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Abstract

On many two-sided platforms, users on one side not only care about user participation and usage levels on the other side, but they also care about participation and usage of fellow users on the same side. Most prominent is the degree of seller competition on a platform catering to buyers and sellers. In this paper, we address how seller competition affects platform pricing, product variety, and the number of platforms that carry trade.

Keywords: Network effects, two-sided markets, platform competition, intermediation, pricing, imperfect competition

JEL-Classification: D43, L13, L86

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1 Introduction

Many platforms enable or facilitate trade between buyers and sellers. Probably since the Stone Age, people gather at central places to exchange goods and provide services. Medieval trade fairs brought buyers and sellers into contact. The offline world features many platforms including stock exchanges, currencies, flea markets, shopping malls, newspapers, magazines, and broadcasters. Electronic payment systems, software platforms, and digital marketplaces are more recent prominent platforms allowing two distinct groups of participants to interact and exchange goods or services.

Starting with the seminal papers by Caillaud and Jullien (2003), Rochet and Tirole (2003), and Armstrong (2006), the economic literature on two-sided platforms focuses on cross-group external effects. Such focus seems natural as cross-group effects directly stem from the desire of the two groups of agents to interact and, thereby, give their raison d'être to two-sided platforms. However, in many economic environments, platforms also have to factor in the fact that the attractiveness of a platform for the members of one group also depends on the participation of the members of the very same group. That is, there exist within-group external effects, which platforms have to take into account when choosing their strategies. Let us describe a number of settings in which such effects are present.

Negative within-group effects appear when the members of one group compete with one another to interact with the other group. For instance, given a set of buyers on the platform, the expected profits of sellers on Ebay decrease in response to the entry of competing sellers. Similarly, if an additional competing shop opens in a shopping mall, the expected profits of existing shops decrease given a set of buyers in the mall. Another example is dating apps. These are characterized by positive cross-group external effects, as the app becomes more attractive the more it is used by people of the opposite gender. However, they are also characterized by negative within-group external effects, as more people of the same gender make it less likely that a match materializes for a particular person. Different from a buyer-seller context, there is typically no monetary transaction between users on a dating app.

Negative within-group effects may also arise because of congestion problems—for instance, sellers may compete for buyer attention, which is scarce. Consumption externalities are another instance of negative within-group effects. For instance, referring to Airbnb visitors, Slee (2016) reports that "as their numbers grow, they erode the very atmosphere in which they bask and threaten the livability of the city for residents." This arguably also applied to fellow visitors. Congestion effects may also be present on digital platforms with limited bandwidth such that, e.g., the delivery of research result is slowed down—this would imply that the stand-alone utility of the platform suffers from a lot of buyer participation. In the offline world, congestion problems appear when the platform's physical venue is too crowded; for instance, shoppers may get stuck in a crowded shopping mall and, as a result, make fewer purchase attempts.[1]

[1] By contrast, there also exist market environments with positive within-group effects; for instance, Belleflamme, Omrani and Peitz (2015) explain that a larger 'crowd' of funders on a crowdfunding platform increases the

In this paper, we focus on competition in a buyer-seller context and we examine how such competition affects outcomes in platform markets. We consider a two-sided platform that enables trade between buyers and sellers—these sellers make non-discriminatory take-it-or-leave-it offers to buyers. Imperfect competition between sellers has the standard property that an additional seller on the platform leads to lower per-buyer profit for each seller already on the platform—a negative within-group external effect. It also often leads to lower prices and more variety, which buyers like. Thus, the additional seller may generate more participation on the buyer side, which in turn will benefit all sellers—the combination of two positive cross-group external effects. Our objective is to analyze how platforms take these conflicting effects into account when choosing their price- and non-price strategies.

One way to carry out such analysis is to augment standard two-sided platform models by adding a parameter that measures a negative effect within the group of sellers, and to study the allocative effects in response to a change of this parameter; we review below some papers that follow this path (e.g., Belleflamme and Toulemonde, 2009). However, in light of the argument above, such comparative statics can be misconceived, as seller competition also affects how buyers and sellers value the interaction with each other. For instance, an increase in seller competition drives down per-consumer profits and, thus, increases the strength of the negative within-group external effect on the seller side. At the same time, the per-seller consumer benefit is affected and, thus, the strength of the cross-group external effect exerted by sellers on consumers changes as well. Hence, an increase in seller competition affects two parameters in the reduced form model at the same time. This implies that these parameters should not be treated as primitives of the model. We need instead to couple standard two-sided platform models with micro-foundations of seller competition and buyer-seller relationships. This is the route that we take in this paper.[2]

This paper is organized as follows. First, we consider seller competition on a monopoly platform and its effect on prices and product variety. Second, we study platform competition; in particular, we generalize the two-sided singlehoming model of Armstrong (2006) to allow for seller competition. Third, we examine the influence of seller competition on the number of platforms carrying positive volume of trade. Our objective is to synthesize existing literature, which will be referenced in the main text.

2 Prices and product variety on a monopoly platform

In this section, we focus on a single platform that facilitates the interaction between buyers and competing sellers. We first develop a baseline model to derive the main intuitions. We then extend the analysis by reviewing the extant literature.

probability that any project will be realized, which benefits all funders. Another instance is learning from others in the same group on a platform.

[2] Lin, Wu and Zhou (2016) also consider seller competition, and show that a monopoly platform bases its pricing on characteristics that affect both sides of the market.

2.1 A baseline model

Let us define the seller and buyer net surplus of visiting the platform (gross of any opportunity cost) respectively as $v_s = r_s + \pi(n_b, n_s) - m_s$ and $v_b = r_b + u(n_b, n_s) - m_b$. Here, r_g is the stand-alone utility on side $g \in \{b, s\}$ and m_g is the fixed membership or subscription fee charged by the platform to side g. The general functions $\pi(n_b, n_s)$ and $u(n_b, n_s)$ represent the net gains from trade for any seller and any buyer on the platform. They both potentially depend on the number of buyers and on the number of sellers who are present on the platform, meaning that any form of cross-group and within-group external effects are permitted. We assume that both functions are twice continuously differentiable in their two arguments. In this paper, we focus on fixed fees per participant and do not allow the platform to charge usage fees. This is reasonable in situations in which monitoring transactions is prohibitively costly or in which consumers can bypass the platform at negligible cost.[3] We consider a model with three stages: first, the monopoly platform sets the fixed fees; second, buyers and sellers simultaneously decide to enter (alternatively, the platform admits a certain number of buyers of sellers on the platform and fees then clear the market); and, third, participating sellers play an oligopoly game. We analyze properties of the subgame-perfect Nash equilibrium.

In this monopoly model, we assume that a mass of Z buyers and of Z sellers have an outside option that is uniformly distributed on $[0, Z]$, with Z large.[4] Hence, for given m_s and m_b, the equilibrium number of buyers and sellers is implicitly characterized by $n_s = r_s + \pi(n_b, n_s) - m_s$ and $n_b = r_b + u(n_b, n_s) - m_b$. We postulate that there is a unique solution to this system of equations, $n_s(m_s, m_b)$ and $n_b(m_s, m_b)$, which imposes further restrictions on u and π. From the system of equations, we have $m_s = r_s + \pi(n_b, n_s) - n_s$ and $m_b = r_b + u(n_b, n_s) - n_b$. The platform's profit is $\Pi = n_b(m_b - f_b) + n_s(m_s - f_s)$. In light of the buyers' and sellers' participation decisions, the platform's profit maximization problem can be written as $\max_{n_b, n_s} n_b[r_b + u(n_b, n_s) - n_b - f_b] + n_s[r_s + \pi(n_b, n_s) - n_s - f_s]$. The profit-maximizing number of sellers and buyers on a platform satisfies the system of first-order conditions

$$\begin{cases} \dfrac{\partial \Pi}{\partial n_b} = [r_b + u(n_b, n_s) - 2n_b - f_b] + \dfrac{\partial u(n_b, n_s)}{\partial n_b} n_b + \dfrac{\partial \pi(n_b, n_s)}{\partial n_b} n_s = 0, \\ \dfrac{\partial \Pi}{\partial n_s} = [r_s + \pi(n_b, n_s) - 2n_s - f_s] + \dfrac{\partial u(n_b, n_s)}{\partial n_s} n_b + \dfrac{\partial \pi(n_b, n_s)}{\partial n_s} n_s = 0. \end{cases}$$

The second-order conditions require

$$\frac{\partial^2 \Pi}{\partial n_b^2} < 0, \; \frac{\partial^2 \Pi}{\partial n_s^2} < 0 \text{ and } \frac{\partial^2 \Pi}{\partial n_b^2} \frac{\partial^2 \Pi}{\partial n_s^2} - \left(\frac{\partial^2 \Pi}{\partial n_b \partial n_s} \right)^2 > 0.$$

[3] Otherwise, a platform may want to impose usage charges if participants are heterogeneous with respect to the benefit they derive from usage. As discussed by Rochet and Tirole (2006) for the case in which sellers' products are independent (neither substitutes nor complements), membership fees are the"right"instrument to use if platforms only face heterogeneity in opportunity costs from participating. Seller competition does not affect this insight.

[4] Due to seller heterogeneity inframarginal sellers will make a positive net surplus. If sellers were homogeneous, the platform would extract all rents on the seller side. For monopoly pricing with more general distributions, see Hagiu (2009). In models with a discrete number of sellers, we assume that the opportunity cost of the nth seller is n. For expositional convenience, with a finite number of sellers, we treat the number of sellers at stage 1 as a real number.

We now focus on situations in which within-group external effects are negative for sellers (reflecting seller competition) and absent for buyers. As for cross-group external effects, they are positive in both directions. We simplify the surplus functions as follows: $\pi(n_b, n_s) \equiv n_b \tilde{\pi}(n_s)$ and $u(n_b, n_s) \equiv n_s \tilde{u}(n_s)$; both functions will be parametrized by a parameter that measures the intensity of competition among sellers. We now provide two examples with these properties.[5]

Example 1 *Cournot competition with horizontally differentiated products*

Suppose that sellers are Cournot competitors with horizontally differentiated products and constant marginal costs c; the demand for variety k, produced by seller k (with $k = 1 \ldots n_s$) is given by $p_k = a - q_k - \gamma q_{-k}$ (with $q_{-k} = \sum_{g \neq k} q_g$) for strictly positive prices and zero otherwise.[6] Solving for the Cournot equilibrium and setting, without loss of generality, $a - c = 1$, we can compute the equilibrium profit for each seller and the consumer surplus as (see the details in Appendix 6.1):

$$\pi(n_b, n_s) = n_b \tilde{\pi}(n_s) = n_b \frac{1}{(2 + \gamma(n_s - 1))^2} \text{ and } u(n_b, n_s) = n_s \tilde{u}(n_s) = n_s \frac{(1 + \gamma(n_s - 1))}{2(2 + \gamma(n_s - 1))^2}.$$

Example 2 *Monopolistic competition with CES demand*

Suppose that products are differentiated and a continuum of single-product sellers simultaneously set prices. Conditional on visiting the platform, consumers have CES preferences over the differentiated products.[7] Demand for product j is

$$q(j) = \frac{p(j)^{-\frac{1}{1-\rho}} E}{\int_0^{n_s} p(i)^{-\frac{\rho}{1-\rho}} di},$$

where $p(j)$ is the price of variant j, E is income spent on the differentiated goods industry, and $\rho \in (0, 1)$ is inversely related to the degree of product differentiation. Seller j maximizes his gross profit (per unit mass of buyers) $\tilde{\pi} = (p - c)p^{-\frac{1}{1-\rho}} A$, where c is the constant marginal cost of production, and $A \equiv E / \int_0^{n_s} p(j)^{-\frac{\rho}{1-\rho}} dj$. Using symmetry, the first-order conditions of profit maximization yield the equilibrium price $p = c/\rho$. In this example, an increase in product variety has no price effect, so $\partial p / \partial n_s = 0$. In equilibrium, the profit per unit mass of buyers and the utility per unit mass of sellers are respectively given by

$$\tilde{\pi}(n_s) = (1 - \rho) \frac{E}{n_s} \text{ and } \tilde{u}(n_s) = \frac{\rho E}{c} n_s^{\frac{1-2\rho}{\rho}}.$$

A special case is $\rho = 1/2$, as in this case $\tilde{u}(n_s)$ is constant in n_s; this describes a situation in which seller competition generates a negative within-group external effect, whereas seller competition has no effect on a consumer's per-seller gross benefit.

[5] Another example, in which sellers compete on a Salop circle, can be found in Lin, Wu and Zhou (2016).

[6] We suppose here that there is a finite number of discrete sellers and then ignore the integer constrains. For the corresponding version of this model with a continuum of sellers, see, e.g., Ottaviano and Thisse (2011).

[7] This example is taken from Nocke, Peitz, and Stahl (2007).

In both examples, the equilibrium numbers of buyers and sellers is determined by the solution to $n_b = r_b + n_s\tilde{u}(n_s) - m_b$ and $n_s = r_s + n_b\tilde{\pi}(n_s) - m_s$. Substituting the first equation into the second, we obtain $n_s = r_s + [r_b + n_s\tilde{u}(n_s) - m_b]\tilde{\pi}(n_s) - m_s$, which implicitly defines the number of sellers as a function of the platform fees m_b and m_s. The positive indirect network effect is captured by the square bracket—$\tilde{u}(n_s)$ is always increasing in n_s, as more buyers are attracted by a platform hosting more sellers. However, this interacts with a negative direct network effect stemming from the fact that $\tilde{\pi}(n_s)$ is decreasing in n_s.[8] The platform's profit maximization problem can be rewritten respectively as

$$\max_{n_b,n_s} n_b[r_b - n_b - f_b] + n_s[r_s - n_s - f_s] + [\tilde{u}(n_s) + \tilde{\pi}(n_s)]n_s n_b,$$

$$\begin{cases} \dfrac{\partial \Pi}{\partial n_b} = r_b - 2n_b - f_b + [\tilde{u}(n_s) + \tilde{\pi}(n_s)]\, n_s = 0, \\ \dfrac{\partial \Pi}{\partial n_s} = r_s - 2n_s - f_s + [\tilde{u}(n_s) + \tilde{\pi}(n_s)]\, n_b + [\tilde{u}'(n_s) + \tilde{\pi}'(n_s)]\, n_b n_s = 0. \end{cases} \tag{1}$$

The system (1) implicitly defines the optimal numbers of buyers and sellers that the monopoly platform attracts, n_b^M and n_s^M and the associated prices that can implement this allocation.

We now perform two exercises to evaluate how seller competition affects the platform's equilibrium decisions and profits. First, we observe in expression (1) that the term $[\tilde{u}'(n_s) + \tilde{\pi}'(n_s)]\, n_b n_s$ on the bottom line only appears when seller competition is present. We then make the following thought experiment. Upon observing n_b^M, n_s^M and the resulting $\tilde{u}(n_s^M)$ and $\tilde{\pi}(n_s^M)$, what happens if one wrongly believes that the platform maximized its profit while ignoring seller competition, and thus the term $[\tilde{u}'(n_s) + \tilde{\pi}'(n_s)]\, n_b n_s$? This hypothetical platform would solve the following system of equations

$$\begin{cases} r_b - 2n_b - f_b + \left[\tilde{u}(n_s^M) + \tilde{\pi}(n_s^M)\right] n_s = 0, \\ r_s - 2n_s - f_s + \left[\tilde{u}(n_s^M) + \tilde{\pi}(n_s^M)\right] n_b = 0. \end{cases}$$

Graphically, the solution to this system is the intersection of the two linear functions depicting the profiting-maximizing n_b for given n_s and the profit-maximizing n_s for given n_b. Let us now account for the dependence of $\tilde{u}(n_s)$ and $\tilde{\pi}(n_s)$ on n_s. This implies that the profit-maximizing n_s as a function of n_b is shifted inward if and only if $\tilde{u}'(n_s) + \tilde{\pi}'(n_s) < 0$. In this case, the platform's solution must feature fewer sellers and fewer buyers. If the number of buyers is rather insensitive to the number of sellers the effect on the number of buyers is weak; otherwise, the effect is strong. The message that emerges from this simple comparison is that seller competition tends to have a negative effect on product variety on a monopoly platform if $\tilde{u}'(n_s) + \tilde{\pi}'(n_s) < 0$. We note that this comparison is artificial, since the absence of seller competition will have an impact on the level of $\tilde{u}$ and $\tilde{\pi}$ (as we note in our second exercise below).

It is of interest to see on which side a platform makes most or even all of its profits. Denote profit on the buyer side by $\Pi_b = n_b(m_b - f_b) = n_b[r_b + n_s\tilde{u}(n_s) - n_b - f_b]$ and on the seller side

[8] This has also been pointed out by Hagiu (2009).

by $\Pi_s = n_s(m_s - f_s) = n_s[r_s + n_b\tilde{\pi}(n_s) - n_s - f_s]$. Using the first-order conditions of profit maximization, we obtain

$$\begin{aligned}\Pi_b &= n_b[n_b - \tilde{\pi}(n_s)n_s]\\ \Pi_s &= n_s[n_s - \tilde{u}(n_s)n_b] - (\tilde{u}'(n_s) + \tilde{\pi}'(n_s))n_b n_s^2.\end{aligned}$$

Thus, it is less likely that sellers are subsidized if $\tilde{u}'(n_s) + \tilde{\pi}'(n_s) < 0$ compared to a model in which cross-group external effects are constant and fixed at the equilibrium value of the present model.[9]

Returning to our two examples, we observe the following:

$$\tilde{u}'(n_s) + \tilde{\pi}'(n_s) = \begin{cases} -\gamma\frac{4+\gamma(n_s-1)}{2(2+\gamma(n_s-1))^3} & \text{in Example 1,}\\ E\frac{(1-2\rho)n_s^{1/\rho} - cn_s(1-\rho)}{cn_s^3} & \text{in Example 2.}\end{cases}$$

It is immediate that $\tilde{u}'(n_s)+\tilde{\pi}'(n_s) < 0$ in Example 1. In Example 2, we have that $\tilde{u}'(n_s)+\tilde{\pi}'(n_s)$ is locally positive or negative depending on the parameter values; it is necessarily negative if $\rho \geq 1/2$.

Our second exercise consists in assessing directly how the monopoly platform is affected when seller competition becomes stronger; i.e., in our examples, when products are closer substitutes: when γ (Example 1) or ρ (Example 2) increases. As noted in the introduction, a change in these parameters also affects directly the consumer surplus. Letting $\mu \in \{\gamma, \rho\}$, we use implicit differentiation to evaluate how a change in μ affects the platform's optimal number of buyers and sellers, and profit. We summarize here our main results (the details can be found in Appendix 6.2). Using the envelope theorem, we compute the effect of a change in μ on the platform's maximal interior's profit as

$$\frac{d\Pi}{d\mu} = \left(\frac{\partial\tilde{u}(n_s;\mu)}{\partial\mu} + \frac{\partial\tilde{\pi}(n_s;\mu)}{\partial\mu}\right)n_s n_b.$$

In Examples 1 and 2, where the degree of product substitutability measures the intensity of competition, both $\tilde{u}$ and $\tilde{\pi}$ decrease when sellers compete more fiercely. That more competition hurts sellers is obvious. To understand that more competition also reduces the surplus that buyers obtain from each seller, we note that in these two models, an increase in γ or ρ has two opposite effects: it decreases prices (because of more seller competition) but it also decreases utility (because buyers have an intrinsic preference for variety); it turns out that the latter effect dominates the former. As a result, the benefits that both sellers and buyers obtain per transaction are reduced when seller competition increases, which reduces the platform's profit.

By totally differentiating the system of first-order conditions (1) with respect to n_b, n_s and

[9] For an analysis with general distribution functions, see Hagiu (2009). See also Goos, Van Cayseele and Willekens (2013) for a related analysis of a monopoly platform matching two groups, in the presence of positive cross-group and negative within-group external effects.

μ, we obtain

$$
\begin{aligned}
\frac{dn_b}{d\mu} &= \frac{1}{K}\left(-\frac{\partial^2\Pi}{\partial n_b \partial\mu}\frac{\partial^2\Pi}{\partial n_s^2} + \frac{\partial^2\Pi}{\partial n_s\partial\mu}\frac{\partial^2\Pi}{\partial n_b\partial n_s}\right), \\
\frac{dn_s}{d\mu} &= \frac{1}{K}\left(-\frac{\partial^2\Pi}{\partial n_s \partial\mu}\frac{\partial^2\Pi}{\partial n_b^2} + \frac{\partial^2\Pi}{\partial n_b\partial\mu}\frac{\partial^2\Pi}{\partial n_b\partial n_s}\right), \\
\text{where } K &\equiv \frac{\partial^2\Pi}{\partial n_b^2}\frac{\partial^2\Pi}{\partial n_s^2} - \left(\frac{\partial^2\Pi}{\partial n_b\partial n_s}\right)^2 > 0 \text{ (by S.O.C.)}.
\end{aligned}
$$

Evaluating these expressions for the specific surplus functions derived above, we show in Appendix 6.2 that in both examples, the platform chooses to attract fewer sellers and fewer buyers when seller competition intensifies. Noting that in our model, $v_b = n_b$ and $v_s = n_s$, the previous results also mean that in both examples, sellers and buyers are worse off when competition among sellers intensifies.

2.2 Additional issues with monopoly platforms

In the previous section, we studied how a change in the degree of competition among sellers may affect the platform's pricing strategy and, with it, the well-being of the various players (platform, sellers and buyers). In particular, we showed that if the total value generated in a buyer-seller transaction decreases with the intensity of seller competition, then so does the platform's maximal profit. In this section, we explore a number of additional issues that have been studied in the literature. First, as a natural extension of our simple setting, we continue to focus on price strategies and examine whether pricing is efficient, and how the results change when the set of strategies is either restricted (one-sided pricing) or expanded (price discrimination). Next, we ask how seller competition may lead platforms to modify their choices of non-price strategies, such as helping buyers search products or controlling sellers' quality.

2.2.1 Platform's price strategies

Pricing efficiency. Galeotti and Moraga (2009) consider a monopoly platform catering to a fixed discrete number of horizontally differentiated sellers and a continuum of buyers. Their microfoundation of the buyer-seller interaction goes as follows: Sellers choose a probability to participate (this is interpreted as their decision to inform consumers about their product) and a price. Buyers on the platform draw match values and buy the product that maximizes the difference between match value and price. Thus, a seller who increases his participation probability intensifies competition. The authors assume that, in the second stage, sellers set price and make participation decisions, and buyers make participation decisions. Their decisions are guided by the membership fees set by the platform in the first stage.

At the participation stage, buyers and sellers are homogeneous. Therefore, the platform can extract the full surplus generated by intermediation. Galeotti and Moraga show that platform pricing is second-best efficient—that is, a planner with the same instruments would implement the same allocation: The platform sets prices on both sides so as to ensure full participation by buyers and sellers, and this implements the social planner's second-best allocation.

One-sided pricing. Nocke, Peitz and Stahl (2007) analyze the product variety on a monopoly platform that charges only sellers a participation fee.[10] Thus, the platform has a single instrument to steer the degree of competition on the platform.

Since buyers can access the platform for free, their participation increases with the number of sellers hosted by the platform. As for sellers, their profits are the ones derived in Example 2. As we showed above, the per-buyer profit is decreasing in the number of sellers. Yet, a countervailing effect is the market-expansion effect that arises since more sellers attract more buyers. When deciding about how much to charge sellers, a platform has to take these effects into account—it maximizes $n_s m_s - C(n_s)$, where n_s depends on m_s and $C(n_s)$ is the platform's weakly convex cost.

As is well-known from the literature on product variety, the fact that sellers engage in business-stealing tends to lead to socially excessive product variety. However, a monopoly platform takes this effect into account. A profit-maximizing platform sets a high fee such that there is always a socially insufficient number of sellers n_s. Thus, product variety is less than in the second best, in which a social planner can pick the number of sellers hosted by the platform. By contrast, if a platform is open and, thus, does not restrict access by charging fees above marginal costs, product variety may well be socially excessive.

The lack of a pricing instrument on the buyer side suggests that the platform is overly concerned with the gross surplus generated on the seller side. To take an extreme example, suppose that sellers are ex ante homogeneous. A monopoly platform will then extract the full seller surplus.[11] This often means that the platform will set a high membership fee and effectively limit competition on its platform. If sellers offer sufficiently close substitutes this implies that only a single seller will be active and the platform will extract the monopoly rent of this single seller. A platform can create such a commitment by offering a contract that grants exclusivity to the seller on the platform—this has been documented in the case of shopping malls in Ater (2015). By contrast, if the platform can also charge buyers, a lower membership fee on the seller side leads to a larger number of participating sellers. This generates a larger gross surplus on the consumer side, which can be extracted by the platform through the membership fee on the buyer side. Thus, with the additional price instruments the platform allows for more product variety and generates a larger total surplus.

[10] Such a situation arises if a platform cannot monitor participation decision by buyers or if it optimally payed buyers for participation but that such negative fees are not feasible or prohibited.

[11] The number of sellers is determined by $m_s = r_s + \tilde{\pi}\,(n_s)\,n_b$. With two-sided pricing, the platform maximizes $\max_{n_b,n_s} n_b[r_b - n_b - f_b] + n_s[r_s - n_s - f_s] + [\tilde{u}(n_s) + \tilde{\pi}(n_s)]n_s n_b$. If the platform can only charge sellers the platform's problem is $\max_{n_s} -n_b f_b + n_s[r_s - n_s - f_s + \tilde{\pi}(n_s)n_b]$ subject to $n_b = r_b + n_s\tilde{u}(n_s)$. With two-sided pricing, the platform has an additional price instrument that allows it to obtain higher profit. It may do so by paying buyers for participation or by charging them a positive price, depending on the parameters and functions.

Making discriminatory offers. More generally, a platform may not only decide on how many sellers to host, but, taking into account that markets are often not symmetric and products differ by the degree of substitutability, actively pick sellers with particular characteristics by making discriminatory offers. For instance, in the case of shopping malls, the empirical literature has established that a shopping mall manages its portfolio of shops to internalize externalities—see Pashigian and Gould (1998). In particular, a shopping mall provides better terms to those shops which serve as magnets and generate business for other stores (such as, traditionally, anchor stores).

Translated into the online world, this means that a digital platform may be better at internalizing externalities by setting discriminatory membership or access fees on the seller side. Similarly, to internalize externalities, advertising-financed platforms may offer better terms to advertiser who posts ads that are less annoying or more attractive to buyers.

2.2.2 Platform's non-price strategies

Product visibility. Search engines have an interest to guide consumers to products they like.[12] If the rents that accrue to buyer and sellers are correlated, a platform operating as a search engine, is interested in establishing such a match, as it may extract part of the rent on the seller and possibly also on the buyer side.

Suppose that the search engine charges only sellers. Then, as Chen and He (2011) and Eliaz and Spiegler (2011) show,[13] a monopoly search engine may bias its search results when sellers compete. It is in its best interest that sellers with high value are highly ranked. A seller's value increases, as product market competition with other sellers is relaxed. Therefore, the search engine may distort search results to relax product market competition between sellers. In Chen and He (2011) and Eliaz and Spiegler (2011), the search engine has an incentive to decrease the relevance of its search results and, thus, discourages buyers from searching extensively. This degrades the quality of the platform. The platform faces a trade-off between fewer buyers using the search engine and higher profits on a per-buyer base, which it obtains from fees charged to sellers. The monopoly distortion introduced by the platform consists in fewer buyers on the platform who have to pay higher product prices than absent the distortion of the search results.

Quality control by platforms. Platforms may control the quality of sellers and remove underperforming sellers from the platform.[14] In the presence of seller competition this may come at the cost of reducing competitive pressure. However, since quality control is of particular importance under asymmetric information (here, buyers being less informed about the seller's

[12] The following discussion is similar to Peitz and Reisinger (2016). They discuss also other work on the strategies used by search engines, in particular, when they are partially vertically integrated.

[13] Xu, Chen, and Whinston (2010, 2011) and Hagiu and Jullien (2011) analyze related models.

[14] Selling through a for-profit platform may also affect sellers' investment incentives. As Hagiu (2009) shows in a model in which sellers make their participation and non-contractible investment decision prior to buyers' participation decision, a platform who cannot commit to a membership fee on the user side before sellers make their investment decision wants to use a strictly positive royalty rate as an additional instrument.

quality and effort than the seller himself), to investigate the effect of minimum quality standards and other measures invoked by the platform to increase seller quality, one needs to study the interplay of asymmetric information, network effects, and market power.

Absent asymmetric information, reducing seller competition makes the platform less attractive for buyers, everything else given. However, with asymmetric information, removing underperforming sellers may actually make the platform more attractive for buyers, since the expected quality that will be consumed is increased. Thus, for example, security checks for apps on GooglePlay or certification by Apple may be in the mutual interest of platform and buyers.

Buyers are often heterogeneous with respect to seller quality. For instance, some buyers may require fast delivery, whereas others care less about delivery speed. In this case, a platform may establish two market segments for sellers, in one segment they have to promise a certain quality, while in the other they do not. For example, Amazon hosts premium sellers with guaranteed fast delivery and standard sellers without that guarantee.

3 Price structure and product variety on oligopolistic platforms

We now consider situations in which several platforms compete to attract buyers and sellers. As in the previous section, we first draw a number of insights from a baseline model (which directly extends our previous model). We then enlarge the analysis by reviewing the existing literature.

3.1 Extension 1 of the baseline model

We define the seller and buyer net surplus of visiting platform i (gross of any opportunity cost) as we did before: $v_s^i = r_s + \pi\left(n_b^i, n_s^i\right) - m_s^i$ and $v_b^i = r_b + u\left(n_b^i, n_s^i\right) - m_b^i$ (the superscript refers to the platform). The general functions $\pi\left(n_b^i, n_s^i\right)$ and $u\left(n_b^i, n_s^i\right)$, which represent the net gains from trade for any seller and any buyer on platform i, are supposed to be twice continuously differentiable in their two arguments. Buyers and sellers are uniformly distributed on the unit interval. Following Belleflamme and Toulemonde (2016), we consider the two-sided singlehoming model and identify the indifferent seller and buyer in the standard Hotelling fashion. A buyer of type x_b incurs a disutility of $\tau_b x_b$ when visiting platform 1 and of $\tau_b(1-x_b)$ when visiting platform 2; similarly, on the seller side with parameter τ_s applied to a seller of type x_s. The numbers of sellers and buyers at platform i can be expressed as:

$$\begin{array}{c} n_b^i = \frac{1}{2} + \frac{1}{2\tau_b}\Delta u\left(n_b^i, n_s^i\right) - \frac{1}{2\tau_b}(m_b^i - m_b^j), \\ n_s^i = \frac{1}{2} + \frac{1}{2\tau_s}\Delta \pi\left(n_b^i, n_s^i\right) - \frac{1}{2\tau_s}(m_s^i - m_s^j), \end{array} \tag{2}$$

where

$$\begin{aligned} \Delta u\left(n_b^i, n_s^i\right) &\equiv u\left(n_b^i, n_s^i\right) - u\left(1-n_b^i, 1-n_s^i\right), \\ \Delta \pi\left(n_b^i, n_s^i\right) &\equiv \pi\left(n_b^i, n_s^i\right) - \pi\left(1-n_b^i, 1-n_s^i\right). \end{aligned}$$

Let us introduce the following notation:

$$\begin{aligned}\Delta_b^u &\equiv \frac{\partial[\Delta u\left(n_b^i,n_s^i\right)]}{\partial n_b^i}, \Delta_s^u \equiv \frac{\partial[\Delta u\left(n_b^i,n_s^i\right)]}{\partial n_s^i},\\ \Delta_b^\pi &\equiv \frac{\partial[\Delta \pi\left(n_b^i,n_s^i\right)]}{\partial n_b^i}, \Delta_s^\pi \equiv \frac{\partial[\Delta \pi\left(n_b^i,n_s^i\right)]}{\partial n_s^i}.\end{aligned}$$

In words, the function $\Delta u\left(n_b^i,n_s^i\right)$ measures the differential in buyers' net gains from trade between platforms i and j when there are n_b^i buyers and n_s^i sellers on platform i. The derivatives Δ_b^u and Δ_s^u measures the sensitivity of this differential to a change in the mass of, respectively, buyers or sellers on platform i; the function $\Delta\pi\left(n_b^i,n_s^i\right)$ and derivatives $\Delta_b^\pi\left(n_b^i,n_s^i\right)$ and $\Delta_s^\pi\left(n_b^i,n_s^i\right)$ are defined accordingly for sellers.

The system of equations (2) implicitly determines the demand functions for platform i, $n_b^i(m_b^i,m_s^i,m_b^j,m_s^j)$ and $n_s^i(m_b^i,m_s^i,m_b^j,m_s^j)$, which depend on the combination of the four fees.[15] Using implicit differentiation and taking advantage of the fact that $n_s^1=n_s^2=n_b^1=n_b^2=\frac{1}{2}$ at the symmetric equilibrium, it is then possible to show that the platforms set the following membership fees at the symmetric equilibrium of the game:

$$\begin{aligned}m_s^* &= f_s+\tau_s-\tfrac{1}{2}\left(\Delta_s^u(\tfrac{1}{2},\tfrac{1}{2})+\Delta_s^\pi(\tfrac{1}{2},\tfrac{1}{2})\right),\\ m_b^* &= f_b+\tau_b-\tfrac{1}{2}\left(\Delta_b^u(\tfrac{1}{2},\tfrac{1}{2})+\Delta_b^\pi(\tfrac{1}{2},\tfrac{1}{2})\right).\end{aligned}$$

We observe that the equilibrium membership fees depend on the nature and strength of the within- and cross-group external effects. In the complete absence of external effects within and across groups, fees would be as in the Hotelling model.

The presence of positive cross-group external effects from, say, sellers to buyers leads platforms to lower the membership fee for sellers below the level that would prevail absent any external effect. By contrast, the presence of negative cross-group external effects from, say, sellers to buyers leads platforms to raise the membership fee for sellers above the level that would prevail absent any external effect. This is the standard result of Armstrong (2006).

We add here a result related to the presence of external effects *within* groups. Positive external effects within groups leads platforms to lower the membership fee for the group below the level that would prevail absent any external effect. Negative external effects within groups leads platforms to raise the membership fee for the group above the level that would prevail absent any external effect.[16]

[15] It is assumed that the functions u and π are such that the system (2) leads to a unique solution $\left(n_b^i,n_s^i\right)\in(0,1)^2$, which is well-behaved in the sense that both n_b^i and n_s^i are decreasing functions of $(m_b^i-m_b^j)$ and $(m_s^i-m_s^j)$. To make use of examples 1 and 3, n_s^i should be interpreted as the fraction of the total number of sellers; that is, in the examples we have to scale up n_s^i.

[16] To confirm these statements, we recover the results of Armstrong (2006) by setting $\pi\left(n_b^i,n_s^i\right)=\pi n_b^i$ and $u\left(n_b^i,n_s^i\right)=un_s^i$ (i.e., cross-group effects are positive and linear and within-group effects are nil). We have then $\Delta^\pi=\pi\left(2n_b^i-1\right)$, $\Delta^u=u\left(2n_s^i-1\right)$, $\Delta_b^\pi=2\pi$, $\Delta_s^u=2u$, and $\Delta_s^\pi=\Delta_b^u=0$. It follows that $m_s^*=c_s+\tau_s-u$ and $m_b^*=c_b+\tau_b-\pi$.

We return to the special case in which $\pi(n_b, n_s) = n_b\tilde{\pi}(n_s)$ and $u(n_b, n_s) = n_s\tilde{u}(n_s)$. Then, $\Delta_b^u(1/2, 1/2) = 0$, $\Delta_s^u(1/2, 1/2) = 2\tilde{u}(1/2) + \tilde{u}'(1/2)$, $\Delta_b^\pi(1/2, 1/2) = 2\tilde{\pi}(1/2)$, and $\Delta_s^\pi(1/2, 1/2) = \tilde{\pi}'(1/2)$. Hence,

$$\begin{aligned} m_s^* &= f_s + \tau_s - \tilde{\pi}(1/2) - \tfrac{1}{2}\tilde{\pi}'(1/2), \\ m_b^* &= f_b + \tau_b - \tilde{u}(1/2) - \tfrac{1}{2}\tilde{u}'(1/2). \end{aligned}$$

Since an additional seller reduces the profit per seller ($\pi' < 0$), one may think that increased seller competition (captured by less taste for variety in Example 2) has a mitigating effect on the membership fee set on the seller side. However, one has to be careful with such reasoning. Take Example 2, which features that product prices are not affected by the number of sellers. Here, $\tilde{\pi}(1/2) + \frac{1}{2}\tilde{\pi}'(1/2) = 0$ and, thus, a change in the taste for variety (in the example, measured by parameter ρ) does not affect the membership fee on the seller side—it does affect the membership fee on the consumer side.[17]

3.2 Additional issues with competing platforms

We now examine other issues by reviewing a number of papers that consider competition both between platforms and between sellers on the platforms.

Competitive bottlenecks. Hagiu (2009) considers competition among sellers in the competitive bottleneck world—more specifically, sellers multihome and buyers singlehome. Consumers have a preference for variety, which turns out to be a key factor determining the optimal pricing structure of competing platforms. Seller competition adds another force for lower prices on the consumer side in the seminal competitive bottleneck model of Armstrong (2006).[18] Lowering the membership fee on the consumer side, makes also some sellers to withdraw from the competing platform. This further reduces the attractiveness of the competing platform (as u is increasing in n_s).

Consider now a decrease in the intensity of seller competition in the form of consumers' stronger taste for variety (e.g., as in Examples 1 and 2). Then, a given reduction of a platform's membership fee becomes less effective in steering sellers away from the competing platform. This reduces the pressure to reduce the price on the buyer side.

[17] Example 1 needs to be slightly modified to fit with the present setting (we take here n_b^i and n_s^i as continuous values in the $[0, 1]$ interval whereas we took them before as discrete values ranging from 0 to infinity). Belleflamme and Toulemonde (2016) propose the following modification. They assume that before choosing which platform to visit, buyers and sellers draw independently their location from a uniform distribution on the unit interval. Consequently, they consider n_b^i and n_s^i as the expected shares of buyers and sellers that decide to interact on platform i. They show that increased competition (captured by an increase in the degree of product substitutability γ) reduces the buyers' equilibrium surplus, has ambiguous effects on the sellers' equilibrium surplus, and reduces the platforms' equilibrium profits.

[18] Belleflamme and Peitz (2018) show under which conditions platforms do indeed set lower prices for the singlehoming side (here buyers) when sellers are allowed to multihome.

Competing search engines. As pointed out in the previous section, search engines trade off participation with rent extraction from sellers (they do not set prices on the buyer side). An increased bias reduces the attractiveness of the search engine and, hence, reduces buyer participation, but it increases the expected rent of the preferred seller (gross of the payment to the platform) and, thus, allows the platform to make higher profit per unit mass of buyers. If competition between platforms increases the sensitivity by which buyers do not use a particular search engine, the quality reduction as the result of search engine bias becomes more "costly" for the platform. Therefore, we would expect that under competition platforms have weaker incentives to bias their search results. Eliaz and Spiegler (2011) show indeed that, compared to a monopoly search engine, competing search engines set a price-per-click that induces only the highest quality firms to enter the search pools; as a result, search quality is maximized, which clearly benefits buyers.

Bargaining between sellers and platforms. Quite different from other works, Dukes and Gal-Or (2003) propose a bargaining model between platforms and participants on one side of the market. This requires that the number of participants on one side of the market is small. They consider competition between for-profit ad-financed media platforms, which sign exclusivity contracts with advertisers. More specifically, two sellers with horizontally differentiated products post ads on differentiated platforms to inform consumers about the existence of their products—price and advertising competition between sellers is modeled as in Grossman and Shapiro (1984). Consumer preferences with respect to products are independent of their preferences with respect to media platform content.[19] Platforms obtain revenues only from advertisers. Advertising rates are set following a Nash-in-Nash approach, and price and advertising decisions are made concurrently.

In the informative advertising setting of Grossman and Shapiro, higher equilibrium levels of advertising can reduce advertisers' gross profits, since this increases the share of consumers informed about competing offers and, thus, makes price competition in the product market more intense. As media platforms take a cut in the advertisers' profits, their profits decline as well. When platforms provide exclusive advertising (i.e., no-compete clauses in advertising), consumers are less informed about competing offers in the product market, and price competition in the product market is relaxed.

4 The number of platforms with positive volumes of trade

An important issue is the impact that within-side external effects may have on the coexistence of competing two-sided platforms. Positive cross-group effects generate positive feedback loops that may lead to situations where only one platform survives at equilibrium ('winner-takes-

[19] Consumers are implicitly assumed to be ignorant about surplus in the product market when deciding about how much time to spend on the two media platforms; they only experience advertising as a nuisance when consuming platform content.

all') unless competing platforms are sufficiently differentiated. We may conjecture, however, that seller competition may contribute to break the feedback loop and, thereby, facilitate the coexistence of competing platforms, even in the absence of differentiation.

A case in point are industry standards; for example, the modem standard for Internet standards in the 1990s: Augereau, Greenstein, and Rysman (2006) point out that two different, but functionally equivalent, modem standards were used by Internet Service Providers (ISPs, which would be the sellers in our model) despite positive effects of opting for a single standard and that the market seemed to have settled on this outcome—the two modem standards obtained similar market shares. By adopting different standards, ISPs created switching costs for consumers and, thus, were better able to reduce competition among them.

In what follows, we first analyze the impact that seller competition has on the coexistence of platforms in a setting that builds on our previous baseline model. We then review other models proposed in the literature.

4.1 Extension 2 of the baseline model

We sketch here an extended (and modified) version of our baseline model that allows us to discuss how sellers may relax competition among them by trading on different platforms, thereby allowing these platforms to coexist even though, different from the baseline model in the previous section, buyers are sellers are homogeneous. Recall the specification of seller and buyer net surplus with one-sided pricing: $v_s^i = r_s + n_b^i \tilde{\pi}(n_s^i) - m_s^i$ and $v_b^i = r_b + n_s^i \tilde{u}(n_s^i)$. Different from the previous exposition, we assume that sellers and buyers are homogeneous—i.e., from the buyers' and the sellers' perspective, there is no exogenous differentiation between platforms. Karle, Peitz and Reisinger (2017) analyze the two-sided singlehoming model (that is, each buyer and each seller joins exactly one platform) in which buyers observe product offering on a platform only after having visited the platform. Platforms first set access fees on the seller side, and, then, buyers and sellers simultaneously decide which platform to select as their home—sellers can only sell to buyers on the same platform. Subsequently sellers set product prices and buyers make purchase decisions.

If all sellers co-locate on the same platform then, in equilibrium, all buyers will be active on this platform. Thus, there is agglomeration in equilibrium and network effects are fully exploited. In such an equilibrium, all platform profits are competed away and both platforms make zero profits. Such a situation will necessarily emerge absent competition between sellers.

However, imperfect competition between sellers may lead to the equilibrium in which both platforms have a positive number of users and make positive profits in equilibrium.[20] Suppose that there are two sellers that have to decide whether to join platform 1, join platform 2 or not to participate at all. If they both join the same platform, they obtain duopoly profit π^d per buyer, which is less than the monopoly profit π^m per buyer that they would obtain if they were the only seller on the platform. If π^d/π^m is sufficiently small, there is an equilibrium in which

[20] As Karle, Peitz and Reisinger (2017) show, under some conditions, such a segmentation equilibrium also arises when sellers can multihome and some but not all buyers multihome.

sellers list on different platforms. Buyers are indifferent between the two platforms—some will join platform 1 and the others platform 2. Profits are not competed away: platforms can extract the full seller surplus in equilibrium (remember that sellers are homogeneous).[21]

4.2 Within-group external effects and platform coexistence

In the previous model (as in much of our analysis so far), platforms are operated by for-profit intermediaries, which choose price- and non-price strategies in view of internalizing (within- and cross-group) external effects. However, there exist environments in which some or all of the marketplaces buyers and sellers can choose to join are open. Although trade on such marketplaces is not intermediated, it is nevertheless interesting to analyze how seller competition affects the potential coexistence of these marketplaces. We examine this issue first when all marketplaces are open and next, when a 'sponsored' platform competes with an open marketplace. Finally, we return to the competition between 'sponsored' platforms and discuss how within-group external effects may facilitate the coexistence of platforms by being a source of *endogenous* platform differentiation.

Trade on multiple market places. The issue as to whether market activities agglomerate or segment connects to an older literature on location decisions of sellers, which has analyzed the benefits and costs of clustering. Here, marketplaces are not actively managed and neither buyers nor sellers are charged for participation and trade on the platform.

There are typically two opposite forces at work. On the one hand, competing sellers prefer to locate in different market places, so as to relax competition—a segmentation force. On the other hand, sellers realize that a marketplace where many of them locate will attract many buyers, as it will, in expectations, drive prices down and offer a better fit—an agglomeration force. Depending on the setting, either force may dominate. If the segmentation force is stronger, multiple marketplace carry positive volumes of sales.[22] If agglomeration prevails, all sellers and buyers trade on a unique market place.[23]

Platform entry. Belleflamme and Toulemonde (2009) examine the extent to which negative within-group effects among sellers may help a new platform operator lure buyers and sellers away from an existing marketplace. In their model, only the new platform can set membership fees;

[21] As an extreme example, consider pure Bertrand competition between sellers. In this case π^d is equal to zero, and sellers have an incentive to avoid competition by locating at different platforms as long as platforms charge weakly less than $\pi^m/2$. In equilibrium, sellers segment despite the fact that platforms are ex ante homogeneous for both buyers and sellers and make profit $\pi^m/2$ from each seller.

[22] Ellison, Fudenberg, and Möbius (2004) consider competition between two auction sites. They derive conditions for sellers not to agglomerate on one site. The rationale is that segmentation lowers the seller-buyer ratio on each platform and, thus, leads to higher prices. Ellison and Fudenberg (2003) provide general conditions such that tipping does not occur and multiple marketplaces coexist at equilibrium.

[23] For example, Gehrig (1998) shows that, under some conditions, buyers and sellers agglomerate on a single open marketplace even though buyers are heterogeneous with respect to the preferred location of the marketplace. See also Stahl (1982), Dudey (1990), and Church and Gandal (1992) for related analyses.

this is not a model of price competition between platform, but it is not a monopoly model either, as the existing marketplace provides buyers and sellers with an endogenous outside option. As in Caillaud and Jullien (2003), the new platform faces a 'chicken-and-egg' problem, which it tries to solve by using a divide-and-conquer pricing strategy; that is, the platform must subsidize the participation of one side (divide) and hope to recoup the loss through the membership fee it sets on the other side (conquer). The question is whether the platform can make any profit with such strategy. The answer is 'yes' when the interaction among buyers and sellers only generates (positive) cross-group external effects. However, the presence of negative within-group effects among sellers (e.g., because they offer substitutable products) blurs the picture. Competition among sellers turns out to be a mixed blessing for the new platform. The upside is that the sellers' willingness to pay to join the new platform increases if only a few of them make the move; as a consequence, sellers are less sensitive to buyers' participation to the new platform, which alleviates the 'chicken-and-egg' problem. Yet, the downside is that it will be more costly for the new platform to attract buyers if only a small subset of the sellers join. The balance between the two effects depends on the relative strength of the within-group effects (with respect to the cross-group effects). There may be situations in which entry is not profitable.

Within-group external effects as endogenous platform differentiation. On matching platforms (job, dating or real-estate platforms), the external effects across groups are clearly positive, as users in one group are more likely to find an attractive match if the platform attracts more users of the other group. Yet, negative external effects also exist within each group, as a user in one group is less likely to be accepted by her chosen match if there are more users in her own group. Absent these negative within-group effects (and absent sufficient horizontal differentiation), the market for matching platforms would tend to a winner-takes-all situation, as all users would be happy to join the platform that attracts the largest set of users of the other group—a self-reinforcing process. But, the existence of negative within-group effects generates a form of endogenous vertical differentiation, which may allow competing platforms to coexist.

The idea is simple: one platform would choose to be more expensive, so as to reduce participation and the intensity of competition within each group; conversely, the other platform would choose to be cheaper, so as to raise participation and the intensity of the positive cross-group effects. Clearly, for this situation to emerge at equilibrium, there must exist users who value sufficiently being isolated from competition in their own group, with respect to the prospect of finding a large number of potential matches. This is the assumption that Halaburda, Piskorksi and Yilidrim (2017) make. They consider a matching market with heterogeneous agents who differ in the value of their outside option (i.e., the utility they receive if they remain unmatched). Agents with low outside options prefer a platform with restricted choice; because they fear more being unmatched, they suffer more from the competition within their own group. The reverse applies to users with high outside options, who prefer then a platform where choice is not restricted. It follows that platforms of different size can be sustained in equilibrium, leading to endogenous differentiation between platforms. In particular, the platform that restricts choices is able to charge a premium to its users, which compensates for the smaller participation.[24]

5 Conclusion and future research

In this paper, we examined how two-sided platforms manage the external effects that users exert on other users in their own group (so-called 'within-group external effects'). In particular, we have focused on platforms that intermediate between sellers and buyers, with sellers competing with one another (such that a *negative* within-group external effect is present). In such situations, platforms face a trade-off when attracting an additional seller, as this contributes (other things being equal) to raise the buyers' willingness to participate but to reduce the sellers' willingness to participate. It is thus of interest to understand how competition within one group of users affects platforms' decisions, as well as the structure of markets with platforms.

To get some intuition, we developed a simple model throughout the paper. In this model, we assume positive cross-group effects between buyers and sellers, negative within-group effects among sellers, and no external effect among buyers. Starting with a monopoly platform, we showed that a key variable to assess how the intensity of seller competition affects the platform is the total value generated in a buyer-seller transaction: if this value decreases with the intensity of seller competition, then so does the platform's maximal profit. This is the case, e.g., if sellers produce horizontally differentiated products and consumers have a taste for variety; here, a lower degree of differentiation intensifies seller competition and decreases both the buyers' and the sellers' surplus per transaction. We then extended the model to two competing platforms and showed that the presence of negative external effects within a particular group leads platforms to raise the membership fee for that group above the level that would prevail absent any external effect. Finally, we used the extended model to show that negative within-group effects in one group may facilitate the coexistence of platforms with positive volumes of trade.

We complemented the intuition drawn from our simple model with a review of existing literature on the topic. This allowed us to consider a number of additional issues (e.g., price discrimination, non price strategies, entry of platforms). In terms of policy, it is not easy to draw clear-cut lessons given the variety of issues that are studied and the specificities of the models that are used. However, two words of caution clearly emerge. First, negative within-group external effects should not be neglected, as they may deeply impact the platforms' conduct and, thereby, the structure of markets with platforms. Second, the analysis needs to be done carefully and on a case-by-case basis; the reason is that seller competition affects, in a potentially complex way, how sellers *and buyers* value the interaction with each other.[25]

[24] See also Damiano and Li (2008), Ambrus and Argenziano (2009), and Gabszewicz and Wauthy (2014) for contributions in which asymmetric platforms coexist and the asymmetry is endogenously determined by user choices.

[25] Only in special cases is the buyer surplus from a transaction not affected by the degree of seller competition. Such a special case is Example 2 with $\rho = 1/2$, as in this case u is independent of the number of participating sellers. Comparative statics, for example, in the sellers' fixed cost then has no bearing on the buyers' per-seller surplus.

Another conclusion that emerges from the literature review is that a number of important issues still have to be addressed. Within-group external effects are usually abstracted away in the literature on multi-sided platforms; yet, this literature informs policy (e.g., antitrust) decisions. It is thus worthwhile to check if the recommendations drawn from the literature that abstracts from within-group external effects are still valid for environments in which negative within-group external effects are present (as on most platforms that intermediate between buyers and sellers).

To do so, the present analysis should be extended in a number of directions. Arguably, in many markets with platforms, users differ not only in their opportunity costs of participating to a platform but also in their benefits from using the platform. One important direction for future research is to evaluate the impacts of seller competition (or more generally of negative within-group external effects) in settings that allow for heterogeneity in usage benefits and feature usage fees.[26]

Of particular interest, also, is the interplay between platforms' price and non-price strategies in the presence of seller competition. For instance, in a recent paper (Belleflamme and Peitz, 2018), we assess how platforms, buyers and sellers are affected when (non-competing) sellers have the possibility to multihome. We show that the perceived wisdom (according to which platforms and buyers should benefit from this possibility, but sellers should not) is not always correct. Platforms may prefer to prevent sellers from multihoming, which would then hurt buyers. We conjecture that this conclusion is even more likely in environments with competing sellers. Competing sellers are indeed more willing to accept exclusivity agreements, as this can serve as a coordination device for them to split across platforms and, thereby, relax competition among them. This would make exclusive agreements more profitable for platforms (as sellers are more willing to accept them) and even less desirable for buyers (on top of paying higher fees to platforms, they would face sellers that are less numerous and have more market power). These are important insights for antitrust authorities that examine whether exclusivity agreements between platforms and sellers should be allowed or not.

Similarly, one may want to investigate platforms' incentives to provide buyers with first-party content, which is a substitute to the third-party content that sellers provide. In the existing literature (see, e.g., Hagiu and Spulber, 2013), third-party sellers are not competing. The main trade-off for platforms is then the following: first-party content helps attracting buyers and, thereby, sellers; yet, for a given number of buyers, first-party content steals profits from third-party sellers. Now, if sellers not only compete with the platform's integrated content but also among themselves (as is, e.g., the case for third-party sellers on Amazon MarketPlace), novel issues arise. For instance, platforms may want to limit competition by third parties so as to protect their first-party sales. An example could be Apple which has been restrictive to "certify" sellers of accessories. Other platforms appear to be happy to accept more sellers (e.g., Amazon)—this may be a strategy to keep existing or potential competitors at bay and may also be a way for Amazon to learn about demand.[27] Recall that even if platforms do not produce

[26] See, e.g., Rochet and Tirole (2002) or Edelman and Wright (2015) for such settings.
[27] For an empirical investigation, see Zhu and Liu (2018).

their own content, they may have incentives to reduce seller competition; we have indeed shown in Sections 2 and 3 that platforms may suffer from increased seller competition. The additional insight here is that such incentives may even be reinforced when platforms compete themselves with the sellers. Platforms could then increase the horizontal differentiation between their first-party content and the sellers' third-party content; other things being equal, such a move should make buyers better off if they value product variety. Differentiation may also be with respect to the quality of service; for instance, first-party content (physical goods) may be delivered more quickly or return policies may be more generous. Sellers may react to the provision of first-party content, possibly also by adjusting their investment. A profit-maximizing platform must consider such issues when deciding whether to produce first-party content.[28]

Finally, the analysis could be extended by looking deeper into the decisions that competing sellers make and that are relevant for their interaction with buyers on a platform. In our micro-foundations of the buyer-seller relationships, we used simple oligopoly models, in which sellers only choose the price or the quantity of their goods. It would be interesting to consider richer models with multi-dimensional and sequential strategies. For instance, in Belleflamme and Peitz (2010), we study seller's incentives to invest in cost-reducing (or quality-enhancing) technologies when their trade with buyers is intermediated by platforms. This analysis is performed under the assumption that sellers offer independent products. However, if sellers offer substitutes, their investments become strategic if they are made before prices or quantities are chosen. Compared to non-strategic sellers (for instance, non-competing ones), competing sellers tend to invest more in cost-reducing technologies when the subsequent competition is in quantities and less with subsequent price competition. Insofar as cost-reducing investments by sellers increase the surplus that both, sellers and buyers, obtain from transactions, and insofar as platforms compete more fiercely for buyers and sellers when transactions are more valuable, we conjecture that more seller competition should hurt competing platforms when sellers compete in quantities, but should benefit platforms when sellers compete in prices.

As a final disclaimer, all the conjectures that we just made should be properly examined, as should other issues that we did not mention here.

6 Appendix

6.1 Cournot example

Suppose also that each buyer has the following quadratic utility function:

$$U(q_0; q_1, q_2, \ldots, q_{n_s}) = a\sum_{k=1}^{n_s} q_k - \frac{1}{2}\left(\sum_{k=1}^{n_s} q_k^2 + \gamma \sum_{k=1}^{n_s}\sum_{g\neq k} q_k q_g\right) + q_0,$$

where q_0 is the Hicksian composite commodity (with a price normalized to 1), n_s is the number of sellers on the platform and, hence, the number of varieties of the differentiated good that

[28] For an empirical investigation of the video game industry, see Cennamo, Gu, and Zhu (2018). For a general discussion, see Zhu (2018).

the buyer has access to, and $0 < \gamma \leq 1$ measures the strength of the substitutability among varieties (varieties are homogeneous for $\gamma = 1$ and tend to be independent for $\gamma \to 0$). The buyer maximizes her utility $U(q_0; q_1, q_2, \ldots, q_n)$ subject to the budget constraint $y = q_0 + \sum_{k=1}^{n_s} p_k q_k$, which gives rise to the following inverse demand functions $p_k = a - q_k - \gamma q_{-k}$ (with $q_{-k} = \sum_{g \neq k} q_g$) for strictly positive prices and zero otherwise.[29] Seller k chooses its quantity q_k to maximize $n_b (a - c - q_k - \gamma q_{-k}) q_k$. The first-order condition yields $2q_k = a - c - \gamma q_{-k}$. Summing over the n_s sellers and writing Q for $\sum_{k=1}^{n_s} q_k$, one has $2Q = n_s (a - c) - \gamma (n_s - 1) Q$. Solving for Q, one obtains $Q = n_s (a - c) / (2 + \gamma (n_s - 1))$. By symmetry, each seller produces the same quantity at the Cournot-Nash equilibrium: $q = Q/n_s$. It is easily found that, at equilibrium, $p_k - c = q$. Setting, without loss of generality, $a - c = 1$, we compute the equilibrium profit for each seller as

$$\pi (n_b, n_s) = n_b \tilde{\pi}(n_s) = n_b \frac{1}{(2 + \gamma (n_s - 1))^2}.$$

The consumer surplus is found by plugging the equilibrium prices and quantities into $U(\cdot) - \sum_{k=1}^{n_s} p_k q_k$:

$$u (n_b, n_s) = n_s \tilde{u}(n_s) = n_s \frac{(1 + \gamma (n_s - 1))}{2 (2 + \gamma (n_s - 1))^2}.$$

6.2 Comparative statics

We establish here the comparative statics results presented in Section 2.1. Let us recall the surplus functions derived in the two examples:

$$\text{(Example 1) } u (n_s) = n_s \frac{(1 + \gamma (n_s - 1))}{2 (2 + \gamma (n_s - 1))^2} \text{ and } \pi (n_b, n_s) = n_b \frac{1}{(2 + \gamma (n_s - 1))^2}.$$

$$\text{Hence, } \tilde{u}(n_s; \gamma) + \tilde{\pi}(n_s; \gamma) = \frac{3 + \gamma (n_s - 1)}{2 (2 + \gamma (n_s - 1))^2}$$

$$\text{(Example 2) } u (n_s) = n_s \frac{\rho E}{c} n_s^{\frac{1-2\rho}{\rho}} \text{ and } \pi (n_b, n_s) = n_b (1 - \rho) \frac{E}{n_s}$$

$$\text{Hence, } \tilde{u}(n_s; \rho) + \tilde{\pi}(n_s; \rho) = \frac{\rho E}{c} n_s^{\frac{1-2\rho}{\rho}} + (1 - \rho) \frac{E}{n_s}.$$

Recall also that $0 < \gamma \leq 1$, and $0 < \rho < 1$.

Our first exercise aims at identifying the sign of

$$\frac{d\Pi}{d\mu} = n_s n_b \frac{\partial}{\partial \mu} \left(\tilde{u}(n_s; \mu) + \tilde{\pi}(n_s; \mu) \right), \text{ with } \mu = \{\gamma, \rho, \alpha\}.$$

We compute

$$\begin{aligned} \frac{d}{d\gamma} \left(\frac{3 + \gamma (n_s - 1)}{2 (2 + \gamma (n_s - 1))^2} \right) &= - (n_s - 1) \frac{4 + \gamma (n_s - 1)}{2 (2 + \gamma (n_s - 1))^3} \leq 0, \\ \frac{d}{d\rho} \left(\frac{\rho E}{c} n_s^{\frac{1-2\rho}{\rho}} + (1 - \rho) \frac{E}{n_s} \right) &= - \frac{E}{c\rho} (\ln n_s - \rho) n_s^{\frac{1}{\rho}(1-2\rho)} - \frac{E}{n_s} \leq 0 \text{ if } c \geq 1. \end{aligned}$$

[29] Income y has to be sufficiently large relative to the maximal number of sellers Z that can be active since we must have that $y > Zpq$; $y > Z(a - c)(a + c + c\gamma(Z - 1))/[2 + \gamma(Z - 1)]^2$.

For the second exercise, we look for the signs of the following expressions:

$$\begin{aligned} sign\left(\frac{dn_b}{d\mu}\right) &= sign\left(\Phi_b\right) \text{ with } \Phi_b \equiv -\frac{\partial^2\Pi}{\partial n_b \partial \mu}\frac{\partial^2\Pi}{\partial n_s^2} + \frac{\partial^2\Pi}{\partial n_s \partial \mu}\frac{\partial^2\Pi}{\partial n_b \partial n_s}, \\ sign\left(\frac{dn_s}{d\mu}\right) &= sign\left(\Phi_s\right) \text{ with } \Phi_s \equiv -\frac{\partial^2\Pi}{\partial n_s \partial \mu}\frac{\partial^2\Pi}{\partial n_b^2} + \frac{\partial^2\Pi}{\partial n_b \partial \mu}\frac{\partial^2\Pi}{\partial n_b \partial n_s}. \end{aligned}$$

First, we develop the various derivatives of the platform's profit (using the facts that in our examples, the buyer surplus is only a function of n_s and the seller surplus is a linear function of n_b):

$$\begin{aligned} \frac{\partial^2\Pi}{\partial n_b \partial \gamma} &= \frac{\partial u\left(n_b, n_s; \gamma\right)}{\partial \gamma} + \frac{\partial^2 \pi\left(n_b, n_s; \gamma\right)}{\partial \gamma \partial n_b} n_s, \\ \frac{\partial^2\Pi}{\partial n_s \partial \gamma} &= \frac{\partial \pi\left(n_b, n_s; \gamma\right)}{\partial \gamma} + \frac{\partial^2 u\left(n_b, n_s; \gamma\right)}{\partial \gamma \partial n_s} n_b + \frac{\partial^2 \pi\left(n_b, n_s; \gamma\right)}{\partial \gamma \partial n_s} n_s, \\ \frac{\partial^2\Pi}{\partial n_b^2} &= -2, \\ \frac{\partial^2\Pi}{\partial n_s^2} &= 2\frac{\partial \pi\left(n_b, n_s; \gamma\right)}{\partial n_s} - 2 + \frac{\partial^2 u\left(n_b, n_s; \gamma\right)}{\partial n_s^2} n_b + \frac{\partial^2 \pi\left(n_b, n_s; \gamma\right)}{\partial n_s^2} n_s, \\ \frac{\partial^2\Pi}{\partial n_b \partial n_s} &= \frac{\partial u\left(n_b, n_s; \gamma\right)}{\partial n_s} + \frac{\partial \pi\left(n_b, n_s; \gamma\right)}{\partial n_b} + \frac{\partial^2 \pi\left(n_b, n_s; \gamma\right)}{\partial n_b \partial n_s} n_s. \end{aligned}$$

In Example 1, we compute

$$\begin{aligned} \Phi_b &= -\frac{\left(2\gamma^2(3-\gamma)n_s^3+\gamma\left(42-33\gamma+5\gamma^2\right)n_s^2+4\left(18+10\gamma^2-26\gamma-\gamma^3\right)n_s-(8-\gamma)(2-\gamma)(3-\gamma)\right)n_b}{4(2+\gamma(n_s-1))^6} \\ &\quad -\frac{n_s(n_s-1)(4+\gamma(n_s-1))}{(2+\gamma(n_s-1))^3}, \\ \Phi_s &= -\frac{\left(4\gamma^3(6-\gamma)n_s^4+16\gamma^2(2-\gamma)(6-\gamma)n_s^3+24\gamma(2-\gamma)\left(10-8\gamma+\gamma^2\right)n_s^2+16\left(6+\gamma^2-8\gamma\right)(2-\gamma)^2 n_s-4(8-\gamma)(2-\gamma)^3\right)n_b}{4(2+\gamma(n_s-1))^6} \\ &\quad -\frac{n_s(n_s-1)(6-5\gamma+\gamma(\gamma+(1-\gamma)n_s))(4+\gamma(n_s-1))}{4(2+\gamma(n_s-1))^6}. \end{aligned}$$

To show that $\Phi_b < 0$, note that the numerator of the first fraction is an increasing function of n_s; it reaches thus its lowest value for $n_s = 1$, where it is equal to $8\left(3-2\gamma\right) > 0$. As the second fraction is positive, the whole term is negative. We proceed in the exact same way to show that $\Phi_s < 0$; here, the numerator of the first fraction evaluated at $n_s = 1$ is equal to $128 n_b > 0$.

In Example 2, we compute

$$\begin{aligned} \Phi_b &= -\frac{1}{\rho}E\frac{n_s^{\frac{2}{\rho}} E n_b(1-\rho)(1-\rho+\ln n_s)+c n_s^{\frac{1+\rho}{\rho}}\left(E n_b(1-\rho)(\ln n_s+2\rho-1)+2n_s^2(\ln n_s-\rho)\right)+c^2\rho n_s^2\left(2n_s^2+E(1-\rho)n_b\right)}{c^2 n_s^4}, \\ \Phi_s &= -E\frac{\rho E n_s^{\frac{2}{\rho}}(1-\rho)(\ln n_s-\rho)+c n_s^{\frac{1+\rho}{\rho}}\left(2(1-\rho)n_b \ln n_s+\rho^2(1-\rho)E+2\rho^2 n_b\right)+2c^2\rho^2 n_b n_s^2}{c^2\rho^2 n_s^3}. \end{aligned}$$

It is easily seen that both Φ_b and Φ_s are negative for $n_s \geq 3$ (as $\ln n_s > \rho$ in this case). For $n_s = 1, 2$, a sufficiently large value of c guarantees that $\Phi_b, \Phi_s < 0$.

In sum, we have shown that $dn_s/d\mu < 0$ and $dn_b/d\mu < 0$ in both examples.

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