellers, or society) requires the same condition: a relatively small joint strength. Under this condition, exclusivity lures most sellers and buyers to converge on the strong platform, resulting in a stronger network effect. Proposition 5 directly implies the following corollary on observable measures, which can serve as a guide for antitrust investigations.

Corollary 3. *The necessary conditions for exclusivity to benefit consumers and society are:*

(i) there are a limited number of multihoming sellers without exclusivity (i.e., small v), and

(ii) the strong platform holds more buyers or sellers under exclusivity.

We also find that the welfare impacts of equilibrium exclusivity can be linked to its initiator. When only the weak platform enforces exclusivity, both platforms lose some multihoming sellers (and buyers) and offer weaker cross-side network effects. Consumers, sellers, and society are always hurt in this scenario.

Proposition 6. *When only the weak platform enforces exclusivity, consumer surplus, sellers' total profits, and social welfare are always hurt.*

When both platforms enforce exclusivity (i.e., win-win region in Figure 3(c)), consumer surplus, sellers' total profits, and social welfare decrease in most cases, except in the corner near $\mu = 1$.[24] When only the strong platform benefits from exclusivity, consumer surplus, sellers' total profits, and social welfare may increase or decrease.

5 Extensions and discussions

5.1 Buyer membership fee

The main model assumes that buyers do not pay any membership fee when joining a platform. Now, we suppose that buyers pay f_i for joining the platform $i \in \{1, 2\}$. The game proceeds the same as in the main model except that platforms simultaneously decide (p_i, f_i). In the multihoming equilibrium, platform i charges a positive p_i^m to sellers but subsidizes buyers with a negative price f_i^m. This is because when multihoming is allowed, the platforms directly compete for buyers but not for sellers. More specifically, given the market share on the other

[24]The exception vanishes when t is large.

side, a buyer's homing decision depends on both platforms' prices, and whether a seller joins platform i depends on p_i^m only. Therefore, platform competition when multihoming is allowed is similar to the "competitive bottleneck" scenario (Armstrong, 2006).[25] Platforms subsidize buyers, the side they compete fiercely, and recover the loss by charging high prices to sellers on whom they possess significant market power. In the equilibrium, distributions of buyers and sellers are similar to Figure 1 except that multihoming is now chosen by more buyers and sellers.

Under exclusivity, the equilibrium $f_i^e = 0$ and the p_i^e is the same as in the main model. Buyers are no longer subsidized. The reason is that exclusivity compels platforms to compete directly for sellers, leading to increased prices for buyers (similar to the result obtained by Armstrong (2006)). The price comparison on the seller side (i.e., p_i^e vs. p_i^m) is similar to that in the main model and has the same intuition.

We find that strong and weak platforms enforce exclusivity under similar conditions to the main model. As before, exclusivity enhances consumer surplus, social welfare and sellers' total profits only when the joint strength is relatively small. However, there is less scope for welfare improvement here because welfare is high in the multihoming equilibrium due to the larger scale of multihoming agents and hence stronger network effect.

Proposition 7. *When buyers pay an endogenous membership fee, platforms enforce exclusivity under similar conditions to the main model. Exclusivity*

(i) mitigates platforms' price competition for buyers;

(ii) is less likely to enhance consumer surplus and social welfare than when the buyer fee is zero.

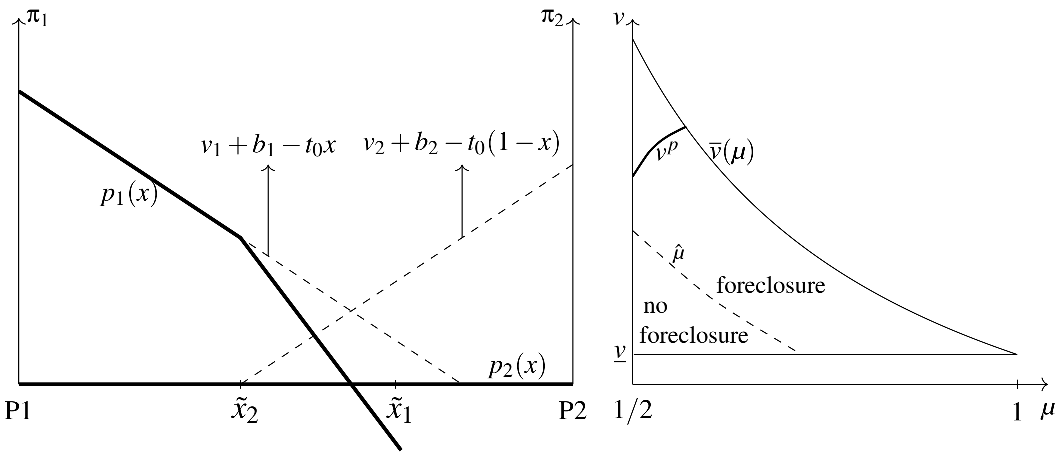
5.2 Personalized pricing

Under uniform pricing, the concern of cannibalizing inframarginal sellers prevents the strong platform from competing aggressively. Platforms in real life often charge discriminatory prices to merchants (Liu and Serfes, 2013; Ding and Wright, 2017) . How does discriminatory pricing affect the results in Section 4? We now turn to a situation where each seller is charged a personalized membership fee under exclusivity (it is still uniform pricing when exclusivity is not enforced). We write $p_i(x)$ for the price charged by platform i to seller $x \in [0, 1]$. A personalized price can be negative. Subsidizing some sellers allows a platform to attract more buyers, which in turn allows the platform to raise the prices for other sellers. We assume $p_2(x) \geq 0$ throughout

[25]Typical competitive bottleneck has one side multihoming and the other side singlehoming. Platforms compete aggressively on the singlehoming side and charge high prices on the multihoming side. In our model, although both sides can multihome, platforms compete aggressively for buyers and possess strong market power over pricing for sellers. Therefore, when multihoming is allowed, our model can be regarded as a modified version of the competitive bottleneck situation.

this section, which is reasonable because strong and weak platforms differ significantly in their financial resources (Kahn, 2017).[26]

Under exclusivity, given sellers' homing strategies, a buyer's homing strategy is the same as in Section 4. Figure 6(a) characterizes the two platforms' equilibrium prices for sellers if exclusivity is enforced. The seller-by-seller price competition drives $p_2(x) = 0$ for any seller in the equilibrium. Platform one charges $p_1(x) = v_1 + b_1 - t_0 x$ for sellers with $x < \max\{\tilde{x}_2, 0\}$ because they obtain strictly negative profits from platform two even though the platform's price is zero. Platform one charges $p_1(x) = v_1 + b_1 - t_0 x - (v_2 + b_2 - t_0(1-x))$ for sellers on $[\max\{\tilde{x}_2, 0\}, \min\{\tilde{x}_1, 1\}]$. Platform one gives up sellers on $[\min\{\tilde{x}_1, 1\}, 1]$ because the subsidies needed are too costly and, at the same time, sets the aggressive off-equilibrium-path prices, which are slightly higher than $p_1(x) = v_1 + b_1 - t_0 x - (v_2 + b_2 - t_0(1-x))$. As a result, the amounts of sellers on the two platforms are $s_1^p = \min\{\tilde{x}_1, 1\}$ and $s_2^p = 1 - \min\{\tilde{x}_1, 1\}$, where the superscript p indicates personalized pricing.



(a) Personalized prices under exclusivity

(b) Equilibrium exclusivity

Figure 6: Personalized prices under exclusivity and equilibrium exclusivity

We find that platform two never enforces exclusivity because its profit drops to zero in that case. Platform one enforces exclusivity if and only if $\Pi_1^p > \Pi_1^m$, leading to the condition $v < v^p$ (see Figure 6(b)). Consistent with uniform pricing, here exclusivity appears in equilibrium when the joint strength is not very large. This result can be attributed to two effects. First, given strength asymmetry μ, when v increases, platform one achieves first-degree price discrimination to fewer or even no sellers because fewer sellers earn negative profit from platform two as the platform's intrinsic value $(1-\mu)v$ rises. Second, platform one's profit in the multihoming equilibrium increases rapidly with v, making exclusivity profit more difficult to exceed.

The threshold v^p increases with strength asymmetry μ. When μ is larger, platform two

[26]Our results do not change if this assumption is relaxed to $p_2(x) \geq \underline{p}$, in which $\underline{p} \leq 0$ and its absolute value is small.

is weaker, and the seller-by-seller competition is less costly for platform one. Therefore, strength asymmetry is conducive to the strong platform's exclusivity under personalized pricing, whereas it is a barrier under uniform pricing. Under equilibrium exclusivity, platform one wins all sellers and buyers when $\mu > \hat{\mu}(v, t)$, implying platform two is foreclosed. The curve of $\hat{\mu}$ is shown in Figure 6(b).

Proposition 8. *When exclusivity is combined with personalized pricing for sellers,*

(i) the strong platform always chooses to enforce exclusivity, and the weak platform never enforces exclusivity;

(ii) exclusivity appears in equilibrium if and only if the joint strength is not too large, i.e., $v \leq v^p$*;*

(iii) fixing the joint strength, a larger strength asymmetry makes the strong platform more likely to enforce exclusivity;

(iv) the weak platform is foreclosed when the strength asymmetry is sufficiently large, i.e., $\mu > \hat{\mu}$*.*

We find that equilibrium exclusivity always increases the strong platform's market share and profitability. When the cross-side network effect is stronger, exclusivity and foreclosure become more likely in the sense that the threshold v^p increases and the no foreclosure region shrinks in Figure 6(b). The reason is that a stronger network effect (i.e., t decreases) allows platform one to attract sellers and buyers with smaller subsidies. When t is sufficiently small, exclusivity appears for any pair of v and μ, and market foreclosure always happens.

The impacts of equilibrium exclusivity on consumer surplus and social welfare are similar to Proposition 5. However, different from the exclusivity under uniform pricing, equilibrium exclusivity here increases sellers' total profits only when platforms' strength asymmetry is small, which leads to fierce seller-by-seller competition.

Suppose that platforms are allowed to enforce exclusivity but must charge uniform prices, a policy referred to as discrimination ban. Compared to exclusivity with personalized pricing, this policy makes exclusivity less likely to appear in equilibrium. That is, $v^p > \overline{v}^e_w$ always holds, as shown in Figure 7(a). Specifically, the strong platform's region of enforcing exclusivity shrinks significantly, but the weak platform can start to enforce exclusivity under the ban.

The discrimination ban can harm and can benefit welfare, depending on the joint strength and strength asymmetry. The policy decreases the possibility for the strong platform to attract more buyers and sellers and generate greater network effects, which harms welfare. In addition, the weak platform can enforce welfare-damaging exclusivity under the ban. As shown in Figure 7(a), the discrimination ban hurts consumer surplus in the blue and green regions and hurts social welfare in the green region. On the other hand, the discrimination ban can prevent the strong platform from enforcing welfare-damaging exclusivity and can protect consumer surplus and social welfare. In particular, consumer surplus is protected in the red region of Figure 7(a), and social welfare is protected in the blue and red regions. Furthermore, without the ability to price discriminate, the strong platform cannot foreclose its rival and monopolize the market with exclusivity. The discrimination ban protects market competition and can be beneficial to welfare in the long run.

Corollary 4. *Suppose platforms are allowed to enforce exclusivity but must charge uniform prices. Compared to allowing exclusivity with personalized pricing,*

(i) exclusivity is less likely to appear in equilibrium;

(ii) consumer surplus and social welfare are reduced when the joint strength is relatively small, but platform competition is maintained.

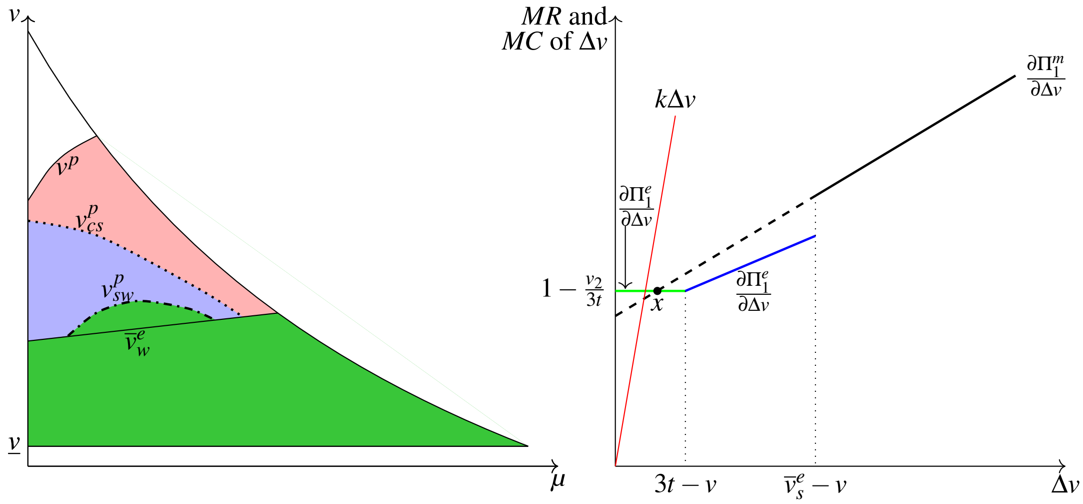
5.3 Platform investment

A number of studies have shown that exclusive dealing can spur firms' investments in the vertical relationship (Segal and Whinston, 2000a; De Meza and Selvaggi, 2007), implying exclusive dealing can be pro-competitive. In some antitrust cases, strong platforms defend their exclusive dealings by arguing that the policy incentivizes platforms to invest in merchant services.[27] We now analyze how the strong platform's investment is affected by exclusivity policy. Suppose the strong platform can invest in raising its intrinsic value (for example, by improving platform infrastructure). In particular, v_1 can be raised by Δv at the cost of $k(\Delta v)^2/2$ for some positive k. We compare two scenarios: exclusivity is banned and it is allowed. The game in each scenario proceeds as follows. At the very beginning, the strong platform decides its investment Δv. If exclusivity is allowed, the two platforms simultaneously decide whether to enforce exclusivity and then decide their prices p_i^e (when at least one platform enforces exclusivity) or p_i^m (when neither platform enforces exclusivity) at the same time. If exclusivity is banned, they simultaneously decide their prices p_i^m. Sellers and buyers make their homing decisions simultaneously after observing platforms' prices. Since the marginal cost of investment does not change with exclusivity, how exclusivity affects investment depends on its impacts on the marginal benefits of investment.

In the scenario of banning exclusivity, platform one's profit function Π_1^m is the same as (4) except that platform one's strength is now $v_1 + \Delta v$. Its optimal Δv^m is uniquely determined by

[27] In the antitrust case of the South Korean FTC vs. Google, Google defends its dominant market share in the app store market with its substantial investments in the success of developers. In the antitrust case of Shanghai Administration for Market Regulation vs. Sherpa's, which is the leading food-delivery platform for foreigners in Shanghai, Sherpa's defends its exclusivity policy on restaurants that exclusivity motivates it to invest more in restaurants to enhance consumers' experience on the platform.

the intersection between marginal revenue $\frac{\partial \Pi_1^m}{\partial \Delta v}$ and marginal cost $k\Delta v$. Figure 7(b) shows the lines of marginal revenue and the marginal cost of investment.



(a) Banning personalized pricing

(b) Exclusivity and platform's investment

Figure 7: Policy discussions on exclusivity

Suppose exclusivity is allowed and platforms compete with uniform prices. Platform one's profit function Π_1^e consists of three parts depending on the joint strength $v + \Delta v$:

$$\Pi_1^e = \begin{cases} \Pi_1^m \text{ in } (4) & \text{when } v + \Delta v > \bar{v}_w^e, \\ \Pi_1^e \text{ in Table 1} & \text{when } 3t < v + \Delta v < \bar{v}_w^e, \\ \Pi_1^e \text{ in Table 1} & \text{when } \underline{v} < v + \Delta v < 3t. \end{cases}$$

Platform one's optimal Δv^e under exclusivity is uniquely determined by the intersection between $\frac{\partial \Pi_1^e}{\partial \Delta v}$ and $k\Delta v$. The strong platform's investment increases under exclusivity (i.e., $\Delta v^e > \Delta v^m$) requires two conditions. First, the line $k\Delta v$ is very steep (above the point x), as shown in Figure 7(b). Second, the line $\frac{\partial \Pi_1^m}{\partial \Delta v}$ crosses the line $\frac{\partial \Pi_1^e}{\partial \Delta v}$, which is equivalent to the joint strength is not large: $v < v^I$.

Suppose platforms enforce exclusivity with personalized pricing. Platform one's marginal revenue of investment $\frac{\partial \Pi_1^e}{\partial \Delta v}$ under exclusivity is always (weakly) larger than its marginal revenue $\frac{\partial \Pi_1^m}{\partial \Delta v}$ when exclusivity is banned. Therefore, platform one always invests (weakly) more under exclusivity.

Proposition 9. *Compared with banning exclusivity policy, allowing exclusivity increases the strong platform's investment*

(i) when exclusivity accompanies personalized pricing, or

(ii) when the joint strength is not large and the marginal cost of investment is very high if platforms compete with uniform pricing.

When the conditions in Proposition 9 fail, exclusivity either decreases or does not change the strong platform's investment.

5.4 Noncompulsory exclusivity

In the analysis thus far, exclusivity is enforced by imposing it as a compulsory policy for sellers. We now discuss how platforms may use price menus or manipulate sellers' cross-side network effects to induce sellers' exclusivity. These inconspicuous tools can achieve the same equilibrium as the compulsory exclusivity and bring the same welfare impacts.

Suppose platform i sets the following price menu for sellers: p_i^s if the seller singlehomes on i and p_i^m if he multihomes, as in Shekhar (2021) and Chica et al. (2021).[28] The stage one of the game in the main model is replaced with platforms simultaneously designing the menu (p_i^s, p_i^m). Since multiple equilibria may exist in the menu competition, we focus on the equilibrium that no seller multihomes. Note that all sellers singlehome when at least one platform chooses a sufficiently high price p_i^m. Without loss of generality, we set $p_i^m \geq v+1$. Then the two platforms compete for sellers with p_i^s. Platform i's equilibrium price p_i^s is characterized by Table 1. The impacts of the equilibrium price menus on welfare follow naturally as in Section 4.

If a platform can control the magnitude of the network effect on individual sellers, it may induce a seller's exclusive dealing with different network effects contingent on whether the seller singlehomes or multihomes. For example, Alibaba diverts buyer attention to sellers who delist from its rival JD.com, and hinders the search for sellers who sell on both platforms.[29] Suppose that platform i chooses network effect multiplier $\delta_i^j(x)$, $j \in \{s, m\}$, on seller x depending on the seller's homing choice, such that the seller's profit is $\pi_i^s = \delta_i^s(x)(v_i + b_i) - t_0 x_i - p_i(x)$ if singlehoming at platform i, and $\pi_m = \delta_1^m(x)(v_1 + b_1) - t_0 x_1 - p_1(x) + \delta_2^m(x)(v_2 + b_2) - t_0 x_2 - p_2(x)$ if multihoming.

Without loss of generality, we assume $\delta_i^j(x) \in \{0, 1\}$. The stage one of games in Sections 4 and 5.2 are replaced with platforms simultaneously designing $(\delta_i^s(x), \delta_i^m(x))$. In the following analysis, we focus on the equilibrium that no seller multihomes. All sellers will singlehome if

[28] In the antitrust cases of JD.com vs. Alibaba and Ele.me vs. Meituan, the strong platforms Alibaba and Meituan charge discriminatory prices to multihoming sellers who promise to singlehome and those who continue to multihome. Food delivery platforms in Hong Kong charge a significantly lower commission for eateries that are the platform's exclusive partners.

[29] In the antitrust case of Ele.me vs. Meituan, Meituan refuses to host the restaurants or makes it harder for consumers to find them if the restaurants refuse to singlehome at Meituan. In the case of South Korea FTC vs. Google, Google gives app developers favorable promotion on Google Play if they agree to exclusive dealing. Another example of a platform manipulating sellers' cross-side network effects can be found in the antitrust case of the District of Columbia vs. Amazon (https://oag.dc.gov/sites/default/files/2021-05/Amazon-Complaint-.pdf). Amazon manipulates third-party sellers' access to the Buy Box and declines their chances to make the sale if they offer lower prices outside Amazon.

platform i chooses $\delta_i^m(x) = 0$, in which case the other platform's choice of $\delta_j^m(x)$ becomes irrelevant. Moreover, a platform's choice of $\delta_i^s(x)$ for potential singlehoming sellers must equal one. Therefore, the subsequent game under $\delta_i^m(x) = 0$ is equivalent to the game under compulsory exclusivity. The equilibrium and welfare impacts are the same as in Section 4 and Section 5.2.

6 Conclusion

In this paper, we study the conditions under which asymmetric platforms enforce exclusivity and its impacts on welfare. We show that exclusivity appears in equilibrium only when the platforms' joint strength is not very large. Therefore, a platform's potent strength hinders its adoption of exclusivity rather than facilitating it. The strength asymmetry encourages the weak platform to enforce exclusivity whereas it constrains the strong platform. Therefore, it can be the weak platform that enforces exclusivity rather than the stronger one. There are also some situations (i.e., intermediate joint strength) in which both platforms gain from exclusivity, resulting in a win-win outcome. Exclusivity in turn reshapes platforms' asymmetry: A platform gains relative salience when it is the only platform that enforces exclusivity. Finally, equilibrium exclusivity can enhance consumer surplus and social welfare, but that happens only when platforms' joint strength is relatively low.

Our paper sheds light on public policies regarding platforms' exclusivity. First, a platform's enforcement of exclusivity does not necessarily indicate its dominance in market competition, and the practice's welfare consequences need to be evaluated carefully. Second, banning a weak platform's exclusivity is likely to improve consumer surplus and social welfare, but such a ban on a strong platform may hurt welfare when few sellers multihome to begin with. Third, a necessary condition for exclusivity to improve welfare is that a platform obtains more buyers or sellers than it does without exclusivity. Fourth, discriminatory pricing may enable a strong platform to foreclose its weak rival under exclusivity, which may not necessarily hurt welfare in the short run. However, a platform may sacrifice short-term profits to establish market monopolization. In that case, a ban on discriminatory pricing can maintain competition and can improve welfare in the long run.

The research can be further extended in several directions: Platforms may endogenously require some but not all multihoming sellers to singlehome, the distribution of sellers and buyers can be more general, and the two platforms may differ in their cross-side network effects rather than in the intrinsic values. We leave these for future work.

A Appendix

This appendix provides proof of the main results. More detailed proofs can be found in the online appendix.

A.1 The multihoming equilibrium in Section 3

When sellers can multihome, we focus on the multihoming equilibrium in which $s_1 + s_2 > 1$ and $s_i \in (0,1)$ hold. Based on (1) and (2), we can derive platform i's number of sellers as a function of prices: $s_i = \frac{(v_i - p_i) - \theta(v_j - p_j) + t\theta}{t(1+\theta)}$. Under Assumptions 2 and 3, $s_1 + s_2 > 1$ implies $b_1 + b_2 > 1$. To satisfy $s_1 + s_2 > 1$ and $s_1, s_2 \in (0,1)$, we need

$$(p_1 - v_1) + (p_2 - v_2) < -t, \quad -t\theta < (v_1 - p_1) - \theta(v_2 - p_2) < t, \quad -t\theta < (v_2 - p_2) - \theta(v_1 - p_1) < t. \quad (16)$$

Maximizing platform i's profit $\Pi_i = p_i s_i$, we can get platform i's best response in pricing, which is characterized by $p_i - v_i = [\theta(p_j - v_j) - v_i + \theta t]/2$. Combining two platforms' best response functions, we can determine the equilibrium prices, each platform's amount of sellers and buyers, and platforms' profits. Condition (16) becomes $\underline{v} < v < \frac{(2-\theta^2)t(\theta+2)}{(2-\theta)(\theta+1)\mu-\theta}$.

However, when v approaches $\frac{(2-\theta^2)t(\theta+2)}{(2-\theta)(\theta+1)\mu-\theta}$, platform one's number of sellers s_1 approaches one, and platform two has very few singlehoming sellers. In this case, platform two has a global deviation strategy to mix between two options: (i) charging a higher uniform price for multihoming sellers and giving up attracting singlehoming sellers, and (ii) charging a lower uniform price to attract more singlehoming sellers. Given any μ, the joint strength v needs to satisfy $v < \bar{v}(\mu)$ to avoid such deviation, in which $\bar{v}(\mu)$ is defined by (7) and is smaller than $\frac{(2-\theta^2)t(\theta+2)}{(2-\theta)(\theta+1)\mu-\theta}$. When $v < \bar{v}(\mu)$ holds, the value of s_1 is bounded such that it would not be extremely close to one.

A.2 The cutoffs in Section 4

Platform one's condition of enforcing exclusivity is

$$v < v_s^e \equiv \begin{cases} \frac{t \cdot h(\theta)}{g(\theta)-1+\mu} & \text{when } \; v \geq 3t, \\ w(\mu,\theta,t) & \text{when } \; v < 3t, \end{cases}$$

in which $h(\theta) \equiv \frac{3(4-\theta^2)\sqrt{1+\theta}-3\sqrt{2}\theta(2+\theta)}{3\sqrt{2}(2+\theta-\theta^2)-2(4-\theta^2)\sqrt{1+\theta}}$, $g(\theta) \equiv \frac{3\sqrt{2}(2-\theta^2)-(4-\theta^2)\sqrt{1+\theta}}{3\sqrt{2}(2+\theta-\theta^2)-2(4-\theta^2)\sqrt{1+\theta}}$, and $w(\mu,\theta,t)$ is defined implicitly by $\delta_2 w^2 + \delta_1 w + \delta_0 = 0$ where $\delta_2 = 9[(2+\theta-\theta^2)\mu - \theta]^2 + (1+\theta)(4-\theta^2)^2(2\mu+1)(1-\mu)$, $\delta_1 = 18t\theta(2+\theta)[(2+\theta-\theta^2)\mu-\theta] - 3t(2+\mu)(1+\theta)(4-\theta^2)^2$, and $\delta_0 = 9t^2\theta^2(2+\theta)^2 + 9t^2(1+\theta)(4-\theta^2)^2$.

Platform two's condition of enforcing exclusivity is

$$\underline{v}_w^e < v < \overline{v}_w^e, \quad \text{in which } \overline{v}_w^e \equiv \frac{t \cdot h(\theta)}{g(\theta) - \mu} \text{ and } \underline{v}_w^e \equiv \frac{t \cdot n(\theta)}{l(\theta) + \mu}.$$

We have $n(\theta) = \frac{3\theta(2+\theta)}{3(2+\theta-\theta^2)-\sqrt{2(1+\theta)}(4-\theta^2)} > 0$ and $l(\theta) = \frac{\sqrt{2(1+\theta)}(4-\theta^2)-3(2-\theta^2)}{3(2+\theta-\theta^2)-\sqrt{2(1+\theta)}(4-\theta^2)} > 0$.

Consumer surplus in the multihoming equilibrium is $CS^m = \frac{\xi_2 v^2+\xi_1 v+\xi_0}{2t^2(1+\theta)^2(\theta+2)^2(\theta-2)^2}$, in which $\xi_2 = 2\mu(\mu-1)(1+\theta)^2(-2+\theta)^2 + (2t^2\theta^4 + 8t^2\theta^3 + 2t\theta^4 + 8t^2\theta^2 + 6t\theta^3 + \theta^4 - 8t\theta - 3\theta^2 + 4), \xi_1 = [-2t\theta(\theta+2)^2 t(6t\gamma(\gamma-1) + 4t^2(\gamma-1) - \gamma - t)]/(\gamma+t)^2$, and $\xi_0 = 2t^2\theta(\theta+2)^2(t^2\theta^3 + 4t^2\theta^2 + t\theta^3 + 4t^2\theta + 3t\theta^2 - 4t + \theta)$. Consumer surplus under equilibrium exclusivity is

$$CS^e = \begin{cases} \frac{(2\mu-1)^2 v^2 + 9t^2}{36t^2} & \text{when } v \geq 3t, \\ \frac{4(1-\mu)^2 v^2 - 12t(1-\mu)v + 18t^2}{36t^2} & \text{when } v < 3t. \end{cases}$$

We can prove that $CS^e > CS^m$ is equivalent to $v < v_{cs}^e$, in which v_{cs}^e is defined by $CS^e = CS^m$.

In the multihoming equilibrium, sellers' total profits are $\pi^m = \frac{(1+t)\left(\iota_2 v^2+\iota_1 v+\iota_0\right)}{2t^2(1+\theta)^2(4-\theta^2)^2}$, where $\iota_2 = [(2+\theta-\theta^2)\mu - \theta]^2 + [2-\theta^2-(2+\theta-\theta^2)\mu]^2, \iota_1 = 2t\theta(1-\theta)(2+\theta)^2$, and $\iota_0 = 2t^2\theta^2(2+\theta)^2$. The sum of platforms' profits is $\Pi_1^m + \Pi_2^m = \frac{t(1+\theta)}{t^2(1+\theta)^2(4-\theta^2)^2}\left(\iota_2 v^2 + \iota_1 v + \iota_0\right)$. Therefore, social welfare is $SW^m = (\kappa_2 v^2 + \kappa_1 v + \kappa_0)/[2t^2(1+\theta)^2(4-\theta^2)^2]$, where $\kappa_i = \xi_i + (1+3t+2t\theta)\iota_i$. Under equilibrium exclusivity, sellers' total profits are

$$\pi^e = \begin{cases} \frac{(t+1)(2\mu-1)^2 v^2}{36t^2} + \frac{v}{2} - \frac{5t-1}{4} & \text{when } v \geq 3t, \\ \frac{(1+t)[2v^2(\mu-1)^2 + 6tv(\mu-1) + 9t^2]}{18t^2} & \text{when } v < 3t. \end{cases}$$

We can prove that $\pi^e > \pi^m$ is equivalent to $v < v_\pi^e$, in which v_π^e is defined by $\pi^e = \pi^m$. The sum of platforms' profits is $\Pi_1^e + \Pi_2^e = 2t[(s_1^e)^2 + (s_2^e)^2]$. Therefore, social welfare is

$$SW^e = \begin{cases} \frac{(5t+2)(2\mu-1)^2 v^2 + 18t^2 v + 9t^2(2-t)}{36t^2} & \text{when } v \geq 3t, \\ \frac{(1-\mu)[4(1+t)(1-\mu)-6t\mu]v^2 + [18t^2\mu - 6t(2-t)(1-\mu)]v + 9t^2(2-t)}{18t^2} & \text{when } v < 3t. \end{cases}$$

We have $SW^e > SW^m$ if and only if $v < v_{sw}^e$ holds and v_{sw}^e is defined by $SW^e = SW^m$.

A.3 The cutoffs in Section 5.2

Platform one wins all sellers in equilibrium when $\mu > \hat{\mu}(v,t)$ holds, in which

$$\hat{\mu}(v,t) \equiv \begin{cases} \frac{1}{2} + \frac{t-2}{2v} & \text{when } v > 3t, \\ \frac{t^2+vt-1}{v(2t+1)} & \text{when } v \leq 3t. \end{cases}$$

Platform one's equilibrium profit is

$$\Pi_1^p = \begin{cases} (2\mu-1)v+1, & \text{when } v \geq \max\left\{\frac{t+1}{1-\mu}, \frac{t-2}{2\mu-1}\right\}, \\ \frac{[(2\mu-1)v+t]^2}{4(t-1)}, & \text{when } \frac{(2t-1)t}{2t(1-\mu)-1} < v < \frac{t-2}{2\mu-1}, \\ \mu v - \frac{(1-\mu)^2 v^2}{2(t+1)} + \frac{1-t}{2}, & \text{when } \frac{t^2-1}{(t+1)\mu-t(1-\mu)} \leq v \leq \frac{t+1}{1-\mu}, \\ \frac{\mu v[(t+1)\mu v+2t^2]-2t\mu(1-\mu)v^2+(t-1)(1-\mu)v[2t-(1-\mu)v]-(t-1)t^2}{4t^2-2}, & \text{when } v \leq \min\left\{\frac{(2t-1)t}{2t(1-\mu)-1}, \frac{t^2-1}{(t+1)\mu-t(1-\mu)}\right\}. \end{cases}$$

Platform one enforces exclusivity if and only if $\Pi_1^p > \Pi_1^m$ or equivalently $v < v^p$ holds, in which v^p is determined by $\Pi_1^p = \Pi_1^m$.

Consumer surplus under exclusivity is

$$CS^p = \begin{cases} 1/2, & \text{when } v \geq \max\left\{\frac{t^2-1}{(t+1)\mu-t(1-\mu)}, \frac{t-2}{2\mu-1}\right\}, \\ \frac{(2\mu v+t-v)^2}{8(t-1)^2} + \frac{(2\mu v-t-v+2)^2}{8(t-1)^2}, & \text{when } \frac{(2t-1)t}{2t(1-\mu)-1} < v < \frac{t-2}{2\mu-1}, \\ \frac{(2\mu tv+\mu v+t^2-tv)^2}{2(2t^2-1)^2} + \frac{(2\mu tv+\mu v-t^2-tv+1)^2}{2(2t^2-1)^2}, & \text{when } v \leq \min\left\{\frac{(2t-1)t}{2t(1-\mu)-1}, \frac{t^2-1}{(t+1)\mu-t(1-\mu)}\right\}. \end{cases}$$

Equilibrium exclusivity enhances consumer surplus if and only if $v < v_{cs}^p$ holds, in which v_{cs}^p is the value of v such that $CS^m = CS^p$ and $v < v^p$ hold.

Sellers' total profits are

$$\pi^p = \begin{cases} (1-\mu)v - \frac{t+1}{2}, & \text{when } v \geq \max\left\{\frac{t+1}{1-\mu}, \frac{t-2}{2\mu-1}\right\}, \\ -\frac{2\mu tv+t^2-2tv-t+v+1}{2(t-1)}, & \text{when } \frac{(2t-1)t}{2t(1-\mu)-1} < v < \frac{t-2}{2\mu-1}, \\ \frac{(1-\mu)^2 v^2}{2(1+t)}, & \text{when } \frac{t^2-1}{(t+1)\mu-t(1-\mu)} \leq v \leq \frac{t+1}{1-\mu}, \\ \frac{(1+t)(2\mu tv-2tv-t+v+1)^2}{2(2t^2-1)^2}, & \text{when } v \leq \min\left\{\frac{(2t-1)t}{2t(1-\mu)-1}, \frac{t^2-1}{(t+1)\mu-t(1-\mu)}\right\}. \end{cases}$$

Equilibrium exclusivity enhances sellers' total profit if and only if $\mu < \mu_\pi^p$ holds, in which μ_π^p defined by $\pi^p = \pi^m$.

Social welfare is

$$SW^p = \begin{cases} 1+v\mu-t/2, & v \geq \max\left\{\frac{t^2-1}{(t+1)\mu-t(1-\mu)}, \frac{t-2}{2\mu-1}\right\}, \\ \frac{4\mu^2tv^2-4\mu tv^2-t^3+2t^2v+tv^2+4\mu v+4t^2-4tv-6t+4}{4(t-1)^2}, & \frac{(2t-1)t}{2t(1-\mu)-1} < v < \frac{t-2}{2\mu-1}, \\ \frac{2(2\mu t+\mu-t)(2\mu t^2+3\mu t-t^2-2t+1)v^2+(4t^4+6\mu t-4t^2+2\mu-4t+2)v-(t-2)(2t^4-2t^2+1)}{2(2t^2-1)^2}, & v \leq \min\left\{\frac{(2t-1)t}{2t(1-\mu)-1}, \frac{t^2-1}{(t+1)\mu-t(1-\mu)}\right\}. \end{cases}$$

Equilibrium exclusivity enhances social welfare if and only if $v < v_{sw}^p$ holds, in which v_{sw}^p is the value of v such that $SW^m = SW^p$ and $v < v^p$ hold.

A.4 The cutoff in Section 5.3

Suppose exclusivity is allowed and platforms compete with uniform prices. Define $v = v_1 + v_2$ and $\mu = \frac{v_1}{v_1+v_2}$. When $v + \Delta v > \overline{v}_w^e$, no platform enforces exclusivity. We have

$$\frac{\partial \Pi_1^m}{\partial \Delta v} = \frac{2(2-\theta^2)^2}{t(1+\theta)(4-\theta^2)^2}\Delta v + \frac{2(2-\theta^2)}{t(1+\theta)(4-\theta^2)^2}[(2-\theta^2)\mu v - \theta(1-\mu)v + t\theta(2+\theta)].$$

When $3t < v + \Delta v < \overline{v}_w^e$, the equilibrium is similar to the first row in Table 1 except that platform one's strength is now $v_1 + \Delta v$. We have $\frac{\partial \Pi_1^e}{\partial \Delta v} = \frac{3t+\Delta v+(2\mu-1)v}{9t}$. When $\underline{v} < v + \Delta v < 3t$, the equilibrium is similar to the second row in Table 1 except that platform one's strength is now $v_1+\Delta v$. We have $\frac{\partial \Pi_1^e}{\partial \Delta v} = 1 - \frac{(1-\mu)v}{3t}$. As shown in Figure 7, the line of $\frac{\partial \Pi_1^m}{\partial \Delta v}$ crosses the line $\frac{\partial \Pi_1^e}{\partial \Delta v}$ if and only if $\frac{\partial \Pi_1^m}{\partial \Delta v}|_{\Delta v=0} < \frac{\partial \Pi_1^e}{\partial \Delta v}|_{\Delta v=0}$ holds. This condition is equivalent to $v < v^I = \frac{t\phi(\theta)}{\psi(\theta)+\eta(\theta)\mu}$, in which $\phi(\theta) = 3(\theta+2)(\theta^4+\theta^3-6\theta^2+8)$, $\psi(\theta) = (1+\theta)(4-\theta^2)^2 - 6\theta(2-\theta^2)$ and $\eta(\theta) = (2-\theta)(1+\theta)(\theta^3-4\theta^2-4\theta+4)$.

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