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Chicken & egg: competition among intermediation service providers

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We analyze a model of imperfect price competition between intermediation service providers. We insist on features that are relevant for informational intermediation via the Internet: the presence of indirect network externalities, the possibility of using the nonexclusive services of several intermediaries, and the widespread practice of price discrimination based on users' identity and on usage. Efficient market structures emerge in equilibrium, as well as some specific form of inefficient structures. Intermediaries have incentives to propose non-exclusive services, as this moderates competition and allows them to exert market power. We analyze in detail the pricing and business strategies followed by intermediation service providers.

Ultimately we're an information broker. On the left side we have lots of products; on the right side we have lots of customers. We're in the middle making the connections. The consequence is that we have two sets of customers: consumers looking for books and publishers looking for consumers. Readers find books or books find readers.

Jeff Bezos, president and CEO, Amazon.com[1]

1. Introduction

■ In the traditional brick-and-mortar economy, intermediaries often buy and resell goods;[2] now, the development of new technologies for information and communication has brought informational intermediation to the forefront of the "new economy."[3] Informational intermediation consists of services such as search, certification, advertising, and price discovery, as opposed to storage, showrooms, or delivery. In these activities, users have larger expected gains, the larger

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[1] Quoted in Harvard Business School (1998, p. 11).

[2] See, e.g., Diamond (1984), Rubinstein and Wolinsky (1987), and Yanelle (1989).

[3] See Varian and Shapiro (1998) for a general presentation of the economics of information.

the number of users on the other side of the market,[4] a property referred to as indirect network externalities. This is the case, for instance, for individuals visiting a matchmaking (e.g., dating) service, for sellers of goods and services participating in a marketplace, as well as for buyers, because a large number of sellers gives them access to more diversity. Indirect network externalities give rise to a "chicken & egg" problem: to attract buyers, an intermediary should have a large base of registered sellers, but these will be willing to register only if they expect many buyers to show up.

This article proposes an analysis of the intermediation market that accounts for such specific aspects of informational intermediation as network externalities, nonexclusivity of services, and price discrimination. The article makes two contributions. First, it determines the equilibrium market structures that are likely to emerge and characterizes their efficiency properties. Second, it provides a precise description and analysis of the pricing strategies that allow intermediation service providers to protect their business or to gain new business.

More precisely, we investigate an imperfect-competition, Bertrand game between two matchmakers in the presence of indirect network externalities. Matchmakers rely on two pricing instruments: registration fees, which are user-specific and paid *ex ante,* and a transaction fee, paid *ex post* when a transaction takes place between two matched parties. We analyze the case of both exclusive and nonexclusive services, depending on whether users can have their request processed by only one intermediary or by several at the same time; in the latter case, users are said to engage in "multihoming."

Because of network effects and imperfect matching technologies, an efficient allocation may involve only one intermediary serving all users or, with nonexclusive technologies and low costs, both intermediaries serving all users, a situation we call "global multihoming." In our model there always exist efficient equilibria. With nonexclusive services, however, there may also exist an inefficient equilibrium that involves multihoming on one side of the market and single-homing on the other side.[5]

We also characterize the relevant pricing strategies and the maximal profits that can be sustained in equilibrium. Due to indirect network effects, the key pricing strategies are of a "divide-and-conquer" nature, subsidizing the participation of one side (divide) and recovering the loss on the other side (conquer).[6] Exclusivity then implies highly contestable market structures, where all potential profits are eroded in order to protect a monopoly position. With nonexclusive services, it is easier to "divide" but more difficult to "conquer"; intermediaries are then able to avoid fierce price competition and make positive intermediation profits in equilibrium. Moreover, the most profitable market equilibrium may precisely be the inefficient one.

Transaction fees appear to be a powerful weapon for intermediation service providers to gain market shares. To highlight this aspect, we compare our conclusions with the ones obtained when intermediaries are unable to monitor the transactions and thus to impose transaction fees.[7] By and large, ruling out transaction fees raises intermediation profits. In the cases in which global multihoming is efficient, however, transaction fees enable intermediaries to profitably differentiate, one offering low registration but high transaction fees, the other adopting the mirror-pricing policy.

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[4] In the traditional buy-and-resell activity, this externality translates into the potential rationing of demand (see Yanelle, 1989).

[5] Efficiency of the market structure refers here to the magnitude of externalities generated in equilibrium. The model does not consider the possibility of efficiency gains from variety (e.g., different types of intermediation services or technologies); nor does it investigate the distortionary effects of intermediation prices on trade between matched parties. In a more general setting, our efficiency results should then be viewed as characterizing an additional source of inefficiency under multihoming.

[6] See Innes and Sexton (1993) for an application to monopoly pricing, Segal (2001) for an application to mechanism design, and Jullien (2001) for an application to network competition.

[7] A companion article (Caillaud and Jullien, 2001a) sketches some preliminary results in this case, derived from a similar model with simplifying assumptions (see below).

The article is in a large part motivated by the development of Internet-related intermediation, which best fits our assumptions.[8] Many B2B websites provide a bundle of services among which matching is critical. The website esteel.com, for example, records types and characteristics of orders, and connects buyers and sellers who want to trade some given quality of steel with some well-specified properties. Most portals, as well as information-oriented or trade-oriented B2C websites, provide information and matching services, such as search facilities or certification.[9] In these activities, the existence of indirect network effects is widespread and well documented.[10]

Informational intermediation and matchmaking on the Internet are often nonexclusive. A websurfer looking for some specific good or service will usually visit and register with several intermediation service providers to increase his chances of finding a match. Similarly, firms offering various services register with different intermediaries in order to benefit from their different user bases.[11] Exclusivity may sometimes be imposed by intermediaries to ensure that their efforts in processing the users' demands end up with a transaction, or because registration involves the specific building of a profile that the intermediary may consider proprietary. Understanding electronic intermediation markets therefore requires a careful analysis of the role of exclusivity.

Finally, a wide array of pricing strategies is observed in intermediation services on the Internet. The use of flat rates is quite common in e-commerce, but different users and different usages are treated differently. Access to general-purpose portals is free for websurfers, while announcers pay on the basis of click-through, or on priority orders, e.g., access to top-screen banners. Auction websites charge fees that are proportional to the transaction price or even piecewise linear,[12] but sellers also have to pay registration fees that depend on their reserve prices.

So, while the insights of our analysis are of wider applicability, they are of particular relevance for e-commerce.

The article is organized as follows. Section 2 spells out the details of our model of intermediation, the equilibrium concept, and the benchmark case of exclusive services. Section 3 analyzes users' behavior when multihoming is possible. Section 4 discusses the results. In Section 5 we briefly present the results for the case where transaction fees are not available. We conclude in Section 6.

2. A basic model with exclusive services

■ **The framework.** Consider a simple pairwise matching model with two homogeneous populations, labelled $i = 1$ and 2, each consisting of a continuum of mass one of *ex ante* identical agents. For a given agent, there exists a unique matching partner on the other side of the market with whom trade is valuable; the total gross gain from trade between matching partners is normalized to one. Matched partners follow an efficient bargaining process to determine the transaction price, which yields a linear sharing of the total net trade surplus, with a share u_i for the type-i agent and a better bargaining position for type-2 agents: $u_2 \geq 1/2 \geq u_1$ and $u_1 + u_2 = 1$.[13]

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[8] Our analysis has some links with the literature on competing stock exchanges (Admati and Pfleiderer, 1988; Pagano, 1989). In this literature, the indirect network effects translate into a positive feedback effect between volume and liquidity, but there is no price discrimination.

[9] See the study by the University of Austin, at www.internetindicators.com, for a decomposition and evaluation of different types of activities related to the Internet, the survey by *The Economist* on e-commerce for a general presentation, and Kaplan and Sawhney (2000) for a discussion of auction sites and the various types of aggregation.

[10] There are also pecuniary externalities between participants on the same side of the market that can be negative (see Baye and Morgan, 2001) but also positive, for instance for demand aggregators such as mobshop.com.

[11] Nonexclusivity is not specific to Internet-related activities, but rather to the low cost of service per customer. In real estate or retail distribution, for instance, the service may or may not be exclusive depending on the contractual agreement.

[12] The fees on final value at aucland.com are 4%, while at eBay.com they amount to 5.25%, 2.75%, or 1.5% of the transaction price depending on its level.

[13] The net trade surplus between matching partners equals the gross trade surplus minus transaction fees that may be charged by intermediaries (see below).

A given j-agent has zero probability of finding his matching partner by just picking randomly within the i-population. But he can turn to an intermediary endowed with an information technology that can perform matchmaking services. This matchmaker builds a database with the characteristics of the agents who register with it. For each potential matching pair, the information technology identifies the match with probability $\lambda \leq 1$, provided both agents are registered in the database; the search fails otherwise. Hence, if n_i randomly drawn agents of type i register with a matchmaker, a j-agent finds his matching partner with probability $\lambda n_i \in [0, 1]$ through this intermediary. λ characterizes the quality of the matching process, the likelihood that there are no mistakes or errors in registration and data processing. It is related to the intermediary's technology, not to the users' characteristics; in particular, two processes performed by two matchmakers would succeed or fail independently.

Two matchmakers, $k \in \{I, E\}$, compete using the same technology.[14] Each matchmaker has a cost c_i of providing services to (a mass of) one i-agent.[15] We assume that intermediation is efficient: $\lambda > c \equiv c_1 + c_2$.

Intermediaries can observe and verify the types of registered users and whether trade takes place, but not the transaction price; so, they can price discriminate using two pricing instruments. First, matchmaker k can charge each i-user an upfront connection or registration fee p_i^k. We do not restrict registration prices to be nonnegative. A negative price can be the consequence of gifts given to joining members, or the result of the addition of free services to the basic free-of-charge matching service.

Second, matchmaker k can also charge a total transaction fee t^k conditional on the occurrence of trade. The net surplus to be shared among matched partners then becomes $(1 - t^k) \geq 0$.[16] We impose that $0 \leq t^k$, since with negative transaction fees, even agents who are not matched would engage in trade. Our focusing only on the total transaction fee is a consequence of several assumptions: the value of trade between partners is constant and common knowledge, users engage in efficient bargaining, and only the occurrence of trade is observable. Models of efficient bargaining with transferable utility, e.g., a Nash bargaining solution with given weights or a bargaining price that equalizes users' net utilities from bargaining, imply that users' utilities depend only upon the sum of individual transaction fees, that is, upon the total transaction fee.[17] Note also that there is no trade distortion associated with the use of transaction fees: efficiency considerations therefore relate only to the intermediation process, not to the possible trade distortion after a match. Finally, in many instances, transaction fees are difficult to implement because the agents may agree *ex post* to bypass the matchmaker. We will present the analysis of such a situation in the last section.[18]

In equilibrium, the agents' expected surplus from trade must be nonnegative. We thus restrict attention to prices $P^k = (p_1^k, p_2^k, t^k)$, such that

$$\lambda u_i(1 - t^k) - p_i^k \geq 0, \qquad i = 1, 2. \tag{1}$$

[14] See Section 4 for a model of competition with different technologies.

[15] It includes the agent's personal cost and the matchmaker's cost of registration and information processing. In some cases, intermediaries finance themselves through advertising. In these cases, c_i should include the advertising revenue that a customer-i generates. This means that the cost c_i could be negative.

[16] Our basic matching process and the possibility of imposing a transaction fee appear in Yavas (1994). This article, however, does not allow for registration fees and focuses on the competition between a matchmaker and a search market with frictions.

[17] Spelling out a bargaining model with heterogeneous matching pairs and observable transaction prices would introduce more instruments for price discrimination. This would reinforce our conclusions with respect to the efficiency properties of equilibria. The level of sustainable profits would be different, but the impact of price discrimination would be qualitatively similar (see the discussion in Section 4).

[18] Caillaud and Julllien (2001a) presents some results on exclusive services and *ex post* monopoly for the case of perfect and costless matching technologies. But these assumptions deliver some nonrobust conclusions. We focus here on nonexclusive services and will rely on this work when relevant.

□ **Timing and equilibrium.** We analyze a two-stage model. In the first stage, both matchmakers set prices P^k simultaneously and noncooperatively. The resulting price system $P = \{P^I, P^E\}$ is publicly observable. In a second stage, users simultaneously choose which matchmakers (if any) to register with.

Let us assume, for the rest of this section, that matchmakers offer "exclusive services"; that is, for technological or legal reasons, users can register with at most one intermediary.[19] Let $\mathcal{N} = \{n_i^I, n_i^E\}_{i=1,2}$ denote the distribution of agents across matchmakers, with n_i^k the number (proportion) of agents of type i who register with matchmaker k. Let

$$U_i(P, k, \mathcal{N}) = n_j^k \lambda u_i(1 - t^k) - p_i^k,$$

for $j \neq i$, denote the net (indirect) expected utility of an i-agent registering with intermediary k for the prices P and the allocation $\mathcal{N}$. By definition, $U_i(P, \emptyset, \mathcal{N}) = 0$. Similarly, let

$$\pi^k(P^k, \mathcal{N}) = \sum_{i=1,2} n_i^k(p_i^k - c_i) + \lambda n_1^k n_2^k t^k$$

denote matchmaker k's profit from charging P^k given the distribution $\mathcal{N}$.

With a continuum of users on each side of the market, the setting does not exactly correspond to a game. The definitions below are adapted from the standard concept of subgame-perfect equilibrium.[20]

Definition 1. A distribution of users $\mathcal{N}$ is an equilibrium distribution for a price system P if, for all $k \in \{I, E, \emptyset\}$,

$$n_i^k > 0 \Longrightarrow U_i(P, k, \mathcal{N}) = \max_{h \in \{I, E, \emptyset\}} U_i(P, h, \mathcal{N}).$$

A market allocation is a mapping $\mathcal{N}(\cdot)$ that associates to each feasible price system P an equilibrium distribution of users $\mathcal{N}(P)$.

In words, if some i-user registers with k, then he must be as well off as if he had registered instead with the other matchmaker or none. As a function of prices P, $n_j^k(P)$ determines j-users' demand for matchmaker k 's services.

There can be multiple market allocations.[21] Although most of our results do not rely on point predictions about the equilibrium outcome, we will use a mild refinement to focus on reasonable market allocations. This refinement amounts to ruling out increasing demand functions.

Definition 2. A market allocation $\mathcal{N}(\cdot)$ is monotone if $\forall k$, $n_i^k(P^k, P^{-k})$ is nonincreasing in P^k.

Monotonicity is not very restrictive. In particular, it imposes no restriction when, say, p_1^k increases while p_2^k decreases. Monotonicity is implied, for instance, by the selection criterion that requires users to coordinate on a Pareto-undominated allocation (for users only).[22]

[19] This assumption simplifies notation in the following definitions. In the next section, we indicate how to extend the definitions in the more general case.

[20] In models with externalities, Ellison and Fudenberg (2002) study finite approximations of equilibria with a continuum of agents. Their analysis depends upon the assumption that the expected utility from choosing one platform asymptotically depends on the ratio of, say, buyers to sellers; our matching model does not fit this framework, and it would be interesting to see how their approach extends in our framework. Note, though, that our setting is equivalent to a game with one agent on each side of the market, using mixed strategies.

[21] That network externalities are a source of multiplicity of equilibria is a well-known phenomenon; see, e.g., Farrell and Saloner (1985), Katz and Shapiro (1985, 1994).

[22] The only caveat is that prices may be viewed as a signal of quality. In our model, the "quality" of the intermediation services depends on the mass of users registering, and so a low price could be perceived as a bad signal, triggering a reduction in demand. But this effect is conceivable only if intermediaries have better information about demand than do consumers when they set prices, which is not the case in our model. We conjecture that a more detailed dynamic process would deliver the monotonicity restriction as a more natural property of equilibrium.

Definition 3. An equilibrium is a pair $(P^*, \mathcal{N}(\cdot))$, where (i) $\mathcal{N}(\cdot)$ is a monotone market allocation and (ii) P^* is a Nash equilibrium of the reduced-form pricing game induced by $\mathcal{N}(\cdot)$, with profits $\pi^k(P, \mathcal{N}(P))$.

Intuitively, an equilibrium consists of a set of prices charged by matchmakers and of a description of how users choose among them for all possible prices. The allocation of users corresponds to a system of demand functions for each matchmaker. Once demand is characterized, the first stage amounts to a classical price-setting game.

It is convenient to interpret this equilibrium concept as a rational-expectation equilibrium where, following the choice of a price system P, each infinitesimal user has expectations about how all other users will allocate among the different matchmakers; in equilibrium expectations are common and fulfilled. We shall use this interpretation repeatedly.

□ **Competition for exclusive services.** As is well known, network externalities induce concentration. When users can register with at most one intermediary and $\lambda > c$, an efficient distribution of users requires all users to register with the same intermediary. We show below that, given the set of pricing instruments, all equilibria are efficient; that is, they all involve only one active matchmaker, say I, on the equilibrium path. Such equilibria are called "dominant-firm equilibria."

A dominant-firm equilibrium price system (P^I, P^E), if it exists, can always be sustained by a "bad-expectation" (or pessimistic) market allocation against E, that is, by a market allocation such that after any price deviation by E, users coordinate on an equilibrium distribution with zero market share for E, whenever possible.[23] So, a dominant-firm equilibrium must be such that no pricing strategy allows E to earn a positive profit, when users have pessimistic beliefs against E.

Given $P = (p_1^I, p_2^I, t^I, p_1^E, p_2^E, t^E)$, there exists a bad-expectation distribution of users against E, with $n_i^E(P) = 0$ and $n_i^I(P) = 1$, as long as

$$\lambda u_i(1 - t^I) - p_i^I \geq -p_i^E, \qquad i = 1, 2. \tag{2}$$

Under (2), users have no incentives to register with E when they expect all others to register with I. To get a positive market share despite pessimistic beliefs, E must adopt a divide-and-conquer strategy (hereafter, DC strategy). First, E must subsidize one group, say, divide i-users:

$$p_i^E < p_i^I - \lambda u_i(1 - t^I) \leq 0. \tag{3}$$

The distribution of users must then be such that $n_i^E = 1$. Second, E extracts part of the ensuing externality benefits on the other group; it conquers j-users, with:

$$p_j^E + \lambda u_j t^E < \lambda u_j + \inf\left\{p_j^I, 0\right\}, \tag{4}$$

since j-users rationally expect all i-users to register with E. Note that the revenue from the transaction fee on i-users, $\lambda u_i t^E$, does not appear, so that it is optimal for E to set the transaction fee at its maximal level $t^E = 1$.

To deny E an active participation in the market, I's pricing strategy must be designed so that no such DC strategy for E is profitable. The proposition below follows straightforwardly.[24]

Proposition 1. With exclusive intermediation services, the only equilibria are dominant-firm equilibria, where one intermediary I captures all users, charges the maximal transaction fee ($t^I = 1$), subsidizes registration, and makes zero profit ($p_1^I + p_2^I = c - \lambda$).

[23] More generally, in a bad-expectation market allocation, users coordinate on a distribution that yields minimal profits for E (see footnote 28).

[24] We refer the reader to Caillaud and Jullien (2001a, 2001b) for a detailed discussion of DC strategies and dominant firm equilibria in the case of exclusive services. The present article only takes this proposition as a benchmark result.

Proof. See the Appendix.

The efficiency property of all equilibria is due to a tension between monotonicity and the nature of DC strategies. With high transaction fees, intermediaries have an incentive to attract more customers by undercutting slightly the registration fees, so as to raise the number of transactions. On the other hand, low transaction fees imply relatively high registration fees, which raises the profitability of DC strategies.

The intuition for the zero-profit property runs as follows. In a dominant-firm equilibrium, the inactive matchmaker could deviate and offer to pay all users, through registration subsidies, slightly more than their expected surplus with the active matchmaker. This deviation attracts all users, independently of their beliefs, and generates maximal aggregate surplus $\lambda - c$. Then, a maximal transaction fee enables the deviating matchmaker to capture this maximal aggregate surplus minus the users' surplus in the candidate equilibrium. In equilibrium, such a deviation cannot be profitable. Hence consumers must receive the total surplus, and the dominant firm cannot make a strictly positive profit. Finally, the transaction fee is maximal, as it is in the dominant firm's best interest to design registration fees that are the most attractive for its customers even when they hold pessimistic beliefs against this matchmaker.

In a model with sequential entry, Proposition 1 characterizes the highest-profit, entry-deterrence equilibrium. In the absence of any fixed cost of entry, users' beliefs constitute the key factor that determines entry barriers. The incumbent monopolizes the market but has to abandon all profits in order to deter entry: the market is highly "contestable."

3. Multihoming

■ As argued in the Introduction, intermediation services, in particular Internet-based services, are usually not exclusive. Moreover, even when it applies, exclusivity often results from a choice by intermediation providers based on their evaluation of competition with nonexclusive services. This section therefore assumes that users can use the services of both matchmakers simultaneously: they can engage in "multihoming."

We assume that the matching processes performed by the two matchmakers are independent. So when j-users engage in multihoming, an i-user may have two motives to do so instead of registering with I only. First, it increases the probability of a match by $(1-\lambda)\lambda$, that is, by the probability that E performs the match while I doesn't; and second, in the case of a double match, that is, with probability λ^2, the i-user can save on transaction fees because he can conclude the transaction via the intermediary that imposes the lowest transaction fee and pay only $u_i \min\{t^I, t^E\}$. Note that the first effect corresponds to a net efficiency gain for the economy as a whole, while the second effect has no impact on efficiency.[25]

As suggested above, there can be two types of efficient allocations, depending on whether or not, once all agents have registered with one intermediary, it is efficient that they also register with the other. A market allocation is now defined as $\mathcal{N} = \{n_i^I, n_i^E, n_i^M\}_i$, where n_i^k is the mass of i-users registering with k only (single-homing) and n_i^M is the mass of users registering with both I and E (multihoming). When $\lambda(1-\lambda) < c$, efficiency requires single-homing ($n_i^I = 1$ for all i); but when $\lambda(1-\lambda) > c$, global multihoming ($n_i^M = 1$ for all i) is efficient.

We start with a critical analysis of E's best response to prices P^I under pessimistic beliefs. Then we study the existence and the properties of equilibria, gathered in two classes.[26] The first class consists of "pure equilibria," where all agents of one type make the same deterministic

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[25] If the probability of success were correlated across matchmakers, the benefit in terms of the total probability of a match would be smaller, and multihoming would be a less attractive option in terms of efficiency; on the other hand, double matches would be more frequent, implying tougher price competition in transaction fees. The nature of the analysis, however, would be similar.

[26] We adjust the equilibrium concept for the fact that multihoming is possible and we maintain the monotonicity requirement on single-homing users, i.e., on n_i^k for $k = I, E$.

choice: they all register with I only, or with both I and E. The second class consists of "mixed equilibria," where some *ex ante* identical agents end up making different choices *ex post*.[27]

□ **Best-response analysis.** We first analyze E's best response to P^I under pessimistic beliefs.

Let $r_i^k \equiv p_i^k + \lambda u_i t^k$ denote the maximum revenue that can be extracted by k from i-users. Expecting all other users to register with I, a given i-user prefers to register with I instead of E if (2) holds; moreover, he prefers to register with I only, instead of registering with both I and E, whenever $p_i^E \geq 0$, since multihoming then involves only this additional registration charge. A profitable entry strategy for E must be a DC strategy, where a group of i-users enjoys registration subsidies: $p_i^E < 0$. The difference with the case of exclusivity is that here, any negative price $p_i^E < 0$ induces i-users to register with E as a "second home," to cash in the subsidy, while still maintaining their registration with I if they expect j-users, for $j \neq i$, to register with I.

Even with $p_i^E < 0$, bad expectations may still prevent E from making a positive profit.[28] This occurs if j-users still register with I and not with E, while i-users engage in multihoming. Then, E cannot earn revenues from j-users' registrations and does not process any transaction. Given (P^I, P^E), $n_j^I = n_i^M = 1$ is an equilibrium distribution of users if

$$r_j^E \geq r_j^I, \tag{5}$$

$$r_j^E \geq \lambda(1-\lambda)u_j + \lambda^2 u_j \max\{t^I, t^E\}. \tag{6}$$

By (5), j-users prefer I to E because they are charged lower total expected fees; by (6), they do not themselves engage in multihoming because the additional expected charge is larger than the sum of the benefits from multihoming. Dividing i-users is almost costless, but E's surplus from conquering j-users is limited by

$$r_j^E < \max\left\{r_j^I; \lambda(1-\lambda)u_j + \lambda^2 u_j \max\{t^I, t^E\}\right\}. \tag{7}$$

$p_i^E < 0$ and (7) induce all users to register with E. Whether or not they also register with I determines the profitability of E's pricing strategy. Hence, we have three possible DC strategies for E:

(i) E as a "second source": E charges $t^E \geq t^I$, users engage in multihoming, and they conclude the transaction via I, in case of a double match. E processes the transaction only when the match has failed at I.[29]

(ii) E as a "first source": E charges $t^E < t^I$, users engage in multihoming, and E processes the transaction whenever it performs the match.

(iii) E as a "sole source": all matches take place through E, since at least one population of users does not register with I.

Note first that the profit as a second source is bounded from above by $\lambda(1-\lambda) - c$, the total additional surplus generated by multihoming. When multihoming is not efficient, a second-source strategy cannot be profitable. When multihoming is efficient, slightly negative registration fees and a maximal transaction fee allows E to earn a profit $\lambda(1-\lambda) - c$ (almost) equal to this upper bound.

In the alternative strategies, E processes all transactions after a successful match. Intuitively, being a first source should be chosen whenever possible, as this is less demanding than acting as a sole source. Under $p_i^E < 0$ and (7), a first-source strategy is feasible if and only if there exists

[27] Our model is formally equivalent to a game with one agent of each type (and two intermediaries) choosing within a set of four pure strategies: register with I, register with E, register with both, or register with none. The labels pure and mixed correspond to pure-strategy equilibria and mixed-strategy equilibria in such a game.

[28] According to the broad concept of bad-expectation market allocation mentioned in footnote 23, we pick a distribution that yields the lowest profits for E.

[29] If $t^I = t^E$, we say that both intermediaries are a second source, as they would be treated in the same way by customers considering multihoming.

$t^E < t^I$ such that all users engage in multihoming. Then, multihoming is a market allocation if no user of type h prefers registering with E only: for all h,

$$r_h^I \leq \lambda(1-\lambda)u_h + \lambda^2 u_h \max\{t^I, t^E\}.$$

Let us define below a measure z^I of the minimal surplus for any user of using I as a second source: formally,

$$z^I \equiv \min_h \{\frac{\lambda(1-\lambda)u_h + \lambda^2 u_h t^I - r_h^I}{\lambda^2 u_h}\}.$$

Users engage in multihoming if and only if $\max\{t^I, t^E\} \geq t^I - z^I$. E being a first source requires that $t^E \leq t^I$ and consequently is possible only if $z^I \geq 0$. If $z^I < 0$, the only alternative to being a second source for E is to act as a sole source; then E can charge a transaction fee t^E as high as $t^I - z^I$.

The next proposition characterizes E's best response among all three DC strategies.

Proposition 2. Under pessimistic beliefs, E's best response to prices P^I (if E sells) is one of two strategies:

(i) If $z^I \geq 0$, E adopts a first-source strategy with $t^E = t^I$ or a second-source strategy;
(ii) If $z^I < 0$, E adopts a sole-source strategy with $t^E = t^I - z^I$ or a second-source strategy.

The profit as a sole or first source is $\pi^F = \lambda(1-\lambda)u_2 + \lambda(u_1 + \lambda u_2)t^E - c$. The profit as a second source is $\lambda(1-\lambda) - c$.

Proof. See the Appendix.

Note that $\pi^F > \pi^{SS}$ if and only if $t^E > (1-\lambda)u_1/(u_1 + \lambda u_2)$. Thus the best response is determined by the highest transaction fee among t^I, $t^I - z^I$ and $(1-\lambda)u_1/(u_1 + \lambda u_2)$; if t^I or $t^I - z^I$ is the highest, t^E is set equal to this level, and in the last case, t^E is maximal. E can improve on being a second source if I's transaction fee is high. Whether it will do so as a sole source or a first source depends on the level of I's registration fees (through the term z^I).

□ **Pure equilibria.** Pure equilibria are such that users of the same population all make the same choice. They correspond either to equilibria that involve global multihoming ($n_1^M = n_2^M = 1$) or to dominant-firm equilibria ($n_1^I = n_2^I = 1$). If an efficient equilibrium exists, it must necessarily be a pure equilibrium. Conversely, the intuition provided in the previous subsection suggests that if there exists a pure equilibrium, it must necessarily be efficient.

Proposition 3. The market allocation of a pure equilibrium is efficient.

Proof. If $\lambda(1-\lambda) > c$, a dominant-firm equilibrium cannot exist, since the inactive firm can profitably use a second-source strategy and make a profit (almost) equal to $\lambda(1-\lambda) - c > 0$ with a small registration subsidy to all users and a maximal transaction fee. If $\lambda(1-\lambda) < c$, a global multihoming equilibrium cannot exist, since at least one firm would be a second source and would make losses. *Q.E.D.*

For a given set of parameters, there can only be one type of pure equilibrium.[30] As we shall see below, this uniqueness and efficiency property is a consequence of the possibility of charging transaction fees. In the rest of this subsection, we prove that efficient equilibria do actually exist and that they may involve positive profits for the active firms.

We first focus on global multihoming equilibria when $\lambda(1-\lambda) > c$. A firm can secure a profit at least equal to $\lambda(1-\lambda) - c$ by relying only on its transaction fee (with small registration subsidies). Existence should therefore not be an issue. This also suggests that equilibrium profits should be equal to the marginal contribution of each firm to total surplus, that is, to $\lambda(1-\lambda) - c$. This intuition turns out to be wrong; it would be valid only if in equilibrium $t^I = t^E$ (= 0 by

[30] We will not consider the limit case $\lambda(1-\lambda) = c$.

monotonicity with respect to transaction fees). But if $t^I < t^E$, registering with I in addition to E allows one user to reduce his transaction payment by an expected amount $\lambda^2(t^E - t^I)$ compared to the option of single-homing with E. This means that I contributes to the users' surplus by more than $\lambda(1-\lambda) - c$. This translates into higher equilibrium profits.

Proposition 4. A global multihoming equilibrium exists if and only if $\lambda(1-\lambda) > c$; the highest-profit equilibrium is characterized by $t^I < t^E$ and profits π^I and π^E such that

$$\pi^I = \lambda(1-\lambda) + \frac{\lambda^2(1-\lambda)u_1}{\lambda u_2 + u_1} - c > \pi^E = \lambda(1-\lambda) - c.$$

Proof. See the Appendix.

The maximal-profit, global multihoming equilibrium is not symmetric: matchmakers play different roles. Firm I sets a low transaction fee and acts as a first source of intermediation, that is, as the provider through which transactions are implemented whenever possible, while E sets a high transaction fee and acts as a second source, concluding transactions between trading partners who have not been matched elsewhere. Overall E is cheaper in terms of registration fees for both categories of users, but once registered with E, all users are still willing to register with I because this allows them to save on the transaction fee if they are matched. The equilibrium configuration exhibits endogenous differentiation between the matchmakers.

Assuming $\lambda(1-\lambda) < c$, let us now study whether dominant-firm equilibria exist, with I as the dominant firm. The next proposition proves existence and characterizes the level of profit that can be sustained in a dominant-firm equilibrium.

Proposition 5. A dominant-firm equilibrium exists if and only if $\lambda(1-\lambda) \leq c$. The highest equilibrium profit π^{DI} is such that

$$\pi^{DI} = \frac{(\lambda - c)}{u_1 + \lambda u_2}(1-\lambda)u_1 \leq c.$$

Proof. See the Appendix.

Any profit that can be attained in a dominant-firm equilibrium can be supported by strategies with a zero transaction fee, $t^I = 0$: matchmaker I does not have to impose a transaction fee to make a profit, registration fees are sufficient. This contrasts with the results under exclusivity. Indeed, under exclusivity, the dominant firm protects its market share by making it costly for E to divide. With multihoming, E can easily divide through small registration subsidies; so, I must reduce the benefits for E of conquering. This is best achieved by setting a low transaction fee, which ensures that E's services are used only as a second source in case of multihoming.

With $t^I = 0$, entry with multihoming cannot be profitable for E (because $\lambda(1-\lambda) \leq c$). The dominant firm only has to prevent entry of E as a sole source. This is easier than in the case of exclusivity: I just has to set its prices so that global multihoming prevails whenever entry occurs. The highest attainable profit is then strictly positive.

□ **Mixed equilibria.** With nonexclusive services, mixed equilibria can emerge where users of the same type make different choices. These equilibria must, however, involve "some multihoming," in a sense made precise by the next proposition.

Proposition 6. When intermediation services are not exclusive, there do not exist equilibria with two active firms ($n_i^I > 0$ and $n_i^E > 0$) and no multihoming ($n_1^M = n_2^M = 0$) if $c \neq \lambda/2$ (that is, generically).

Proof. See the Appendix.

On the equilibrium path, the distribution of users must involve multihoming by at least one group, say i-users.[31] Users of the other group (j-users) are single-homing users who register with only the least costly intermediary (by monotonicity). In equilibrium, matchmakers charge single-homing users identical total prices: $p_j^I + \lambda u_j t^I = p_j^E + \lambda u_j t^E$. Moreover, monotonicity implies that reducing p_j^k so as to attract more single-homing users and to generate more transactions is not profitable, which amounts to

$$p_j^k + \lambda t^k \leq c_j. \tag{8}$$

Hence matchmakers make losses (or zero profit) on single-homers. But for a given quality of the matching process, the additional benefit of registering with an additional matchmaker must be smaller, for j-users, than the corresponding additional price; otherwise, j-users would rather engage in multihoming. It follows that if costs are trivial, no market-sharing equilibrium (that is, with $n_i^M = 1$, $n_j^I > 0$ and $n_j^E > 0$) exists.

Proposition 7. For a fixed $\lambda < 1$, a market-sharing equilibrium does not exist when the costs are close to zero.

Proof. See the Appendix.

Note, however, that when the matching process is almost perfect, the additional benefit of multihoming is small and, for given costs, a market-sharing equilibrium may exist, as shown in Proposition 8 below.

Monotonicity has no bite with respect to registration fees charged to multihoming users. Therefore, a high registration fee p_i^k for multihoming users and potentially high profits can be supported in equilibrium. The following proposition takes into account all other possible deviations.

Proposition 8. Fix all parameters except λ and assume that $c_i/u_i \leq c_j/u_j$. There exists a market-sharing equilibrium for λ close to 1 if and only if $1 - c > c_i/u_i$. Under this sufficient condition, the maximal aggregate profit is attained in a symmetric market-sharing equilibrium with $n_i^M = 1$, $n_j^I = n_j^E = 1/2$, and $t^I = t^E = 0$, and it is approximately equal to

$$\inf\left\{\frac{u_i}{u_j}c_j - c_i, \frac{u_i}{1+u_i}\left(1 - \frac{c_i}{u_i} - c\right)\right\}.$$

Proof. See the Appendix.

In equilibrium, matchmakers' equilibrium profits and users' equilibrium surplus depend only upon the total prices charged to users. Positive transaction fees, however, leave room for potentially profitable deviations, e.g., first-source deviations for users who want to save on transaction fees. Therefore, in equilibrium, matchmakers extract the multihoming users' surplus through registration fees, and the transaction fees can be set equal to zero.

To provide a better intuition for Proposition 8, set $\lambda = 1$ and focus on symmetric equilibria with zero transaction fees. Monotonicity implies $p_j \leq c_j$. The multihoming users' matching surplus is equal to u_i, which matchmakers could jointly extract with $p_i = u_i/2$. With this price structure, second-source deviations fail, since all matches are performed by both matchmakers and trade is concluded at the lowest transaction fee. There is no scope for first-source deviations either. Setting $p_i^E = p_j^E$ slightly negative, however, enables a deviating firm to attract both sides of the market, and, setting $t^E < \max\{p_i/u_i, p_j/u_j\}$, E becomes a sole source; for, in this case, even if all users anticipate that their matching partner registers with I, at least one group has an incentive to register only with E, where their expected surplus is larger. This sole-source strategy

[31] More precisely, this group of i-users engages in some multihoming; in limit cases, equilibria can be such that i-users are indifferent between registering with I only, with E only, or with both. We omit the analysis of these cases.

is profitable against $p_i = u_i/2$ and $p_j = c_j$. To prevent such a deviation in equilibrium, the matchmakers must leave more surplus to the group of users with the largest price-to-utility ratio and therefore, depending on the parameters, either extract only part of the multihoming users with $p_i < u_i/2$, or price access below marginal cost for single-homing users ($p_j < c_j$).

Note that for $\lambda = 1$, the maximal profit in a dominant-firm equilibrium is zero. So, when the value of the intermediation services is large, an intermediary prefers to share the market in a market-sharing equilibrium rather than being either the dominant firm or the entrant in a dominant-firm equilibrium.

4. General discussion and extensions

■ This section discusses the implications of the previous results.

□ **Efficiency.**[32] When matchmakers provide undifferentiated exclusive intermediation services, competition yields an equilibrium with an efficient market structure that involves monopolization. When all services are nonexclusive, an efficient equilibrium always exists; but there may also exist inefficient equilibria where matchmakers induce multihoming by some users.[33]

□ **Intermediation profits.** Under exclusive services, the market is highly contestable with low (vanishing) profits. Nonexclusivity, however, induces a less severe degree of competition and allows positive profits in any type of equilibrium.[34] When multihoming is efficient, each matchmaker appropriates at least the marginal social benefit of allowing multiple registration. When single-homing is efficient, the dominant matchmaker's profit is bounded from above by the total marginal cost of intermediation. Inefficient equilibria yield larger profits than those in a dominant-firm equilibrium when the matching process is very efficient.

□ **Consumer welfare.** The consumers' welfare under exclusivity equals $\lambda - c$. It can easily be seen that the consumers' welfare is higher under exclusive services than in any equilibrium with nonexclusive services.[35] Thus, from the total consumers' welfare perspective, exclusivity is the best alternative even though it results in lower efficiency.

□ **Exclusivity choice and entry.** Suppose we consider a preliminary stage where matchmakers could freely and noncooperatively choose whether to let users who register with them also register with their opponent. Exclusivity can be imposed unilaterally. In our model, exclusivity exacerbates competition between intermediation service providers and forces profits down to zero, while nonexclusivity allows a whole range of strictly profitable equilibria. So, in equilibrium, matchmakers would choose to allow for multiple registration.

When firms can choose to be exclusive, a more interesting question is: To what extent will established firms use exclusivity to deter entry? To discuss this issue, let us consider a situation with two periods. In the first, firm I with quality λ^I enters and commits through irreversible technological choices to be exclusive or not. In the second period, a potential entrant appears, with quality λ^E drawn randomly from a common knowledge distribution. The entrant decides to enter or not, and whether to be exclusive or not in case of entry. Then firms make pricing decisions, given their exclusivity choices and their respective quality parameters. For simplicity, let us assume both firms incur a cost c. Then the questions are: Will I choose to be exclusive? When does E enter, and how?

[32] Efficiency refers to the market structure. In particular, we do not introduce the possibility that transaction taxes could have a distortionary effect on trade between matched agents.

[33] In this form, these conclusions apply to the case of $K > 2$ matchmakers (proof available upon request).

[34] These conclusions also extend to the case of K identical intermediaries.

[35] In global multihoming equilibria, the total profit is at least $2\lambda(1 - \lambda) - 2c$, so that the total consumers' welfare is at most λ^2, which is smaller than $\lambda - c$ under the assumption that $\lambda(1 - \lambda) > c$.

For the sake of brevity we make restrictive assumptions that could be relaxed: we assume that only pure equilibria can emerge and that, in a global multihoming equilibrium, E is second source (as a newcomer). E enters only if its profit is positive.

(i) Under exclusivity, firm E will be active if and only if $\lambda^E > \lambda^I$, capturing the whole market with equilibrium profit $\lambda^E - \lambda^I$ (assuming that I does not play a weakly dominated strategy).[36] In particular, if I chooses to be exclusive, entry occurs only when $\lambda^E > \lambda^I$, but I loses the market in this case.

(ii) Suppose now that I chooses to be nonexclusive. This reduces barriers to entry and entails a cost for I, as entry now may occur for $\lambda^E < \lambda^I$. But at the same time, when $\lambda^E > \lambda^I$, I may remain active if E chooses nonexclusivity and if a global multihoming equilibrium prevails.

Let $\Pi_I^{ss} = \lambda^I(1-\lambda^E)-c$ and $\Pi_E^{ss} = \lambda^E(1-\lambda^I)-c$ denote the second-source profits of I and E respectively.[37] For $\lambda^E > \lambda^I$, E prefers nonexclusivity with a global multihoming equilibrium to exclusivity whenever $\Pi_E^{ss} > \lambda^E - \lambda^I$, which is equivalent to $\Pi_I^{ss} > 0$. Moreover, when $\Pi_I^{ss} > 0$ and $\Pi_E^{ss} > 0$, the unique equilibrium under nonexclusivity precisely involves global multihoming. This implies that when $\lambda^E > \lambda^I$, a global multihoming equilibrium with nonexclusive services emerges if $\Pi_I^{ss} > 0$, while E enters and becomes the only active matchmaker otherwise.[38]

Assume first that $c > \lambda^I(1-\lambda^I)$. Then $\Pi_I^{ss} > 0$ is incompatible with $\lambda^E > \lambda^I$, and so I loses the market whenever $\lambda^E > \lambda^I$. So I would rather concentrate on the case where $\lambda^E < \lambda^I$ and choose to be exclusive.[39]

Now assume $\lambda^I(1-\lambda^I) > c$. Then E will enter as a second source when $\inf\{\Pi_I^{ss}, \Pi_E^{ss}\} > 0$, which reduces to $\lambda^E \in (c/(1-\lambda^I), (\lambda^I - c)/\lambda^I)$, and as a sole source if $\lambda^E > (\lambda^I - c)/\lambda^I$.[40] Choosing nonexclusivity over exclusivity yields for I a net minimal gain equal to

$$\Pr\left\{\lambda^I < \lambda^E < \frac{\lambda^I - c}{\lambda^I}\right\} E\left\{\Pi_I^{ss} \mid \lambda^I < \lambda^E < \frac{\lambda^I - c}{\lambda^I}\right\}$$
$$- \Pr\left\{\frac{c}{1-\lambda^I} < \lambda^E \leq \lambda^I\right\} E\left\{\Pi^M - \Pi_I^{ss} \mid \frac{c}{1-\lambda^I} < \lambda^E \leq \lambda^I\right\},$$

where Π^M denotes the monopoly profit, equal to $\lambda^I - c$. Rearranging, this gain is positive whenever

$$\Pr\left\{\lambda^E > \lambda^I \mid \frac{c}{1-\lambda^I} < \lambda^E < \frac{\lambda^I - c}{\lambda^I}\right\} > E\left\{\frac{\lambda^I\lambda^E}{\lambda^I - c} \mid \frac{c}{1-\lambda^I} < \lambda^E < \frac{\lambda^I - c}{\lambda^I}\right\}.$$

The choice of nonexclusivity over exclusivity only depends upon the distribution of λ^E conditional on the equilibrium under nonexclusivity being global multihoming. I will choose to be nonexclusive if it is more likely to face a more efficient entrant in this range than a less or equally efficient one. For example, when $c = 0$, the condition becomes $\Pr\{\lambda^E > \lambda^I\} > E\{\lambda^E\}$, so that I chooses to be nonexclusive if λ^I is below some threshold.

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[36] We skip the proof, as it follows the same steps as Proposition 1. To fight the entrant, firm I is constrained by $p_1^I + p_2^I \geq c - \lambda^I$, while a dominant-firm equilibrium would require $p_1^I + p_2^I < c - \lambda^I u_i - \lambda^E u_j$ for all $i \neq j$. So when $\lambda^E > \lambda^I$ and with weakly undominated strategies, there is entry with $p_1^E + p_2^E = c - \lambda^I$, $p_1^I + p_2^I = c - \lambda^I$, and the entrant's profit is equal to $\lambda^E - \lambda^I$.

[37] The analysis of pure equilibria under nonexclusivity with different quality parameters is omitted, as it follows steps similar to those in the previous section's analysis.

[38] Whether E chooses to be exclusive or nonexclusive to enter as a sole source may depend on the equilibrium selection under nonexclusivity.

[39] E cannot enter in a global multihoming equilibrium if $\lambda^E < \lambda^I$, since $\Pi_E^{ss} < 0$. But there is the possibility that under nonexclusivity E becomes a sole source if λ^E is smaller but close to λ^I. This follows from the fact that profits are positive in Proposition 5.

[40] If $\lambda^E < \lambda^I$, $\Pi_I^{ss} > 0$, so that E cannot be a sole source, implying that E enters if $\Pi_E^{ss} = \inf\{\Pi_I^{ss}, \Pi_E^{ss}\} > 0$; if $\lambda^E > \lambda^I$, E chooses global multihoming whenever $\Pi_I^{ss} = \inf\{\Pi_I^{ss}, \Pi_E^{ss}\} > 0$.

To sum up, in our simple model of entry, the first mover will choose to enter with exclusive services when the quality of its matching technology is high enough; this enables him to deter entry most of the time and to monopolize the market, but it implies a risk of being driven out of the market if a very efficient entrant appears and captures all the market. When the quality of I's matching is low, however, I will propose nonexclusive services; entry will take place quite often, but when the entrant's quality is not too high, the first mover will still be active on the market. Of course, high-quality entrants will still drive I out by acting as sole sources.

□ **The strategic use of transaction fees.** The impact of transaction fees is quite different between the situations with and without exclusivity. Under exclusive services, matchmakers use transaction fees as an additional instrument to extract profit and overcome consumers' coordination failures. With nonexclusive services, transaction fees can still be used to capture efficiency gains generated by an aggressive registration policy, but a crucial point is the possibility of proposing a smaller transaction fee than the opponent's (in first-source strategies). So in dominant-firm equilibria or in market-sharing equilibria, matchmakers are forced to set zero transaction fees to limit the possibility of profitable deviations. In global multihoming equilibria, however, matchmakers endogenously differentiate, relying on all pricing instruments: one sets a low transaction fee and acts as a first source, the other charges a high transaction fee and captures the benefit of acting as a second source.

5. Competition without transaction fees

■ When transactions do not give rise to physical or monetary exchanges, such as for pure informational intermediation or pure matching, or when they are difficult or costly to monitor, the possibility of using transaction fees is not a reasonable assumption. In this section we investigate how our findings are modified under the restrictive assumption that transaction fees cannot be used. Since we have sketched some of this analysis elsewhere, we provide here only the main results and intuition.[41]

When transaction fees are not feasible, a deviating intermediary has fewer instruments to generate efficiency gains and to capture them. Therefore, larger profit levels can be sustained in equilibrium and other types of equilibria may emerge. With exclusive services and no transaction fees, Proposition 1 is modified as follows:

(i) There may exist inefficient equilibria, where both matchmakers are active and the market is segmented; these equilibria are symmetric and equilibrium profits are null.[42]
(ii) There exist dominant-firm equilibria with positive maximal profits for the dominant firm given by $\lambda \inf\{u_1, u_2 - u_1\}$.

With nonexclusive services, the analysis of best responses is somewhat simpler, since only sole-source strategies matter. Moreover, there is no scope for endogenous differentiation. From the proof of Proposition 4, a firm cannot obtain more than $\lambda(1 - \lambda) - c$ in a global multihoming equilibrium. Whenever this is positive, prices such that $p_i^k = \lambda(1 - \lambda)u_i$ are indeed equilibrium prices. For any other P^E, users register with I (except when monotonicity has some bite). Thus E cannot obtain more than the additional surplus $\lambda(1-\lambda)-c$. Proposition 4 becomes the following:

Proposition 9. Suppose transaction fees are not feasible. A global multihoming equilibrium exists if and only if multihoming is efficient. The equilibrium with maximal profits is symmetric; profits are equal to $\lambda(1 - \lambda) - c$.

As for dominant-firm equilibria, we saw in the discussion of Proposition 5 that transaction fees are not needed for the dominant matchmaker; but they constitute an instrument for entry. So when transaction fees are not available, the entrant has fewer instruments. It can subsidize one

[41] All the proofs are omitted, since they can be found in our working paper (Caillaud and Jullien, 2001b), where transaction fees are restricted to $t \in [0, T]$ for a given T.

[42] However, the market allocation would be unstable (at fixed prices).

group of users and undercut the registration fee for the other group, so as to become a sole source. Its deviation profit is then equal to $\max\{p_1^I, p_2^I\} - c$, and if the dominant matchmaker sets each price equal to the total marginal cost c, no such deviation is profitable. Or, it acts as a second source, subsidizes one group of users, and charges the other group (say, group h) at most the expected benefit from multihoming, $\lambda(1-\lambda)u_h$. When $c \geq \lambda(1-\lambda)u_2$, this strategy is not profitable either. This leads us to modify Proposition 5 as follows:

Proposition 10. Suppose transaction fees are not feasible. A dominant-firm equilibrium exists if and only if $c \geq \lambda(1-\lambda)u_2$. The highest attainable profit for the dominant firm is equal to c.

Note that the argument in Proposition 3 cannot be replicated in the absence of transaction fees. Indeed, the previous result shows that pure equilibria are not necessarily efficient, since for $u_2 \leq c/\lambda(1-\lambda) \leq 1$, a dominant-firm equilibrium exists although multihoming is efficient.

Finally, we sketch the analysis of market-sharing equilibria for the case where $\lambda = 1$. In this case, the same steps as in Proposition 8 show that the highest-profit market-sharing equilibrium is symmetric and involves $p_j \leq c_j$, $p_i \leq u_i/2$, $n_i^M = 1$, and $n_j^k = 1/2$. Now, consider indeed the candidate equilibrium: $p_i = u_i/2$ and $p_j = c_j$. A deviating matchmaker might consider undercutting p_i; but the same distribution of users can prevail, making this deviation unprofitable. By $p_j \leq c_j$, undercutting p_j cannot be profitable either. Other deviations involve a subsidy to one group of users, say h-users, and for the other group of users (7) becomes $p_{-h}^E < p_{-h}$. These deviations are therefore undercutting deviations themselves, hence nonprofitable. Maximal profits of $u_i/2 - c_i$ can then be sustained provided $u_i \geq 2c_i$.

Proposition 11. Suppose transaction fees are not feasible. A market-sharing equilibrium exists for $\lambda = 1$ if and only if $\inf\{c_1/u_1, c_2/u_2\} \leq 1/2$. The highest attainable profit in a market-sharing equilibrium is equal to $\max_h\{u_h/2 - c_h\}$.

Consequently, the first conclusion drawn for exclusive services also applies for nonexclusive services. Namely, when transaction fees are not available, inefficient market configurations can emerge in equilibrium: dominant-firm equilibria may be supported even though they are inefficient, and market-sharing equilibria exist for a wider range of parameters, when λ is close to one. The second conclusion does not extend, though. Equilibrium profits in a dominant-firm equilibrium or a market-sharing equilibrium are indeed larger when transaction fees are not feasible, but equilibrium profits in global multihoming equilibria are smaller. The intuition has already been alluded to in the previous section. In dominant-firm equilibria or market-sharing equilibria, transaction fees are only an additional instrument for deviations; ruling them out can only improve equilibrium profits. In global multihoming equilibria, they play a central role in extracting users' surplus, and ruling them out puts limits on attainable profits.

6. Conclusion

■ This article has proposed a framework to analyze imperfect competition between matchmakers with indirect network externalities, with a particular emphasis on relevant features of the intermediation activity on the Internet. Intermediation services usually are not exclusive, and users often rely heavily on the services of several intermediation providers.

As should be expected, multiple equilibria exist. Under the assumption that any generated matching surplus is efficiently shared, we prove that, depending upon the imperfection and cost of the matching technology, the efficient market structure may be monopolistic or duopolistic, and that an equilibrium with the efficient market structure always exists. But inefficient equilibria also exist, especially when the matching technology is effective or the ability to rely on transaction fees is limited. The intermediation market is moreover partially contestable: depending upon the pricing instruments and the exclusivity of services, concentrated market structures may go along with limited or zero intermediation profits. Intermediation providers still have an incentive to open up the intermediation market so as to allow users to turn to several intermediaries simultaneously: this moderates price competition and reinforces market power and intermediation profits.

We have also characterized relevant business strategies on the intermediation market. These are divide-and-conquer strategies, where one side of the market is subsidized and profits are made on the other side. The possibility of such business strategies have strong consequences in terms of market equilibrium and market structures that are likely to emerge. Moreover, the use of transaction fees is shown to be central in these pricing and business strategies.

Intermediation markets, and particularly Internet-based markets, therefore have some strong specificities. The design of competition policy rules with respect to such markets should thus take these characteristics into account. Concentration may not necessarily carry strong inefficiencies; in fact, the opposite may be true. Intermediation profits may be larger in market-sharing configurations, and the users' surplus may have better protection in concentrated markets where one large intermediary dominates, provided that there is enough contestability.

These first conclusions must obviously be challenged by further research. In particular, the potential impact of intermediation pricing on the efficiency of trade between users must be investigated, using a model where the bargaining over the matching surplus may be affected by the matchmakers' business strategies. Rochet and Tirole (2001) is one attempt in this direction.

Appendix

■ Proofs of Propositions 1, 2, and 4–8 follow.

Proof of Proposition 1. The proof of the existence of dominant-firm equilibria and the characterization of pricing are similar to Caillaud and Jullien (2001a) and hence omitted.

Suppose there exists an equilibrium with prices $P = (P^I, P^E)$ and an inefficient distribution of users (two active firms). Let $s_i = \lambda u_i(1 - t^k)n_j^k - p_i^k$ denote the *ex ante* surplus of i-users in this equilibrium. The profits are

$$\Pi^k = \lambda n_1^k n_2^k - \sum_i (c_i + s_i)n_i^k \geq 0.$$

Firm k could undercut slightly and serve the whole market (because $n_i^k > 0$) with profit approximately equal to

$$\lambda - c - s_1 - s_2 - \sum_i \lambda u_i(1 - t^k)n_j^{-k} \leq \Pi^k.$$

It is shown in our working paper (Caillaud and Jullien, 2001b) that these four inequalities are only consistent with $n_i^k = 1/2$, $t^I = t^E = 0$, $p_i^I = p_i^E = p_i$, and $p_1 + p_2 = c$ (zero profit).

But with the DC strategy described in (3) and (4), a firm could obtain $p_i + \inf\{p_j, 0\} + \lambda u_j - c$. Using $p_i - c = -p_j$ and $p_j \leq \lambda[u_j/2]$ $(s_j \geq 0)$, we see that the deviation profit is strictly positive, a contradiction with the zero-profit result. *Q.E.D.*

Proof of Proposition 2. We follow the steps of analysis provided in the text.

First, E can always choose to act as a second-source with profit π^{SS} close to $\lambda(1 - \lambda) - c$ by setting $t^E = 1$ and p_i^E slightly negative. For this choice of prices, multihoming is indeed an equilibrium distribution, since users obtain $\lambda u_i - r_i^I \geq 0$ if they all register with I and E, while they just have zero if they register with E only. Then, E is indeed a second source.

Suppose that $0 \leq z^I$. In this case, there exists a market allocation where all users register with I for all P^E. So, E's alternative to second-sourcing is to set prices such that, for some i, $t^E < t^I$, $p_i^E < 0$, and

$$r_j^E \leq \max\{r_j^I, \lambda u_j \left[1 - \lambda + \lambda t^I\right]\} = \lambda u_j \left[1 - \lambda + \lambda t^I\right],$$

and act as a first source. E's profits are then given by

$$p_i^E + p_j^E + \lambda t^E - c < \lambda t^E u_i + \lambda u_j \left[1 - \lambda + \lambda t^I\right] - c.$$

Setting optimally t^E as close as possible to t^I, with p_i^E and r_j^E as large as possible, yields maximal profits for $i = 1$ and $j = 2$ almost equal to

$$\pi^F = \lambda u_1 t^I + \lambda u_2 \left[1 - \lambda + \lambda t^I\right] - c.$$

Suppose now that $z^I < 0$. Then I cannot be a second source. E may choose to act as a sole source. This occurs if

$p_i^E < 0,$

$$r_j^E < \max\{r_j^I, \lambda u_j \left[1 - \lambda + \lambda \max\{t^I, t^E\}\right]\},$$

and one group of users does not register with I, that is,

$$r_i^I > \lambda u_i \left[1 - \lambda + \lambda \max\{t^I, t^E\}\right]$$

or

$$r_j^I > \lambda u_j \left[1 - \lambda + \lambda \max\{t^I, t^E\}\right].$$

This last condition reduces to $t^E \leq t^I - z^I$ (conditions are simpler than (7) because $p_i^E < 0$ and $r_j^E < r_j^I$). E's profits are given by

$$p_i^E + p_j^E + \lambda t^E - c < \lambda t^E u_i + \max\{r_j^I, \lambda u_j \left[1 - \lambda + \lambda \max\{t^I, t^E\}\right]\} - c.$$

Setting optimally t^E as close as possible to $t^I - z^I$, $i = 1$, and $j = 2$ yields

$$\pi^F = \lambda u_1(t^I - z^I) + \lambda u_2 \left[1 - \lambda + \lambda(t^I - z^I)\right] - c.$$

Q.E.D.

Proof of Proposition 4. Consider an asymmetric multihoming equilibrium with $t^I < t^E$. Given prices satisfying $\lambda u_i \geq p_i^k + \lambda u_i t^k$, a global multihoming equilibrium distribution requires:

$$\lambda(1 - \lambda)u_i + \lambda^2 u_i t^E \geq r_i^I \qquad \text{for all } i, \tag{A1}$$

$$\lambda(1 - \lambda)u_i \geq r_i^E - \lambda^2 u_i t^E \qquad \text{for all } i. \tag{A2}$$

We also know that $\pi^E = \lambda(1 - \lambda) - c$, which is only possible if $p_i^E + \lambda(1 - \lambda)u_i t^E = \lambda(1 - \lambda)u_i$, for $i = 1, 2$ (and thus $z^E = 0$).

First, it cannot be profitable for I to undercut prices. E could, however, undercut I with a slightly lower transaction fee (still preserving multihoming by monotonicity), thereby becoming a first source instead of a second source. Such a strategy changes the revenues raised by transaction fees from $\lambda(1 - \lambda)t^E$ to λt^I; it is not profitable if t^I is small enough, that is,

$$t^I \leq (1 - \lambda)t^E. \tag{A3}$$

For the other deviations, we apply Proposition 2. For I, using $z^E = 0$, we obtain

$$\pi^I \geq \max\{\lambda(1 - \lambda)u_2 + \lambda(u_1 + \lambda u_2)t^E, \lambda(1 - \lambda)\} - c.$$

For E, using $t^I - z^I = \max_h\{[r_h^I - \lambda(1 - \lambda)u_h]/\lambda^2 u_h\}$, the conditions that deviations as a first source and as a sole source are not profitable reduce to

$$t^I \leq \frac{(1 - \lambda)u_1}{u_1 + \lambda u_2} \tag{A4}$$

$$p_i^I + \lambda u_i t^I \leq \left[\frac{\lambda + u_1}{\lambda u_2 + u_1}\right]\lambda(1 - \lambda)u_i. \tag{A5}$$

Now set any t^E such that

$$\frac{u_1}{(u_1 + \lambda u_2)^2}(1 - \lambda)\left[u_1 + \lambda + \lambda u_2\right] \geq t^E \geq \frac{u_1}{u_1 + \lambda u_2}(1 - \lambda)$$

$t^I = 0$ and

$$p_i^I = \left[\frac{\lambda + u_1}{\lambda u_2 + u_1}\right]\lambda(1 - \lambda)u_i;$$

this yields an equilibrium with maximal profits equal to

$$\pi^I = \lambda(1 - \lambda)(\frac{\lambda + u_1}{\lambda u_2 + u_1}) - c = \lambda(1 - \lambda) + \frac{\lambda^2(1 - \lambda)u_1}{\lambda u_2 + u_1} - c.$$

Q.E.D.

Proof of Proposition 5. Note first that it is not necessary to look at undercutting strategies with the monotonicity restriction, because I could not possibly gain by undercutting while the distribution of users following E's undercutting is not restricted at all, since E has no market share in a dominant-firm equilibrium. Therefore, we only need to guarantee that E's best-response profits in Proposition 2 are nonpositive.

The conditions that deviations as a first source and as a sole source are not profitable for E reduce to

$$\lambda(1-\lambda)u_2 + \lambda(u_1+\lambda u_2)t^I \le c, \tag{A6}$$

$$\lambda(1-\lambda)u_2 + \lambda(u_1+\lambda u_2)\max_i \left\{ \frac{r_i^I - \lambda(1-\lambda)u_i}{\lambda^2 u_i} \right\} \le c. \tag{A7}$$

The last inequality can be written as

$$r_i^I \le \left(\frac{c+(1-\lambda)u_1}{u_1+\lambda u_2} \right) \lambda u_i.$$

Setting maximal r_i^I in these constraints, along with $t^I = 0$, yields maximal profit equal to

$$\left(\frac{c+(1-\lambda)u_1}{u_1+\lambda u_2} \right) \lambda - c = \frac{(\lambda - c)}{u_1+\lambda u_2}(1-\lambda)u_1.$$

This profit is smaller than c under the assumption that $c \ge \lambda(1-\lambda)$.

E's pricing strategy can then be given by $P^E = P^I$. Note first that $p_i^E = p_i^I > 0$, so that E is indeed not active in equilibrium. Then, assume that users hold pessimistic beliefs against I when I attempts to deviate by increasing one price; I has no profitable deviation. *Q.E.D.*

Proof of Proposition 6. Suppose there exists an equilibrium such that the equilibrium distribution of users satisfies $0 < n_i^I = 1 - n_i^E < 1$. The necessary conditions are

$$0 \le \lambda n_j^I u_i(1-t^I) - p_i^I = \lambda n_j^E u_i(1-t^E) - p_i^E \le \lambda n_j^I u_i(1-t^I) + \lambda n_j^E u_i(1-t^E) - p_i^I - p_i^E.$$

This implies that $\lambda n_j^k u_i(1-t^k) = p_i^k$ for all $i = 1, 2$, $j \ne i$, and $k = I, E$. Intermediaries profits then become

$$\pi^k = \lambda n_1^k n_2^k - c_1 n_1^k - c_2 n_2^k \ge 0.$$

If a firm slightly reduces one of its prices, it captures the whole market in a monotonic market allocation. A necessary equilibrium condition is then

$$\lambda n_1^k n_2^k - c_1 n_1^k - c_2 n_2^k \ge p_1^k + p_2^k + \lambda t^k - c = \lambda \left(n_2^k u_1 + n_1^k u_2 \right)(1-t^k) + \lambda t^k - c.$$

Using the fact that $n_i^{-k} = 1 - n_i^k$ and the nonnegativity of profits, it follows that

$$\lambda n_1^k n_2^k \ge c_1 n_1^k + c_2 n_2^k \ge \lambda \left(n_2^{-k} u_1 + n_1^{-k} u_2 \right)(1-t^{-k}) + \lambda t^{-k} - \lambda n_1^{-k} n_2^{-k} \tag{A8}$$

for $k = I, E$. Summing these double inequalities for $k = I$ and E yields

$$2\lambda(n_1^I n_2^I + n_1^E n_2^E) \ge \lambda + \lambda t^I(1 - n_1^I u_1 - n_2^I u_2) + \lambda t^E(1 - n_1^E u_1 - n_2^E u_2) \ge \lambda.$$

Since $n_i^E = 1 - n_i^I$, the inequality between the extreme left-hand side and the extreme right-hand side is possible only for $n_i^k = 1/2$ and $t^k = 0$ for $i = 1, 2$ and $k = I, E$. The double inequality (A8) then yields $\lambda = 2c$. *Q.E.D.*

Proof of Propositions 7 and 8. Consider a candidate equilibrium (p_i^k, p_j^k, t^k), $0 < n_j^I = 1 - n_j^E < 1$ and $n_i^M = 1$. On the equilibrium path, the market allocation satisfies

$$0 \le \lambda u_i n_j^k (1-t^k) - p_i^k \tag{A9}$$

$$\lambda u_j \left(1 - \lambda + \lambda \max\{t^I, t^E\} \right) \le p_j^I + \lambda u_j t^I = p_j^E + \lambda u_j t^E \le \lambda u_j. \tag{A10}$$

The matchmakers' profits are given by

$$\pi^k = p_i^k - c_i + n_j^k(p_j^k + \lambda t^k - c_j).$$

Price equilibrium conditions consist of (8), for undercutting deviations, and of the conditions given in Proposition 2, that is,

$$\pi^k \geq \lambda(1-\lambda)u_2 + \lambda(u_1 + \lambda u_2)t^{-k} - c$$
$$\pi^k \geq -(1-\lambda)u_1 + (u_1 + \lambda u_2)\max_h \left\{ \frac{p_h^{-k} + \lambda u_h t^{-k}}{\lambda u_h} \right\} - c$$
$$\pi^k \geq \lambda(1-\lambda) - c.$$

Consider a reduction in transaction fees t^k while maintaining constant $p_i^k + \lambda u_i n_j^k t^k$ and $p_j^k + \lambda u_j t^k$. This preserves profits and utility levels while relaxing all equilibrium conditions. It follows that we can look for an equilibrium with $t^I = t^E = 0$, $p_j^I = p_j^E = p_j \leq c_j$. Then, taking the average of the conditions over the two firms, one can conclude that if there exists a market-sharing equilibrium with (p_i^k, p_j, n_j^k), then there also exists a symmetric market-sharing equilibrium with $p_i = (p_i^I + p_i^E)/2$, $n_j^k = 1/2$, and the same p_j, with identical total profits of intermediation. Hence, we can narrow our analysis to the search for the highest-profit symmetric equilibrium with zero transaction fees.

Matchmakers' profits is given by $\pi = p_i - c_i + (1/2)(p_j - c_j)$. So, in the plane (p_i, p_j), the set of equilibrium conditions for a symmetric, zero-transaction-fee equilibrium consists of the intersection of a rectangle, given by

$$p_i \leq \frac{\lambda u_i}{2}, \tag{A11}$$
$$\lambda(1-\lambda)u_j \leq p_j \leq \inf\{\lambda u_j, c_j\}, \tag{A12}$$

with a cone, given by

$$2\left(\lambda u_j + (1-\lambda)u_1\right) p_i \leq \lambda u_i \left[p_j + c_j + 2(1-\lambda)u_1\right],$$
$$[\lambda u_i + \lambda + 2(1-\lambda)u_1]\, p_j \leq 2\lambda u_j \left[p_i + (1-\lambda)u_1 + \frac{1}{2}c_j\right],$$

and of a last condition on profit:

$$\pi = p_i - c_i + \frac{1}{2}(p_j - c_j) \geq \max\{\lambda(1-\lambda) - c, 0\}. \tag{A13}$$

The rectangle is not empty only if $c_j \geq \lambda(1-\lambda)u_j$. Hence Proposition 7: for a given $\lambda < 1$, costs must be large enough for a market-sharing equilibrium to exist.

Straightforward computation shows that the intersection of the rectangle and the cone is nonempty if and only if

$$c_j + \lambda^2 u_i \geq \lambda(1-\lambda)(1-2u_1), \tag{A14}$$

and within this intersection, maximal profits are obtained for

$$p_i = \inf\left\{\frac{\lambda u_i}{2}, \left(\frac{c_j + (1-\lambda)u_1}{\lambda u_j + (1-\lambda)u_1}\right)\lambda u_i\right\}$$
$$p_j = \inf\left\{\left(\frac{\lambda u_i + 2(1-\lambda)u_1 + c_j}{\lambda u_i + 2(1-\lambda)u_1 + \lambda}\right)\lambda u_j, c_j\right\}.$$

When λ goes to 1, (A14) holds, and profit-maximizing prices converge to

$$p_i \longrightarrow \inf\{\frac{u_i}{2}, u_i\frac{c_j}{u_j}\}$$
$$p_j \longrightarrow \inf\{u_j\left(\frac{u_i + c_j}{u_i + 1}\right), c_j\},$$

so that profit converges to

$$\pi \longrightarrow \inf\left\{\frac{u_i}{u_j}c_j - c_i, \frac{u_i}{1+u_i}\left(1-\frac{c_i}{u_i}-c\right)\right\}.$$

Finally, (A13) reduces to the nonnegativity of profit, which is equivalent to

$$c + \frac{c_i}{u_i} \leq 1 \quad \text{and} \quad \frac{c_j}{u_j} \geq \frac{c_i}{u_i}. \tag{A15}$$

The conditions thus define i as the type with the smaller cost-to-utility ratio. The condition $c_i < u_i/2$ then necessarily holds (as $c < \lambda = 1$). Thus (A15) is the only condition for the existence of the equilibrium in the limit case where λ goes to 1. *Q.E.D.*

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