# Platform Ownership*

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**Abstract**

We develop a general theoretical framework of trade on a platform on which buyers and sellers interact. The platform may be owned by a single large, or many small independent or vertically integrated intermediaries. We provide a positive and normative analysis of the impact of platform ownership structure on platform size. The strength of network effects is important in the ranking of ownership structures by induced platform size and welfare. While vertical integration may be welfare-enhancing if network effects are weak, monopoly platform ownership is socially preferred if they are strong. These are also the ownership structures likely to emerge.

**Keywords:** Two-Sided Markets, Network Effects, Intermediation, Product Diversity
**JEL-Classification:** L10, D40

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# 1 Introduction

Most markets do not form spontaneously, but need to be organized. In a market place which may be a physical or virtual location, buyers and sellers interact on what we call a trading platform. Examples of market places in physical location are abundant in economic geography. An example of a market place in virtual location is the internet platform. The interesting central feature common to many market places are two-sided network effects: buyers are attracted to market places or platforms that house many sellers; sellers are attracted to market places that draw many buyers. The size of the trading platform reflects the number of sellers it houses: a larger number of sellers need a larger platform.

We observe widely differing institutional arrangements or ownership structures of platforms. The platform may be owned by a monopoly intermediary, by competitive intermediaries, or by buyers or sellers active on the platform. Dispersed platform ownership may further be distinguished by contractual arrangements and property rights: incumbent platform owners may or may not have the right to restrict entry onto the platform. Examples for monopoly platform ownership are that of a shopping center developer or the independent supplier of an internet platform. An example for dispersed ownership by intermediaries is the retail space supplied by landlords within a downtown shopping district. Another example are stock exchanges such as the NYSE which is owned by market makers. Here, the companies which list their stocks correspond to the sellers on the platform and the investors correspond to the buyers.

In this paper, we develop a general theoretical framework of trade on a platform, in which we avoid making functional form assumptions and allow for both horizontally or vertically integrated and non-integrated ownership structures. Our framework is sufficiently rich to encompass as special cases a number of existing models of intermediated and non-intermediated trade, with very different micro foundations.

We apply this framework to address three sets of questions. (1) What is the impact of ownership structure on platform size or, equivalently, on the number of varieties offered by sellers? Does monopoly platform ownership lead to more or less product diversity than a platform owned by a large number of small intermediaries? What is the effect of vertical integration on platform size? How do these answers depend on the strength of platform externalities? (2) From a social point of view, does the "market" over- or underprovide product variety? How does this depend on the ownership structure? Are monopoly intermediation or vertical integration necessarily harmful for welfare? What are the welfare effects of allowing incumbent intermediaries to exclude potential entrants from the platform? More generally, which ownership structure is socially preferred? (3) Which ownership structure is likely to emerge and how does this depend on the strength of platform effects? Why do we observe different ownership structures in different industries?

To address these questions, we consider a market in which buyers and sellers interact exclusively on one trading platform. A large number of heterogeneous sellers each rent a platform slot to sell a differentiated product. The platform slots are let by either a large number of intermediaries or by a monopoly platform owner. A large number of heterogeneous buyers decide whether or not to visit the platform to purchase the products offered by the sellers. Network effects are two-sided: the larger the number of sellers (i.e., the greater the product variety), the more attractive is the platform to buyers; and *vice versa*, for a given platform size, the larger the number of buyers, the more attractive it is for sellers to rent a platform slot. The basic platform ownership structures we consider are: two modes of competitive ownership, namely an open access platform and a closed platform or club, where access is restricted by the incumbent intermediaries; and monopoly platform ownership. Furthermore, we analyze vertically integrated platform ownership where each platform slot is owned by one seller, and access to the platform may be either open or closed.

One might expect that the downward integration of sellers into a platform would give rise to undue restrictions on the size of a platform. However, this is not the case. Indeed, downward integration may not prevent a socially excessive platform size if platform externalities are weak. By contrast, vertically-integrated sellers forming a club and thus actively restricting the entry of other sellers onto the platform may form a socially preferred platform size.

Similarly, one might expect that giving market power to a monopoly platform owner would lead to high rental charges, and thus drive down seller profits. Under free entry of sellers, this would induce a small platform size. This intuition is correct only if platform externalities are weak. If they are strong, however, the opposite result obtains. In this case, a monopoly platform owner subsidizes sellers at the margin in order to exploit platform effects. Such a subsidization at the margin cannot occur if platform ownership is decentralized and entry of intermediaries is unrestricted.

Our analysis indicates that competition policy in two-sided markets should be aware of some important aspects. First, allowing sellers to integrate downwards into the platform may be socially beneficial, in particular under closed ownership and weak platform effects. Second, while allowing incumbent intermediaries to exclude potential entrants from the platform is detrimental to welfare if platform effects are sufficiently weak, such a policy may be socially beneficial otherwise. Third, monopoly platform ownership is socially preferable to fragmented ownership if platform externalities are strong.

Our model predicts the emergence of monopoly intermediation whenever platform effects are strong. If platform effects are weak, however, vertically integrated ownership structures may be stable: a monopoly intermediary may not be able to compensate the sellers for the negative externality that results from a monopolization of the platform.

*Related Literature.* Our model is related to several strands of the literature. What sets our paper apart from all strands of the literature, however, is our focus on the effect of platform ownership structure on trade.

First, our paper is closely related to the recent literature on two-sided markets (e.g., Rochet and Tirole, 2003; Armstrong, 2004), which builds on the older literature on network effects in non-intermediated trade (e.g., Katz and Shapiro, 1985) and, in particular, on indirect network effects (e.g., Chou and Shy, 1990). As in our model, there are two-sided network effects on the trading platform: buyers care about the number of sellers, and sellers care about the number of buyers. However, throughout this literature it is assumed that each platform is owned by a single intermediary. Moreover, there is no competition between sellers.[1] Much of this literature focusses on the pricing structure on both sides of the market, while we assume that buyers are

[1] An exception is the recent work on the credit card payment industry, which provides a formal analysis of the functioning of Visa and Mastercard; see Rochet and Tirole (2002) and Schmalensee (2002).

not charged for access to the platform.[2]

Second, our paper is closely related to the literature on optimal product variety (e.g., Spence, 1976; Dixit and Stiglitz, 1977) and on optimal entry (e.g., von Weizsäcker, 1980; Mankiw and Whinston, 1986; Suzumura and Kiyono, 1987). At the heart of this literature lies the question whether the market over- or underprovides product variety or the number of sellers. The literature differs from our paper in that there is no intermediated trade, and there are no platform (or network) effects.

Third, our paper is also related to the literature on geographical market places (e.g., Stahl, 1982; Schulz and Stahl, 1996; Legros and Stahl, 2002). While the focus of this literature is different from that of our paper, the models may be interpreted as special cases of our general framework with non-intermediated trade.

Fourth, our paper is loosely connected to the literature on intermediation (e.g., Spulber, 1999), which is concerned with explaining the emergence and role of intermediaries. In contrast, we take the existence of a trading platform as given and focus on the effect of ownership structure of the platform.

*Plan of the Paper.* In the next section, we present our theoretical framework of trade on a platform. In section 3, we analyze equilibrium under the three basic ownership structures. In section 4, we consider vertically integrated ownership structures. In section 5, we investigate the stability of the different ownership structures. In section 6, we study the welfare properties of the different ownership structures and provide a (partial) welfare ranking. Finally, we conclude in section 7.

## 2 A Formal Model of Trading on a Platform

We consider a model of trading on one platform. There are three types of economic agents: sellers, buyers, and intermediaries who own the trading platform. To offer her good to buyers, each seller needs to rent a slot on the trading platform. The rental charge of any given slot is determined by its owner (intermediary). We allow for various ownership structures of the trading platform, which are described in detail in sections 3 and 4.

*Buyers.* There is a continuum of (atomless) buyers who decide whether or not to visit the platform. A buyer's type is denoted by $\zeta$; the empirical support of $\zeta$ in the population of buyers is $[0, \infty)$. If a buyer of type $\zeta$ takes up the outside option, he obtains a utility of $g(\zeta)$. If instead he decides to visit the market place, he derives a utility $u(m_s)$, where $m_s$ is the measure of sellers on the platform. (Alternatively, we may assume that the value of the outside option is zero for all types, and $g(\zeta)$ is the "transport cost" of visiting the platform.) We assume that $u(\cdot)$ is a continuously differentiable function, and $g(\cdot)$ continuously differentiable and strictly increasing with $g(\zeta) \to \infty$ as $\zeta \to \infty$. The properties of $g(\cdot)$ ensure existence of a marginal

[2] Anderson and Coate (2004) analyze pricing of advertisements on a media platform, and allow for pricing on only one side of the market. They show that there may be over- or underprovision of advertising from a social point of view. Rysman (2004) structurally estimates a related model of the market for yellow pages, where pricing is again only on one side of the market. Baye and Morgan (2001) analyze a model of a monopoly gatekeeper in the internet, where pricing is on both sides of the market.

type $z(m_s) \equiv g^{-1}(u(m_s))$ such that a buyer of type $\zeta$ visits the market place if and only if $\zeta \leq z(m_s)$. Since $g(\cdot)$ can always be chosen appropriately, we assume w.l.o.g. that, for any $x > 0$, the measure of buyers whose types fall into the interval $[0, x]$ is given by $x$.

*Sellers.* There is a continuum of (atomless) sellers who decide whether or not to rent a platform slot. A seller's type is denoted by $\mu_s$; the empirical support of $\mu_s$ in the population of sellers is $[0, \infty)$. If a seller decides not to participate on the platform, she obtains a zero payoff. Otherwise, she needs to rent a platform slot at rental price $r$. A seller of type $\mu_s$ then has to incur a setup cost of $f(\mu_s)$. A seller's variable profit per unit mass of buyers is given by $\pi(m_s)$, where $m_s$ is the measure of entering sellers. Sellers have constant marginal costs of production. Further, since all buyers (who decide to visit the market place) have identical demand, a seller's variable profit is proportional to the mass $z(m_s)$ of buyers visiting the market place. We assume that $\pi(\cdot)$ is a continuously differentiable function, and $f(\cdot)$ continuously differentiable and strictly increasing with $f(\mu_s) \to \infty$ as $\mu_s \to \infty$. Since $f(\cdot)$ can always be chosen appropriately, we assume w.l.o.g. that, for any $x > 0$, the measure of potential sellers whose types fall into the interval $[0, x]$ is $x$.

We denote a seller's variable profit by $\Pi(m_s) \equiv z(m_s)\pi(m_s)$. We refer to a seller's profit as her profit net of her setup cost $f(\mu_s)$, but gross of the rental charge $r$. The net profit of seller $\mu_s$ is given by $\Pi(m_s) - f(\mu_s) - r$. Optimal entry decisions imply existence of a marginal type $m_s$ such that a seller rents a platform slot if and only if $\mu_s \leq m_s$. Hence, the measure $m_s$ of entering sellers is implicitly defined by $\Pi(m_s) - f(m_s) - r = 0$.

*The Platform.* There is a continuum of (atomless) slots on the platform which can be developed by their owners to host sellers. A slot type is denoted by $\mu_p$; the empirical support of $\mu_p$ is $[0, \infty)$. If its owner decides to develop a slot of type $\mu_p$, he has to incur a fixed cost $c(\mu_p)$. Under each ownership structure, platform owners will first develop the slots with the lowest development costs. We assume that $c(\cdot)$ is a continuous and strictly increasing function. (It becomes increasingly costly to offer the same services or convenience to consumers as more retailers are active on the platform.) Since $c(\cdot)$ can always be chosen appropriately, we assume w.l.o.g. that, for any $x > 0$, the measure of platform slots with types in $[0, x]$ is $x$. Each platform slot hosts one seller, and so sellers of measure $m_s$ need retail space of measure $m_p = m_s$. Retail space of measure $m_p$ is provided at a minimum development cost of $C(m_p) \equiv \int_0^{m_p} c(\mu_p) d\mu_p$. Since $c(\cdot)$ is strictly increasing, $C(\cdot)$ is strictly convex. Note that platform slots differ only in their development costs; from the sellers' point of view, all developed slots are homogeneous. Consequently, the equilibrium rental price is independent of the type of the slot.

*Market Clearing.* Under any ownership structure, the rental market for platform slots will clear in equilibrium. Since a single slot accommodates a single seller, in equilibrium, the measure of entering sellers must be equal to the measure of developed platform slots, i.e., $m_s = m_p = m$. We will refer to $m$ as the platform size.

*Payoffs.* To summarize, we can write the equilibrium payoff of a seller of type $\mu_s$ as $\Pi(m) - f(\mu_s) - r$, where $m$ is the equilibrium platform size and $r$ the (uniform) equilibrium rental price. The equilibrium surplus of a buyer of type $\zeta$ from visiting the platform (rather than taking up the outside option) is $u(m) - g(\zeta)$. Aggregate profits for intermediaries are the revenues collected through rental charges, $mr$, minus the accumulated platform development costs $C(m)$. These expressions are collected in table 1.

| | |
|---|---|
| a seller $\mu_s$'s payoff | $\Pi(m) - f(\mu_s) - r$ |
| aggregate platform profits | $mr - C(m)$ |
| a buyer $\zeta$'s surplus | $u(m) - g(\zeta)$ |

Table 1: Equilibrium Payoffs

*Timing.* We consider the following sequence of decisions, involving first the intermediaries, then the sellers, and finally the buyers:

**Stage 1a** The measure $m_p$ of platform slots is developed by their owner(s).

**Stage 1b** The rental charge $r$ is set by the platform owners (intermediaries).

**Stage 2** Sellers decide whether or not to rent a slot on the trading platform.

**Stage 3** Buyers decide whether or not to visit the platform.

*Underlying Micro Structure.* While not necessary for our formal analysis, it may be helpful to consider the micro structure we have in mind. Each seller offers a unique variety of a differentiated good, and hence faces a downward-sloping residual demand curve. Varieties are symmetric, and so the platform size $m$ is the measure of varieties offered by sellers. We expect a seller's variable profit (per unit mass of buyers), $\pi(m)$, to decrease with $m$ for two reasons. First, for given prices, buyers purchase less from each seller as the number of sellers increases.[3] This may be dubbed the *market share effect.* Second, as the number of sellers increases, competition becomes more intense and prices fall (assuming that the goods offered by sellers are substitutes). This may be dubbed the *price effect.* (If the goods offered are complements, however, the price effect is positive, and may locally outweigh the market share effect.) The *competition effect* is then defined as the sum of the market share and price effects. Likewise, buyers' utility $u(m)$ (and, hence, the mass $z(m)$ of buyers visiting the platform) should be increasing in variety $m$ for two reasons. First, buyers have a taste for variety. Second, as the number of sellers increases, prices tend to fall (provided varieties are substitutes). The effect of an increase in $m$ on the mass $z(m)$ of buyers may be dubbed the *market size effect.*

If varieties are substitutes, an increase in platform size tends to have two countervailing effects on a seller's variable profit $\Pi(m)$: a positive market size effect and a negative competition effect. We speak of (locally) positive *platform effects* at platform size $m$ if the overall effect is positive:

$$m\frac{\Pi'(m)}{\Pi(m)} = m\frac{z'(m)}{z(m)} + m\frac{\pi'(m)}{\pi(m)} > 0, \tag{1}$$

[3] There may be a countervailing effect as variety increases, however, namely that variety-seeking consumers may optimally decide to spend a larger fraction of their income on the goods produced in the differentiated goods industry.

i.e., if the sum of the demand and profit elasticities with respect to platform size is positive. If varieties are complements, we should expect platform effects to be positive everywhere.

**Remark 1** *Throughout the recent literature on two-sided markets (e.g., Rochet and Tirole, 2003; Armstrong, 2004), which is concerned with monopoly platform ownership, it is assumed that there is no competition effect, and so $\pi$ is a constant, while buyer surplus depends on the number of sellers, and so $z$ is not constant. In contrast, in much of the literature on optimal product variety (e.g., Dixit and Stiglitz, 1977), which is concerned with non-intermediated trade, it is assumed that the number of participant buyers is exogenous, and so $z$ is a constant. On the other hand, there is competition between firms, and so $\pi$ is decreasing in $m$.*

*Reduced-Form Assumptions.* Our discussion of the underlying micro-structure motivates the following assumptions on the reduced-form payoff functions.

**Assumption 1** *There exists a unique $\widehat{m} \in [0, \infty) \cup \{\infty\}$ such that the marginal seller's profit $\Pi(m) - f(m)$ is strictly increasing on $[0, \widehat{m})$ and strictly decreasing on $(\widehat{m}, \infty)$.*

For the marginal seller's profit to (locally) rise with platform size $m$, platform effects must be (locally) positive and outweigh the rising fixed cost $f(m)$. If $\widehat{m} = \infty$, then $\Pi(m) - f(m)$ is monotonically increasing in $m$. In this case platform effects are said to be *very strong*: platform effects are globally positive and globally dominate the sellers' cost effect. If $\widehat{m} = 0$, then the marginal seller's profit is monotonically decreasing in $m$. In this case, platform effects are said to be *very weak*: platform effects are either negative or always dominated by the cost effect. If $0 < \widehat{m} < \infty$, the maximizer is implicitly defined by the first-order condition

$$\Pi'(\widehat{m}) - f'(\widehat{m}) = 0. \tag{2}$$

In this case, as $m$ increases, positive platform effects initially dominate the marginal seller's rising fixed cost, but eventually platform effects become smaller (relative to the fixed cost effect) or even negative.

**Assumption 2** *There exists a unique $m^* > 0$ such that the sum of marginal net profits of sellers and platform owners, $\int_0^m [\Pi(\mu) - f(\mu)]\, d\mu - C(m)$, is strictly increasing in $m$ on $[0, m^*)$ and strictly decreasing on $(m^*, \infty)$, and strictly positive at $m^*$.*

Assumption 2 implies that $\Pi(0) - f(0) \geq c(0)$. The marginal seller's profit function $\Pi(\cdot) - f(\cdot)$ intersects the slot development cost function $c(\cdot)$ at a unique positive platform size $m^*$:

$$\Pi(m^*) - f(m^*) - c(m^*) = 0 \tag{3}$$

Platform sizes $\widehat{m}$ and $m^*$ are illustrated in figure 1. If the marginal development cost function $c(\cdot)$ intersects (from below) the marginal seller's profit function $\Pi(\cdot) - f(\cdot)$ to the left of the latter's peak, then $m^* < \widehat{m}$. In this case, we say that platform effects are *strong*. If the intersection is to the right of the peak, then $m^* > \widehat{m}$. In this case, we say that platform effects are *weak*. In terms of elasticities, platform effects are strong if, at $m^*$, the sum of the demand

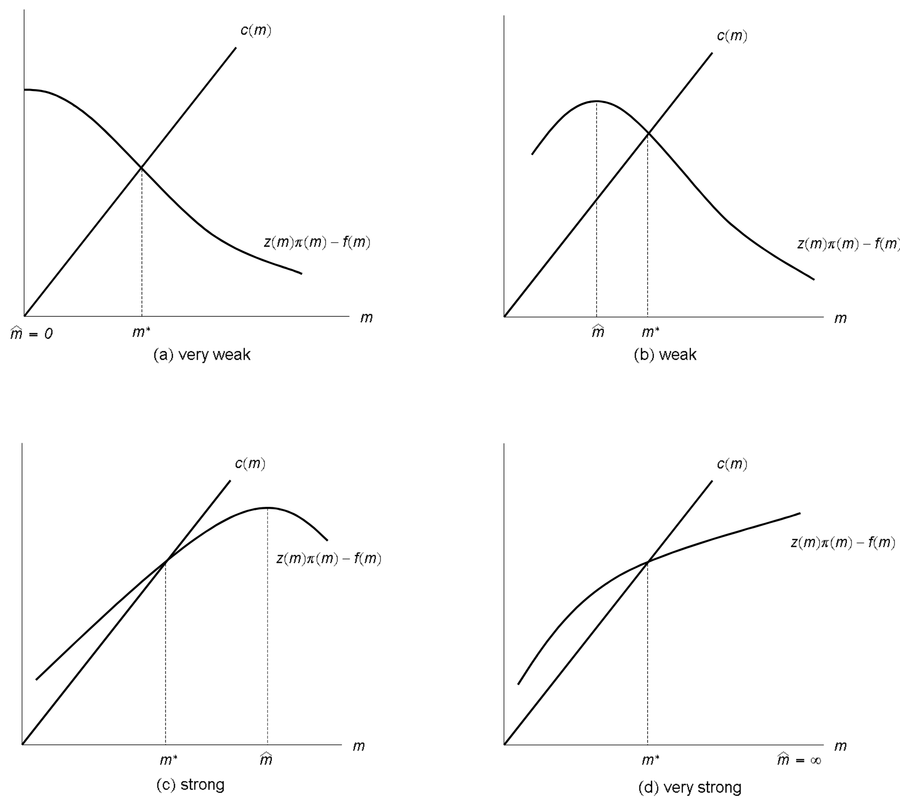


Figure 1: A Taxonomy of Platform Effects

and profit elasticities is larger than the seller's cost elasticity times the ratio between costs and variable profits,

$$m^* \frac{z'(m^*)}{z(m^*)} + m^* \frac{\pi'(m^*)}{\pi(m^*)} > m^* \frac{f'(m^*)}{f(m^*)} \frac{f(m^*)}{z(m^*)\pi(m^*)}.$$

If the reverse inequality holds, platform effects are weak. Clearly, the case of very weak (very strong) platform effects is a special case of weak (strong) platform effects.

We provide a taxonomy of platform effects in figure 1. Table 2 summarizes the four different regimes (very weak, weak, strong, and very strong platform effects) and the rankings of $m^*$ and $\widehat{m}$ in each regime.

In the following we consider an example that is flexible enough to generate very weak, weak, strong, and very strong platform effects.

**Example 1** A CES Model with an Outside Option and Power Cost Functions. *Consumers (buyers) make a discrete choice between visiting the market place and an outside option. Consumer type $\zeta$'s value of the outside option (or, equivalently, the transport cost associated with*

| | |
|---|---|
| weak | $m^* > \widehat{m} \geq 0$ |
| very weak | $m^* > \widehat{m} = 0$ |
| strong | $m^* < \widehat{m} \leq \infty$ |
| very strong | $m^* < \widehat{m} = \infty$ |

Table 2: Platform Effects and Critical Platform Size

*visiting the platform) is given by $g(\zeta) = t\zeta$. Conditional on visiting the market place, consumers have CES preferences over the variants offered by the retailers (sellers). Demand for variant $j$ is*

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

*where $p(j)$ is the price of variant $j$, $E$ is income spent on the differentiated goods industry, and $\rho \in (0, 1)$ measures the degree of product differentiation. Each retailer $j$ maximizes her profit $\pi = (p - c)p^{-\frac{1}{1-\rho}} A$, where $c$ is the marginal cost of production, and $A = E / \int_0^m p(j)^{-\frac{\rho}{1-\rho}} dj$. Using symmetry, the first-order conditions of profit maximization yield the equilibrium price $p = c/\rho$. Here, an increase in product variety has no price effect: $\partial p/\partial m = 0$. Equilibrium quantity is given by $x(m) = (E/m)(\rho/c)$, so there is a market share effect, and equilibrium profit $\pi(m) = (1 - \rho)E/m$ is decreasing in $m$. In equilibrium, utility $u(m) = E(\rho/c)m^{\frac{1-\rho}{\rho}}$ is increasing in $m$. The marginal consumer $z$ who is indifferent between visiting the market place and taking up the outside option is defined by $u(m) - tz = 0$, and hence $z(m) = u(m)/t$. A retailer's variable profit is then given by*

$$\Pi(m) = \frac{E^2}{t} \frac{\rho(1 - \rho)}{c} m^{\frac{1-2\rho}{\rho}}.$$

*Here, $\Pi(\cdot)$ is monotone in $m$: it is decreasing if the variants are sufficiently good substitutes, $\rho > 1/2$, and increasing if the reverse inequality holds. Hence, a necessary condition for $m^* > 0$ is that $\rho < 1/2$.*

*With respect to costs, we assume that sellers' fixed costs take the form $f(\mu_s) = a\mu_s^b$, where $a, b > 0$; and that the development cost function takes the form $C(\mu_p) = \alpha\mu_p^\beta$, where $\alpha > 0$ and $\beta > 1$.*

*Assumption 1 concerns the marginal seller's profit. If $\rho > 1/2$, then the marginal seller's profit $\Pi(m) - f(m)$ is monotonically decreasing in $m$, and so $\widehat{m} = 0$. If $\frac{1}{b+2} < \rho < 1/2$, then there exists a unique interior maximum $\widehat{m}$. If $\rho < \frac{1}{b+2}$, then the marginal seller's profit is monotonically increasing in $m$, and so $\widehat{m} = \infty$.*

*Assumption 2 concerns the sum of marginal net profits of sellers and platform owners. The sum of marginal net profits of sellers and platform owners $\int_0^m [\Pi(\mu_s) - f(\mu_s)] \, d\mu_s - C(m)$*

*is single-peaked in $m$ and has a unique positive maximizer, $m^*$, provided assumption 1 holds as well. Specifically, if $\rho > 1/2$, $\Pi(\cdot) - f(\cdot)$ is monotonically decreasing, while $c(m)$ is increasing in $m$, and so the assumption holds trivially. If $\min\left\{\frac{1}{\beta+1}, \frac{1}{b+2}\right\} < \rho < 1/2$, then $\int_0^m [\Pi(\mu_s) - f(\mu_s)]\, d\mu_s - C(m)$ is single-peaked with an interior maximum.*

*To sum up, assumptions 1 and 2 hold in this example under the weak restriction that $\min\left\{\frac{1}{\beta+1}, \frac{1}{b+2}\right\} < \rho$, which requires a minimum degree of convexity of one of the two aggregate cost functions.*

*In the special case $b = \beta - 1$ the above restriction reduces to $\rho > 1/(\beta+1)$. Then, platform effects are very weak if $1 > \rho > 1/2$. Suppose furthermore that $a = \alpha$. Then, platform effects are weak, but not very weak, if $1/2 > \rho > (\beta+1)/(3\beta+1)$; they are strong if $(\beta+1)/(3\beta+1) > \rho > 1/(\beta+1)$.*

## 3 Independently-Owned Platforms

In this section, we derive the equilibrium under three ownership structures that are all vertically disintegrated: open platform ownership ($O$), closed platform ownership ($C$), and monopoly platform ownership ($M$).

- Open platform ownership ($O$). A population of ex ante identical (potential) intermediaries sequentially enter the market for intermediation on the platform and decide which platform slots to develop. Each intermediary can develop at most one slot $\mu_p$ at cost $c(\mu_p)$, and offer it to one seller at the competitive rental price.

- Closed platform ownership ($C$). A population of ex ante identical (potential) intermediaries sequentially enter the market for intermediation on the platform and reserve platform slots for development. However, early entrants (incumbent club members) can deny access to the platform to later entrants (prospective members).[4] After being admitted, each intermediary develops his reserved slot $\mu_p$ at cost $c(\mu_p)$, and offers it to one seller at the market-clearing rental price.

- Monopoly platform ownership ($M$). All platform slots are owned by a monopoly intermediary. The monopolist decides which platform slots to develop, and sets the rental price for each platform slot (being unable to discriminate between different types of sellers).

Ownership is fragmented under open and closed platform ownerships and concentrated under monopoly ownership. Under open platform ownership, incumbent intermediaries cannot deny access to other intermediaries – in contrast to the cases of closed and monopoly platform ownerships. The welfare consequences of allowing incumbent platform owners to exclude potential entrants are discussed in section 6.

[4] As we will later show, the interests of all of the admitted members are perfectly aligned. Hence, we can remain agnostic about the club's admission procedure (e.g., giving individual veto power to each club member yields the same outcome as requiring unanimity).

*Open Platform Ownership.* Under open platform ownership, free entry of (rental-price taking) intermediaries implies that the cost of developing the marginal platform slot of type $m_p$ is equal to the rental price $r$:

$$r = c(m_p).$$

Optimal participation decisions of sellers imply that the marginal seller's profit net of the rental price is equal to zero,

$$\Pi(m_s) - f(m_s) = r.$$

The competitive rental price $r$ clears the rental market, $m_p = m_s$. The equilibrium platform size $m^O$ is thus determined by

$$\Pi(m^O) - f(m^O) = c(m^O). \tag{4}$$

Comparing (3) and (4), we obtain the following lemma.

**Lemma 1** *Under open platform ownership, the equilibrium platform size $m^O$ is given by $m^O = m^*$. From assumption 2, it follows that $m^O$ is unique.*

Hence, the platform size under open platform ownership maximizes the sum of marginal net profits of sellers and platform owners, as defined in assumption 2.

*Closed Platform Ownership.* Under closed platform ownership, incumbent intermediaries can deny prospective intermediaries access to the platform. Since the most efficient platform slots will be reserved first, the optimization problem for incumbent intermediaries consists in maximizing each active intermediary's profit with respect to the number of active intermediaries, subject to: the participation constraint for sellers, the market clearing condition for platform slots, and the condition that each intermediary makes nonnegative profits. Formally,

$$\begin{aligned} &\max_{m_p} r - c(m_p) \\ \text{s.t.} \quad &\Pi(m_s) - f(m_s) = r, \\ &m_s = m_p, \\ &r \geq c(m_p). \end{aligned}$$

Note that, conditional on being granted access to the platform, all intermediaries on the platform agree on the optimal number of active intermediaries. Market clearing implies a platform size $m = m_s = m_p$. The optimization problem can thus be rewritten as

$$\begin{aligned} &\max_{m} \Pi(m) - f(m) \\ \text{s.t.} \quad &\Pi(m) - f(m) \geq c(m). \end{aligned} \tag{5}$$

The constraint reflects that prospective intermediaries cannot be forced to join the platform. It follows trivially that the equilibrium platform size $m^C$ cannot be larger than under open platform ownership: $m^C \leq m^O = m^*$.

Solving the maximization problem, we obtain the following result.

**Lemma 2** *Under closed platform ownership, equilibrium platform size $m^C$ is given by*

$$m^C = \min\{\widehat{m}, m^*\}.$$

*From assumptions 1 and 2, it follows that $m^C$ is unique.*

**Proof.** Suppose first that the constraint in (5) is non-binding. Then, the equilibrium platform size $m^C$ is implicitly defined by

$$\Pi'(m^C) - f'(m^C) = 0.$$

Comparing this equation with (2), we conclude that $m^C = \widehat{m}$. If on the other hand the constraint in (5) is binding, we have

$$\Pi(m^C) - f(m^C) = c(m^C),$$

and hence, from (3), $m^C = m^*$. ■

Suppose platform effects are weak, $m^* > \widehat{m}$. Then, the marginal development cost function $c(m)$ intersects the marginal seller's profit function to the right of the latter's peak; see figure 1. Since incumbent club members' interests with respect to platform size are perfectly aligned (provided each member makes nonnegative profits), each club member's profit is maximized at the platform size $\widehat{m}$, where the marginal seller's profit $\Pi(m) - f(m)$ is maximized. The marginal club member at platform size $\widehat{m}$ obtains a strictly positive profit, $r - c(\widehat{m}) > 0$, where $r = \Pi(\widehat{m}) - f(\widehat{m})$. In the special case where platform effects are very weak, $\widehat{m} = 0$, the equilibrium platform size is of measure zero since, in this case, an incumbent club member's profit is decreasing in the number of club members.

Suppose now that platform effects are strong, $m^* < \widehat{m}$. Then, the marginal club member would make a loss at platform size $\widehat{m}$. In this case, incumbent club members would like to admit more members than the number of entering intermediaries under free entry, and so the equilibrium platform size is equal to that under open platform membership, $m^C = m^O = m^*$.

*Monopoly Platform Ownership.* Suppose now that all platform slots are owned by a monopolist. The monopolist's optimization problem consists in maximizing his profit with respect to the total number of platform slots $m_p$, subject to the free-entry condition for sellers and the rental market clearing condition. Formally,

$$\begin{aligned} &\max_{m_p} m_p r - C(m_p) \\ \text{s.t.} \quad &\Pi(m_s) - f(m_s) = r, \\ &m_s = m_p. \end{aligned}$$

Market clearing implies a platform size $m = m_s = m_p$. The optimization problem can thus be rewritten as

$$\max_m m\left[\Pi(m) - f(m)\right] - C(m).$$

Solving this problem, we obtain the following result.

**Lemma 3** *Under monopoly platform ownership, the equilibrium platform size $m^M$ satisfies $m^M \in (\widehat{m}, m^*)$ if platform effects are weak, and $m^M \in (m^*, \widehat{m})$ if platform effects are strong. Otherwise, if $\widehat{m} = m^*$, we have $m^M = \widehat{m} = m^*$.*

**Proof.** The equilibrium platform size under monopoly ownership, $m^M$, must satisfy the first-order condition

$$\Pi(m^M) - f(m^M) + m^M[\Pi'(m^M) - f'(m^M)] = c(m^M) \tag{6}$$

Note that there may be more than one platform size which satisfies the first-order and second-order conditions of profit maximization. In general, our assumption do not imply that the monopolist's objective function is single-peaked.[5] Clearly, the monopolist selects the solution to the first-order condition that maximizes his profit. Hence, $m^M$ is generically unique.

We can rewrite the first-order condition as follows:

$$\varphi(m^M) + m^M \psi(m^M) = 0,$$

where

$$\begin{aligned} \varphi(m) &\equiv \Pi(m) - f(m) - c(m), \\ \text{and } \psi(m) &\equiv \Pi'(m) - f'(m). \end{aligned}$$

By assumption 1, $\psi(m) > 0$ if $m < \widehat{m}$, and $\psi(m) < 0$ if the reverse inequality holds. Similarly, by assumption 2, $\varphi(m) > 0$ if $m < m^*$, and $\varphi(m) < 0$ if the reverse inequality holds. Consequently, if $\widehat{m} \neq m^*$, we have $\varphi(m) + m\psi(m) > 0$ for $m \leq \min\{\widehat{m}, m^*\}$ and $\varphi(m) + m\psi(m) < 0$ for $m \geq \max\{\widehat{m}, m^*\}$. If $\widehat{m} = m^*$, then $\varphi(m) + m\psi(m) > 0$ for $m < \widehat{m} = m^*$ and $\varphi(m) + m\psi(m) < 0$ for $m > \widehat{m} = m^*$. ■

Suppose first that platform effects are weak, $\widehat{m} < m^*$. In this case, we have $m^M \in (\widehat{m}, m^*)$. To see that $m^M > \widehat{m}$, note that at any platform size $m \leq \widehat{m}$, a marginal increase in platform size has a non-negative effect on profits for inframarginal platform slots, while for all $m < m^*$ the marginal slot makes a positive contribution to total profits as $\Pi(m) - f(m) > c(m)$. To see that $m^M < m^*$, note that at any platform size $m > \widehat{m}$, a marginal increase in platform size reduces the profits for inframarginal platform slots, while for all $m \geq m^*$ the marginal slot makes a non-positive contribution to total profits as $\Pi(m) - f(m) \leq c(m)$.

Suppose now that platform effects are strong, $\widehat{m} > m^*$. We then have $m^M \in (m^*, \widehat{m})$. To see that $m^M > m^*$, note that at any platform size $m < \widehat{m}$, a marginal increase in platform size increases the profits for inframarginal platform slots, while the marginal slot makes a non-negative contribution to total profits as $\Pi(m) - f(m) = c(m)$ for all $m \leq m^*$. To see that $m^M < \widehat{m}$, note that at any platform size $m \geq \widehat{m}$, a marginal increase in platform size has a non-positive effect on profits for inframarginal platform slots, while for $m > m^*$ the marginal slot makes a negative contribution to total profits as $\Pi(m) - f(m) < c(m)$. Hence, when platform effects are strong, the monopoly platform owner optimally "subsidizes" the marginal seller by setting a rental price below marginal development cost.

[5] In the CES example, there is a unique solution to the first-order condition, provided parameters are such that assumptions 1 and 2 holds.

*A Comparison of Platform Sizes under the Three (Vertically Non-Integrated) Ownership Structures.* We now turn to a comparison of the three ownership structures considered above. From our above analysis, it is immediate to see that monopoly ownership leads unambiguously to a larger platform size than closed platform ownership. Compared to the open platform, the monopoly platform has a larger platform size if and only if platform effects are strong. This result is summarized by the following proposition:

**Proposition 1** *The equilibrium platform size under the three vertically non-integrated ownership structures can be ranked as follows. If platform effects are weak, $m^* > \widehat{m}$, then $m^O > m^M > m^C$. If platform effects are strong, $m^* < \widehat{m}$, then $m^M > m^O = m^C$.*

**Proof.** This follows immediately from lemmas 1 to 3. ■

To develop a better intuition for this result, it may be helpful to interpret platform size $m$ as the "output" of the intermediaries, the "price" of which is the rental charge $r$. Under this interpretation, intermediaries are "producers" (of platform slots), who face the industry production cost function $C(m)$. Under a fragmented ownership structure, each potential producer has a capacity of one unit of output. The "inverse demand function" (for platform slots) is then given by the marginal seller's willingness to pay for a platform slot, $\Pi(m) - f(m)$. By assumption 1, the inverse demand function is single-peaked and obtains a unique maximum at $\widehat{m} \geq 0$. When comparing open and monopoly platform ownerships, we are thus comparing a competitive market with a monopoly.

Suppose first that platform effects are weak, $m^* > \widehat{m}$. In the special case of very weak platform effects, $\widehat{m} = 0$, inverse demand is downward-sloping. As is well known from intermediate microeconomics, equilibrium output will then be lower under monopoly than in a competitive market, since the monopolist has an incentive to restrict output so as to be able to charge a higher price. Under closed platform ownership, members have an incentive to deny access since further entry will reduce the price members can charge. Since each (atomless) member produces a single unit of output (which is a slot of measure zero), closed platform ownership leads to a measure zero of output. Equilibrium output is thus lower than under monopoly. More generally, the comparison between the three ownership structures is similar to the case where $\widehat{m} = 0$, the main difference being that the equilibrium platform size under closed platform ownership is of positive measure. Note that if the marginal development cost function $c(m)$ were constant (as typically assumed in the literature on network effects; see Economides, 1996), then platform effects would necessarily be weak.

Suppose now that platform effects are strong, $m^* < \widehat{m}$. In this case, the industry (production) cost function $C(m)$ intersects the inverse demand function in the latter's increasing part. Consequently, the equilibrium output levels of the open and closed competitive markets coincide: under closed platform ownership, incumbent producers would like to increase industry output above and beyond the level provided under open platform ownership, but cannot force production of additional producers at a price below cost. In contrast, the monopolist can internalize network effects (which cause the inverse demand function to be locally upward-sloping) and subsidize production at the margin. Hence, the ranking of output levels between competitive markets and monopoly is reversed if the relevant part of the inverse demand function is upward-sloping.

## 4 Vertically Integrated Platforms

In the previous section, we assumed that sellers cannot become intermediaries. In this section, we provide a positive analysis of vertically integrated platforms, where each active seller owns her own platform slot; the welfare aspects of vertical integration are studied in section 6. Since there are no longer independent intermediaries, this can be thought of as representing non-intermediated trade. We distinguish between an open integrated ($OI$) and closed integrated ($CI$) platform ownership structures. (Since our reduced-form approach assumes that sellers are atomless, we do not analyze the case of a vertically integrated monopoly supplier-intermediary.)

- Open integrated platform ownership ($OI$). A population of (potential) sellers sequentially decide whether and which platform slots to develop. Each seller can develop at most one slot $\mu_p$ at cost $c(\mu_p)$ to sell his own good.
- Closed integrated platform ownership ($CI$). A population of (potential) sellers sequentially decide whether and which platform slots to reserve for development. However, early entrants (incumbent club members) can deny access to the platform to later entrants (prospective members).[6] After being admitted, each seller develops his reserved slot $\mu_p$ at cost $c(\mu_p)$ to sell her own good.

Since sellers and platform slots are heterogeneous, equilibrium under both ownership structures depends on the sequence under which sellers decide whether and which platform slots to develop. We assume that sellers' participation decisions are taken in increasing order of fixed costs: more efficient sellers move before less efficient sellers.[7] Since each entrant will want to develop the best available platform slot, this sequencing results in a perfectly positive correlation between seller type and slot type across seller-slot pairs.

*Open Integrated Platform Ownership.* Consider first the case of an open integrated platform. Since seller and slot types will be perfectly correlated across active seller-slot pairs, the marginal seller $m$ with fixed cost $f(m)$ faces development costs $c(m)$. The equilibrium platform size $m^{OI}$ is thus determined by

$$\Pi(m^{OI}) - f(m^{OI}) = c(m^{OI}). \tag{7}$$

Hence, the outcome is identical to that of an open non-integrated platform, $m^O = m^{OI} = m^*$. This is summarized in the following lemma.

**Lemma 4** *Under open integrated platform ownership, the equilibrium platform size $m^{OI}$ is given by $m^{OI} = m^*$. From assumption 2, it follows that $m^{OI}$ is unique.*

[6] As we will later show, the interests of all of the admitted members are perfectly aligned. Hence, we can remain agnostic about the club's admission procedure (e.g., giving individual veto power to each club member yields the same outcome as requiring unanimity).

[7] This assumption may be justified as follows. In a natural dynamic extension of our model, suppose that the sequential entry of sellers onto the platform takes time and sellers discount profits. In this case, more efficient sellers have a higher willingness-to-pay for early (rather than late) entry than less efficient sellers.

*Closed Integrated Platform Ownership.* Consider now the case of a closed integrated platform. The maximization problem for each incumbent seller-intermediary of type $\mu_s = \mu_p = \mu$ is

$$\max_{m \geq 0} \Pi(m) - f(\mu) - c(\mu)$$
$$\text{s.t. } \Pi(m) - f(m) - c(m) \geq 0.$$

Solving this optimization problem, we obtain the following result.

**Lemma 5** *Under closed integrated platform ownership, the equilibrium platform size $m^{CI}$ satisfies $\widehat{m} \leq m^{CI} \leq m^*$ if platform effects are weak (with the first inequality being strict if platform effects are not very weak), and $m^{CI} = m^*$ if platform effects are strong.*

**Proof.** The constraint in the maximization problem implies that $m^{CI} \leq m^*$. The first-order condition of the unconstrained problem may be written as

$$\Pi'(m^{CI}) = 0. \tag{8}$$

If platform effects are very weak, $\widehat{m} = 0$, $m^{CI} \geq \widehat{m}$ is trivially satisfied. If platform effects are weak but not very weak, we have $\widehat{m} > 0$, and the l.h.s. of (8) is strictly positive if evaluated at any $m \leq \widehat{m}$. Hence, $m^{CI} > \widehat{m}$. If platform effects are strong, $\widehat{m} > m^*$, the constraint in the maximization problem is necessarily binding, and so $m^{CI} = m^*$. ■

Recall that in the CES-example, $\Pi(m)$ is either monotonically increasing or decreasing (depending on the elasticity of substitution). In this case, $m^{CI} = 0$ if platform effects are very weak, and $m^{CI} = m^*$ otherwise.

*The Effect of Vertical Integration on Equilibrium Platform Size.* What is the effect of vertical integration on equilibrium platform size? From our above analysis, we obtain the following result.

**Proposition 2** *Under an open ownership structure, vertical integration has no effect on equilibrium platform size: $m^{OI} = m^O$. Under a closed ownership structure, vertical integration weakly increases the equilibrium platform size: $m^{CI} \geq m^C$, where the inequality is strict if platform effects are weak but not very weak.*

To see that $m^{CI} \geq m^C$, note that, under a closed non-integrated ownership structure, the intermediaries do not capture all of the inframarginal rents of sellers (due to the uniform rental charge). The incumbent intermediaries thus have less incentives to admit additional member than under vertical integration, where they capture all of the inframarginal rents of sellers.[8] Observe that if all sellers were homogeneous (i.e., if $f$ were constant), all intermediaries would make zero profit in equilibrium under vertical separation. Under closed ownership, vertical integration would in this case not affect the allocation.

[8] If buyers' utility $u(m)$ increases with platform size (or variety) $m$ (as seems very plausible), vertical integration may thus benefit consumers. In the existing literature on vertical restraints, consumers profit from vertical integration only if integration eliminates double marginalization or if there are productivity gains.

## 5 Stable Ownership Structures

We now investigate the incentives of intermediaries to horizontally integrate. We call an ownership structure "stable" (with respect to horizontal integration) if no outside player can make a positive profit by acquiring all property rights on the platform in the following acquisition game (prior to stage 1). First, an outside player makes a take-it-or-leave-it bid $b(\mu) \geq 0$ for each platform slot $\mu$, which is being paid only if *all* slots are acquired. Then, all initial owners of platform slots (intermediaries) decide whether or not to accept the offers. The outside player acquires all of the platform slots if and only if all bids are accepted; otherwise, no slots are acquired and no transfers are made. If successful, the outside player operates the platform as a monopolist.

Since the aggregate profits of intermediaries are maximized under monopoly ownership, the open and closed ownership structures, $O$ and $C$, are always unstable. A more interesting question is whether (and under what conditions) the vertically integrated ownership structures, $OI$ and $CI$, are stable. As we have shown above, when there is open access to the platform, vertical integration has no effect on profits of seller-intermediary pairs, and therefore no effect on platform size: $m^O = m^{OI}$. Hence, one might suspect that the open integrated platform ownership structure $OI$ is always unstable. However, this ignores that monopolization of the platform imposes an externality on sellers. To see this, suppose the (internal) transfer rental charge under $OI$ is the competitive rental charge, which is equal to $c(m^{OI}) = c(m^*)$. If platform effects are weak, we have $m^{OI} > m^M$, and so the rental price under $M$ is higher than the competitive rental charge. In this case, platform monopolization imposes a *negative* externality on sellers, which makes it more costly for an outside player to monopolize the platform (as he needs to compensate the sellers). The negative externality on sellers may or may not dominate the internalization of horizontal externalities through monopolization. Hence, ownership structure $OI$ may or may not be stable if platform effects are weak. If platform effects are strong, however, we have $m^{OI} < m^M$, and so the rental price under $M$ is less than the competitive rental charge. In this case, platform monopolization imposes a *positive* externality on sellers, which makes it less costly for an outside player to monopolize the platform. Consequently, ownership structure $OI$ is unstable if platform effects are strong. Similar arguments apply to the stability of ownership structure $CI$. Note, however, that we may have $m^{CI} < m^M$ even if platform effects are weak.

**Proposition 3** *Ownership structures $O$ and $C$ are always unstable. If platform effects are weak, ownership structures $OI$ and $CI$ may be stable. If platform effects are strong, both vertically integrated ownership structures are unstable.*

**Proof.** The instability of ownership structures $O$ and $C$ is trivial. Consider now ownership structure $X \in \{OI, CI\}$. Suppose $m^M > m^X$. (For $X = OI$, this holds if and only if platform effects are strong. For $X = CI$, this holds if platform effects are strong.) In this case, the outside player can make the bid $b(\mu) = 0$ for any platform slot $\mu \geq m^X$. $X$ is unstable if

$$\begin{aligned} & m^X \Pi(m^X) - \int_0^{m^X} f(\mu) d\mu - C(m^X) \\ < \ & m^M r^M - C(m^M) + m^X \Pi(m^M) - \int_0^{m^X} f(\mu) d\mu - m^X r^M, \end{aligned}$$

where $r^M = \Pi(m^M) - f(m^M)$ is the equilibrium rental charge under monopoly. The term on the l.h.s. of the inequality are the aggregate profits of sellers and intermediaries under ownership structure $X$. The term on the r.h.s. are the monopoly platform owner's profits plus the sum of the profits of sellers $\mu \leq m^X$ under $M$. Sellers $\mu \in \left[m^X, m^M\right)$ make positive profits under $M$, and zero profits under $X$. Since $b(\mu) \geq 0$, their profits under $M$ cannot be used by the outside player to compensate the other seller-intermediary pairs. The inequality can be rewritten as

$$\begin{aligned} & \left\{m^M[\Pi(m^M) - f(m^M)] - C(m^M) - \left(m^X[\Pi(m^X) - f(m^X)] - C(m^X)\right)\right\} \\ + \ & \left\{m^X[f(m^M) - f(m^X)]\right\} > 0. \end{aligned}$$

By definition of $m^M$, the first term in curly brackets is positive. Since $m^M > m^X$, the second term in curly brackets is positive as well. Hence, if $m^M > m^X$, ownership structure $X$ is unstable.

Suppose now that $m^M < m^X$. $X$ is unstable if

$$\begin{aligned} & m^X \Pi(m^X) - \int_0^{m^X} f(\mu) d\mu - C(m^X) \\ < \ & m^M \Pi(m^M) - \int_0^{m^M} f(\mu) d\mu - C(m^M), \end{aligned}$$

where the term on the r.h.s. are the aggregate profits of the monopoly platform owner and *all* sellers under $M$ because there are fewer active sellers under $M$ than under $X$. The inequality can be rewritten as

$$\begin{aligned} & \left\{m^M[\Pi(m^M) - f(m^M)] - C(m^M) - \left(m^X[\Pi(m^X) - f(m^X)] - C(m^X)\right)\right\} \\ + \ & \left\{m^M f(m^M) + \int_{m^M}^{m^X} f(\mu) d\mu - m^X f(m^X)\right\} > 0. \end{aligned}$$

Again, the first term in curly brackets is positive but now the second term in curly brackets is negative. In the CES-example, it is easy to find parameter constellations such that $OI$ and $CI$ are stable (respectively, unstable) under weak platform effects. ■

According to our notion of stability, ownership structure $M$ is always stable. However, it is straightforward to extend our stability concept by allowing the outside player to sell the platform to a set of atomless intermediaries or sellers. This means that the outside player can effectively redistribute ownership rights on the platform. According to this extended notion of stability, ownership structure $M$ is unstable if $OI$ or $CI$ are stable.[9]

We conclude our stability analysis with an important caveat. We have assumed that an outside player can make take-it-or-leave-it bids and commit to acquire any given platform slot only if all of his other bids are accepted. To the extent that such conditional bidding is infeasible, a free rider problem may emerge: the owner of a given platform slot may prefer not to sell his slot if monopolization of the remaining slots leads to higher rental prices. As is well known from the literature on endogenous horizontal mergers (and, more generally, noncooperative coalition formation), fragmented ownership structures may survive in this case (even though there exist bids such that all initial platform owners and the outside player would be better off if all platform slots were acquired by the outside player). The more interesting result of our stability analysis is thus not the predicted instability of the fragmented, non-integrated ownership structures $O$ and $C$, but rather the potential stability of the fragmented, integrated ownership structures $OI$ and $CI$, even if a potential acquirer can commit to conditional bids.

## 6 Welfare Analysis

In this section, we investigate the welfare properties of different ownership structures. Our welfare analysis consists of two parts. First, we derive the welfare-maximizing platform size and compare it with the equilibrium platform size under different ownership structures. Second, we derive the platform size that maximizes aggregate profits of sellers and intermediaries to obtain a (partial) welfare ranking of ownership structures. Throughout this section, we will assume that buyers' utility is strictly increasing in platform size $m$. As discussed in section 2, this can be for two reasons: consumers value variety and prices may decrease with the number of sellers.

**Assumption 3** *The utility function $u(\cdot)$ is continuously differentiable and strictly increasing.*

*The Planner's Problem.* We consider the problem of a benevolent social planner whose objective it is to maximize total surplus (of buyers, sellers, and intermediaries) with respect to platform size $m$. We assume that the planner cannot directly control the measure of buyers, $z$; instead, $z$ is determined by buyers' participation decisions.[10] Recall that $z(m) = g^{-1}(u(m))$. The planner's objective function is then given by the sum of buyers' surplus and aggregate

[9] Suppose both $CI$ and $OI$ are stable with respect to horizontal integration. Then, under the extended notion of stability, both are stable if $m^{CI} = m^{OI}$; otherwise, if $m^{CI} < m^{OI}$, $CI$ is stable if the aggregate profits of sellers and intermediaries is higher under $CI$ than under $OI$, while $OI$ is stable if the reverse holds.

[10] In our reduced-form model where price-setting of sellers is not explicitly modelled, the planner's problem consists in choosing the platform size $m$. As regards our underlying micro structure, however, we implicitly assume that the price setting stage is beyond the control of the planner. As is common in the I.O. literature on socially optimal entry (e.g., Spence (1976); von Weizsäcker, 1980; Mankiw and Whinston, 1986), the planner thus chooses the "second-best solution" by only determining the number of entrants (both sellers and intermediaries), taking consumer behavior and sellers' pricing as given.

profits of sellers and intermediaries:

$$\begin{aligned} W(m) &= g^{-1}(u(m))u(m) - \int_0^{g^{-1}(u(m))} g(\zeta)d\zeta \\ &\quad + mg^{-1}(u(m))\pi(m) - \int_0^m f(\mu)d\mu - C(m). \end{aligned}$$

The planner solves $\max_m W(m)$. The socially optimal platform size $m^W$ satisfies the first-order condition, which is given by

$$z(m^W)u'(m^W) + \left\{\Pi(m^W) - f(m^W) - c(m^W) + m^W\Pi'(m^W)\right\} = 0. \tag{9}$$

We now compare the socially optimal platform size $m^W$ with the platform size $m^*$ that maximizes the sum of *marginal* net profits of sellers and platform owners. From (3) and (9), it follows that $m^W > m^*$ if and only if

$$z(m^W)u'(m^W) + m^W\Pi'(m^W) > 0. \tag{10}$$

Since $u'(\cdot) > 0$, a necessary condition for $m^W < m^*$ is thus that $\Pi(m)$ is decreasing in $m$ at $m = m^W$, which can occur only if platform effects are weak, $m^* > \widehat{m}$.

*Socially Excessive or Insufficient Platform Size.* Suppose that platform effects are strong, $m^* < \widehat{m}$. As we have shown in sections 3 and 4, ownership structure $M$ induces the largest platform size amongst all admissible ownership structures $\{O, C, M, OI, CI\}$. Consequently, since $m^W > m^M$, all ownership structures induce a socially insufficient platform size.

Suppose now that platform effects are weak, $m^* > \widehat{m}$. Then, either $O$ (together with $OI$ and possibly $CI$) or $M$ induce the largest platform size amongst the admissible ownership structures. Since $m^W > m^M$, the only ownership structure that may induce a socially excessive platform size is the open platform ownership structure $O$ (together with $OI$ and possibly $CI$). This is stated in the following proposition.

**Proposition 4** *Consider the set of admissible ownership structures $\{O, C, M, OI, CI\}$. If platform effects are weak, only the open ownership structure $O$ and the vertically integrated ownership structures, $OI$ and $CI$,* may *induce a socially excessive platform size; the other ownership structures, $C$ and $M$, necessarily induce a socially insufficient platform size. If platform effects are strong, all ownership structures necessarily induce a socially insufficient platform size.*

The literature on optimal product variety (e.g., Spence, 1976; Dixit and Stiglitz, 1977), which is concerned with non-intermediated trade, has shown that the market may over- or underprovide product variety from a social point of view. In our general framework, these models are akin to the special case of ownership structure $OI$ when platform effects are very weak.

We could provide a partial welfare ranking if we were to assume that the planner's objective function is single-peaked. This would require an assumption on the joint behavior of buyers' surplus and sellers' and intermediaries' aggregate profits. However, as in our positive analysis, we prefer to avoid making assumptions on the shape of buyers' surplus function.

*Aggregate Profits of Sellers and Intermediaries.* To obtain a partial welfare ranking, it proves useful to consider the platform size $m^S$ that maximizes the aggregate profits of sellers and intermediaries:

$$m^S = \arg\max_m m\Pi(m) - \int_0^m f(\mu)d\mu - C(m).$$

We assume that the aggregate profits of sellers and intermediaries is single-peaked in $m$.

**Assumption 4** *There exists a unique $m^S \geq 0$ such that the aggregate profits of sellers and intermediaries, $m\Pi(m) - \int_0^m f(\mu)d\mu - C(m)$, is strictly increasing in $m$ on $[0, m^S)$ and strictly decreasing on $(m^S, \infty)$, and strictly positive at $m^S$.*

In our CES example, assumption 4 holds if $\min\left\{\frac{1}{\beta+1}, \frac{1}{b+2}\right\} < \rho$. This is the same parameter restriction as the one for assumptions 1 and 2 to hold.

By assumption 4, the total profits of sellers and intermediaries are single-peaked in $m$, and attain their maximum at $m^S$. Since by assumption 3, buyers' utility $u$ is increasing in $m$, buyers' surplus increases monotonically with platform size $m$. It then follows that $m^S < m^W$.[11] Hence, if two ownership structures both induce equilibrium platform sizes that are less than $m^S$, the ownership structure that induces the larger platform size is socially preferable.

**Lemma 6** *If platform effects are weak, the platform size $m^S$ that maximizes aggregate profits of sellers and intermediaries satisfies $m^S > \widehat{m}$. If platform effects are strong, we have $m^S > m^*$.*

**Proof.** If $m^S > 0$, $m^S$ is the unique solution to the first-order condition

$$\Pi(m^S) - f(m^S) - c(m^S) + m^S\Pi'(m^S) = 0. \tag{11}$$

Comparing $m^S$ with $m^*$, we obtain that $m^S > m^*$ if platform effects at $m^*$ are positive, i.e.,

$$\frac{m^*\Pi'(m^*)}{\Pi(m^*)} = \frac{m^*z'(m^*)}{z(m^*)} + \frac{m^*\pi'(m^*)}{\pi(m^*)} > 0.$$

This necessarily holds if platform effects are strong. We have $m^S < m^*$ if the reverse inequality holds.

Comparing $m^S$ with $\widehat{m}$, we obtain that $m^S > \widehat{m}$ if

$$\Pi(\widehat{m}) - f(\widehat{m}) - c(\widehat{m}) + \widehat{m}\Pi'(\widehat{m}) > 0.$$

This necessarily holds if platform effects are weak. We have $m^S < \widehat{m}$ if the reverse inequality holds. This holds trivially if platform effects are very strong. ■

An immediate implication of the lemma is that $m^S > m^M$: since the monopolist does not extract all of the surplus from the sellers, he has less incentive to develop the platform than if he obtained all of the surplus. If on the contrary all sellers were homogeneous (i.e., if $f$ were

[11] Formally, the reason is that marginal welfare is greater than the marginal aggregate profits of sellers and intermediaries. Note that this implies that $m^W > m^S$, independently of whether or not the welfare function is single-peaked.

constant), the monopolist would absorb all of the sellers' surplus, and so $m^S = m^M$. Note also that the profit-maximizing platform size $m^S$ would be implemented in equilibrium by a monopoly platform owner if he were able to perfectly price discriminate between sellers (i.e., if the rental charge $r$ could be conditioned on the seller's type $\mu_s$).

*Welfare Ranking of Ownership Structures.* We obtain a (partial) welfare ranking of ownership structures by comparing the platform size $m^S$ that maximizes aggregate profits of sellers and intermediaries with the equilibrium platform size under the different ownership structures.

**Proposition 5** *Consider the set of admissible ownership structures $\{O, C, M, OI, CI\}$. If platform effects are weak, ownership structure $C$ can never be socially preferred, and is dominated by $M$, while all other ownership structure may be socially preferred. If platform effects are strong, $M$ is socially preferred, while all other ownership structures yield the same welfare.*

**Proof.** Recall that welfare is monotonically increasing in $m$ on the interval $[0, m^S]$. To show the first assertion of the proposition, note that $m^W > m^S > m^M > \widehat{m}$ if platform effects are weak. In this case, we have $m^C = \widehat{m}$, and so welfare is higher under $M$ than under $C$. To show the second assertion of the proposition, observe that, if platform effects are strong, all ownership structures other than $M$ induce the same platform size, namely $m^*$. However, in this case, $m^* < m^M < m^S < m^W$, and so $M$ dominates all other ownership structures. ■

The only ownership structures that may induce an equilibrium platform larger than $m^S$ are the open and vertically integrated ownership structures, $OI$ and $CI$, and this only if platform effects are weak. However, the closed vertically-integrated ownership structure $CI$ may induce a socially excessive platform size if the free-entry constraint is binding, i.e., if $m^{CI} = m^*$; otherwise, $m^{CI} < m^S$.[12] Under ownership structures $C$ and $M$, the induced equilibrium platform size is smaller than $m^S$. If platform effects are weak, the open ownership structures $O$ and $OI$ (and possibly $CI$) induce the largest platform size (amongst the admissible ownership structures). In this case, ownership structure $M$ or $CI$ can be socially preferable to $O$ (and $OI$) only if the platform size under $O$ (and $OI$) is socially excessive.

Note that if $\pi$ is independent of $m$ (i.e., if there is no competition effect), as is typically assumed in the literature on two-sided markets (e.g., Rochet and Tirole, 2003; Armstrong, 2004), the platform size under any ownership structure is always socially insufficient.[13] Note also that in the CES example with $b = \beta - 1$, one can show that platform size under any ownership structure is always socially insufficient, unless platform effects are very weak. Under very weak platform effects, there are parameter constellations such that $O$ (and $OI$) induce a socially excessive platform size; furthermore, there are parameters such that $M$ is socially preferred to $O$ (and $OI$).[14]

For competition policy, three important sets of questions arise. First, given that platform ownership is closed (respectively, open), should the platform better be owned by independent intermediaries or by the sellers? This question is answered in the following corollary.

[12] To see this, note that if $m^{CI} < m^*$, either $m^{CI} = 0$, or else $m^{CI}$ is given by $\Pi'(m^{CI}) = 0$. In the latter case, the free-entry constraint is non-binding, i.e., $\Pi(m^{CI}) - f(m^{CI}) - c(m^{CI}) > 0$, and so $m^{CI} < m^S$.

[13] To see this, note that if $\pi$ is constant, we necessarily have $m^* < m^S$. The claim then follows from proposition 4.

[14] However, in this particular example, $CI$ cannot lead to a socially excessive platform size.

**Corollary 1** *Under closed platform ownership, vertical integration weakly increases welfare, $W(m^C) \leq W(m^{CI})$, where the inequality is strict if and only if platform effects are weak, but not very weak. Under open platform ownership, vertical integration has no effect, $W(m^O) = W(m^{OI})$.*

The second question of interest is the following: given that the platform is owned by independent intermediaries (respectively, the sellers), should the incumbent owners be allowed to exclude potential entrants? This question is addressed in the following corollary.

**Corollary 2** *Exclusion of potential entrants has welfare effects only if platform effects are weak. If platform effects are very weak, exclusion is socially harmful: $W(m^C) < W(m^O)$ and $W(m^{CI}) \leq W(m^{OI})$. If platform effects are weak, but not very weak, the welfare effects of exclusion are ambiguous.*

Third, given that the seller side is fragmented, is horizontal integration necessarily harmful from a social point of view? As proposition 4 indicates, the answer is "no": horizontal integration is beneficial to welfare if platform effects are strong. Importantly, this efficiency defense for monopoly intermediation is not based on cost efficiency but on internalization of demand externalities.

# 7 Discussion and Conclusion

Intermediaries figure very importantly in the formation of two-sided markets. In this paper, we have developed a general theoretical framework of a trading platform with two-sided network effects, which allows for intermediated and non-intermediated trade. We have shown that the ranking of ownership structures by induced platform size (or product diversity) and welfare crucially depends on the strength of network or platform effects. If platform effects are strong, equilibrium platform size under monopoly ownership is larger than under dispersed ownership. In this case, all ownership structures induce a socially insufficient product diversity, and monopoly is the socially preferred ownership structure. In contrast, if platform effects are weak, monopoly ownership induces a smaller platform than an open ownership structure. In this case, only an open or vertically integrated ownership structure may induce a socially excessive product variety. Moreover, we have shown that vertical integration may be welfare-enhancing. Further, exclusion of potential entrants by incumbent platform owners may increase welfare. Finally, we have shown that the stability of an ownership structure also crucially depends on the strength of platform effects. If platform effects are strong, only monopoly ownership is stable. In contrast, if platform effects are weak, vertically integrated ownership structures may emerge.

In the remainder of this section, we first describe in detail three real-world examples (out of many possible) to which our analysis applies, and then briefly discuss possible re-interpretations and extensions of our model. The three examples we consider are retail market platforms; ports and airports as platforms for the exchange of goods; and stock exchanges. The examples serve two purposes: to show that the examples can be well described by our general theoretical framework, and to show that our analysis covers the relevant platform ownership structures.

*Real-World Examples.* A striking example of a platform with dispersed ownership is a city's downtown retailing district. In a great number of instances, landlords occupy single lots and offer space to one retailer. This corresponds to open platform ownership. In some instances, the sellers are also the owners of their retail space, which corresponds to vertically integrated platform ownership. In both cases, the assumption that the costs of providing such space are non-decreasing in the number of slots can be justified as follows: the worse the location of a retail slot, the larger the costs that have to be incurred to make the slot as attractive to consumers as a better located slot.[15] We may expect that in most downtown shopping districts, actual sellers' profits are declining in the number of rival retailers: a large number of office workers need to travel to the city center for work, and so nearby shops may be visited by many customers even if the retailing district does not offer a large variety. This suggests that platform effects are weak in downtown retailing districts. An example for monopoly platform ownership in the retailing market is the shopping mall operated by a shopping center developer. Most shopping malls are located outside of cities, and many consumers travel to them only if they offer a sufficiently large variety of retailers. Moreover, a shopping center developer actively selects retailers and adjusts rental contracts to internalize externalities.[16] This suggests that platform effects are stronger for shopping malls than for downtown retailing districts.

Our second example concerns ports and airports in which the platform consists of physical and time slots. Our assumption of increasing development costs is naturally satisfied, as the development of port or airport facilities naturally starts at the least cost location and continues with higher cost locations. Most airports and many ports are operated by a monopoly platform owner. However, there are some ports such a Bremen in Germany in which ownership is dispersed.

Our third example concerns stock exchanges. A stock exchange provides liquidity to companies and investment opportunities to investors. Companies are attracted by exchanges with many investors and investors are attracted by an exchange on which many stocks are traded. Companies have to pay a fixed fee to be listed on the exchange. Some stock exchanges are owned by an outsider; this corresponds to monopoly ownership. Other stock exchanges such as the NYSE are jointly owned by the market makers. In particular, on the NYSE, each specialist market maker handles a small number of stocks and there is a positive relationship between the number of stocks and the number of specialists on the platform. Therefore, the NYSE can be seen as an example of a fragmented, non-integrated ownership structure which fits quite well into our framework.

[15] If the cost is incurred by the seller, the rental price paid to the landlord has to be adjusted accordingly.

[16] In our framework, consumers care only about the number of sellers on the platform, and all sellers impose the same externality on all other sellers. In the real world, however, some sellers may impose greater externalities on rival sellers than some other sellers (e.g., by offering complementary rather than substitute products). To the extent that such asymmetries between sellers exist, a monopoly platform owner may be in a better position than fragmented ownership structures to select the sellers that impose the greatest externalities on the other sellers. Indeed, there is empirical evidence that the rental pricing scheme of shopping mall developers internalizes some of the externalities between retailers. See, for example, Pashigian and Gould (1998), and Gould, Pashigian, and Prendergast (2002). It is in principle possible to extend our framework to accomodate such differences between ownership structures, namely by parameterizing the variable profit function by the ownership structure's ability to internalize externalities between sellers. However, we feel that such an extension would be more fruitful in the context of a particular example that imposes additional structure on the problem.

*Seller Oligopoly.* In our model, we have assumed that sellers are atomless. However, our reduced-form approach in principle allows for large oligopoly sellers. In this case, the number of sellers is discrete, and so a formal analysis would require taking into account integer constraints (and potential multiplicity of equilibria). The qualitative features of results should carry over to the discrete setting.

*Seller Heterogeneity.* In our model, we have assumed that sellers are heterogeneous only with respect to their fixed costs. Consequently, a seller's profit $k(m, \mu_s) \equiv z(m)\pi(m) - f(\mu_s)$ is additively separable in a common component that is the same for all sellers (and that depends only on platform size), $z(m)\pi(m)$, and an idiosyncratic component, $f(\mu_s)$. However, except for ownership structure $CI$, our positive results do not depend at all on the additive separability. (Observe that assumptions 1 and 2 involve the function $k(\cdot, \cdot)$, but not $z(\cdot)\pi(\cdot)$ and $f(\cdot)$ separately.) The additional structure we have imposed allows us to better interpret the various effects at work.

*Cost Redistribution of Development Costs.* In our model, we have assumed that each intermediary bears the development costs of his slot. However, if platform owners form a cooperative, development costs may be redistributed among them. In this case, if incumbent owners have the right to exclude potential entrants, incumbent owners are more restrictive in admitting additional intermediaries than without cost redistribution because joining owners inflict a negative externality on incumbent owners by increasing the incumbents' fixed costs. If exclusion is not possible, more intermediaries enter the platform than in the absence of cost redistribution, and independent intermediaries make zero profit in equilibrium since cost redistribution makes them homogeneous ex post. Hence, any overprovision of product diversity under open platform ownership becomes more pronounced when development costs are redistributed.

*Transaction Fees.* In a number of instances, intermediaries do not charge a fixed access fee or rental price but a price which depends on transaction volume. A first set of examples can be found in the case of electronic commerce, in particular the information and booking services for passenger flights. Well-known platforms are Expedia, a publicly-owned internet travel agency, and Opodo, a service that is owned and operated by nine leading European airlines (and a travel industry technology provider).[17] Expedia corresponds to our case of a monopoly owner in the sense that control rights are concentrated in the publicly traded firm's board. The case of Opodo, on the other hand, corresponds to a vertically integrated ownership structure.

Our assumption of increasing costs of providing platform slots can be justified by the observation that including more airlines in the service eventually necessitates the re-organization and re-design of the virtual platform. However, Expedia and other independent platform owners charge a fee per transaction.

A second set of examples are card payment systems such as Visa, Mastercard and American Express. American Express corresponds to our case of monopoly ownership in the sense that control rights are concentrated in the publicly traded firm's board. Visa and Mastercard correspond to open platform ownership: the banks, which are the owners of Visa and Mastercard act as financial intermediaries between a seller and a buyer. The relevant price a seller has to pay to her bank is the transaction fee (abstracting from interchange fees between banks).

[17] Similarly to Opodo, Orbitz was founded by five large US airlines.

Here, the intermediary essentially taxes the seller and our reduced-form analysis with a fixed charge does not directly apply.

Is it possible to extend our model to allow for a fee per transaction (rather than a fixed access charge)? If we introduce a transaction fee in our CES example, a seller's profit is of the form $h(s)z(m)\pi(m) - f(\mu_s)$, where $h$ is a decreasing function of the transaction fee (in percent of revenues) $s$. The impact of different ownership structures on platform size can also be analyzed in this case. In the presence of a transaction charge we would expect that platform size under open ownership depends on whether or not ownership is vertically integrated. We believe that this in an interesting avenue for further research. However, since competition in the product market is directly affected by the level of the transaction fee, a reduced-form approach seems less useful and we expect results to be less general.

*Congestion Externalities.* The network effects present in our model could be counteracted by negative congestion externalities. Such externalities often arise in physical markets. But they also come about in virtual markets whenever there are capacity constraints. These externalities can easily be incorporated into our model. Suppose, in particular, that a platform slot is developed at zero cost but that there exists a congestion cost $C(m)$ so that the congestion cost per intermediary is $C(m)/m$. This interpretation is then formally equivalent to the our model with cost redistribution (briefly discussed above).

*Charging Buyers.* Our framework can be extended to include pricing on both sides on the market. For instance, a monopoly platform owner may want to charge buyers for access to the platform. With this additional instrument to generate revenues for intermediaries, the induced platform size under monopoly ownership may be larger than under open platform ownership (without this instrument) even if platform effects are weak. Under dispersed ownership, charging buyers would require the coordination of intermediaries: buyers can only be charged for access if the intermediaries can agree on a charge levied upon buyers and a collection and redistribution mechanism for these charges. If this coordination was successful, the ranking of platform size between open and monopoly platform ownership would depend on the elasticity of platform size with respect to the access charge paid by buyers.

*Competition between Market Places.* An important extension of our framework is to consider competition not only within, but also between platforms. We will analyze this issue in a separate paper (Nocke, Peitz, and Stahl, 2004).

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