Competition and Strategic Partnership between Intermediary Platforms in the Presence of Heterogeneous Technologies

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Abstract

Should platform based market intermediaries collaborate with their competitors? If so, should they share their technologies, their member networks, or both? These are the questions we seek to answer using a simple two-sided network model where the members’ utilities are driven by both network size and the level of technology provided by the platforms. Consistent with the literature, we find that these network markets are characterized by extremely asymmetric outcomes. Under open competition, the superior-technology platform completely dominates the market and, surprisingly, this extreme asymmetry persists even as the technology gap between the leading and the competing platforms vanishes. Our analysis on the possibility of strategic partnership reveals that platforms would not want to share technologies alone with rivals; however, sharing their networks, with or without side payments, can be pareto optimal. The likelihood of partnership is influenced by platforms’ relative strengths in technology and the cross-platform technology experience.

1. Introduction

Technology-enabled intermediaries play a key role in mediating interactions between the two sides of the market. With a significant share of commercial activity moving to the internet, or other electronic networks, in the last two decades, the role of these intermediaries and competition among them has received considerable academic attention [2, 6, 8, 9, 11, 13, 14] where they are labeled as two-sided markets or networks. This is due to the fact that they comprise of networks of two sets of agents, interactions between whom are mediated by one or more “platforms.” Each agent’s utility is an increasing function of the number of agents of the other type available to interact on the platform, thereby creating indirect or cross-market network effects. Examples of such platforms include PC and mobile operating systems (platform between application developers and application users), online advertising networks (between web properties and advertisers), dating sites (between men & women), job boards (between job seekers & recruiters), real-estate brokerages (between property buyers and property sellers), electronic marketplaces and payment card systems (between merchants and consumers), etc.

In all these two-sided networks, platform providers typically perform two primary functions. First, they match agents on the two sides enabling transactions between them; second, they add to the quality of the transactions in different ways. The utility, that an agent on either side gets, depends not only on the number of agents on the other side of the platform (indirect or cross-market network effects), but also on how well the platform facilitates the transactions (effectiveness of the platform technology). Take for example, Google’s advertising platform. The platform enables online advertisers to display ads on content providers’ websites. It has two components – Adwords and Adsense. Adwords is targeted towards online advertisers, while the Adsense component targets content providers (media sites, retail sites, blogs, etc.). Ads are placed on the Google content network (Google and its partner sites) and advertisers pay for clicks.

The utility to advertisers in this case will generally depend not only on the number of content sites, but also on the click through rates and the fit between their service and advertising vehicle (the content site). These, in turn, depend on the effectiveness of Google’s contextual mapping technology and its matching algorithms. Google also provides advertisers with placement performance...
On the content side, Google provides tools to its partner sites to format the ads, filter inappropriate ads (including competitors’ ads, and ads that may hurt the site’s image), track performance, etc. These technologies provided by Google are a significant part of its value proposition to clients (advertisers and partner sites), and along with the size of its network, a significant reason for its dominance in this space.

Similar value propositions from platform technologies are common across many two-sided markets. For example, better technology from an electronic job board improves the efficiency of the search process and the quality of the match between job seekers and recruiters, thereby creating value for employers and employees. Superior technology in a video game platform provides better tools for game developers and improves the players’ experience. A more stable and secure operating system reduces user frustration and development time for application developers. Improvement in the technology platform provided by real-estate brokers enables sellers to showcase their properties better and buyers to more efficiently find and assess properties of interest.

Despite the undeniable importance of technology in creating value, and influencing competition between platforms, the early literature in this area has mostly focused on issues of pricing (price level & structure) [13, 14], antitrust, and single/multi-homing [1], etc. An exception are papers by Eisenmann, Parker, and Van Alstyne [4, 5], which provides a thorough discussion of the role of technology in creating value on the platform and the importance of managing it optimally to appropriate that value. While their coverage is expansive, Eisenmann et al’s approach is primarily descriptive. In our research, we take an analytical approach and focus on a much narrower problem, namely the effect of platform technology on competition, division of surplus, and its role on the strategic partnership between platforms.

Using a game theoretic model we study two-sided markets with heterogeneous customers on both sides. We explore competition between platforms with different levels of technological capabilities and analyze their incentives to share their technology and/or member networks with each other. We find that these network markets are characterized by outcomes that are extremely asymmetric. The superior technology platform completely dominates the market, and this extreme asymmetry surprisingly persists even as the technology gap between the leading and the competing platform vanishes. Our analysis on the possibility of strategic partnership reveals that platforms would not want to share their technology alone with their rivals; however, sharing network between rivals, with or without side payments, can be pareto optimal. The likelihood of partnership is influenced by platforms’ relative strengths in technology as well as the cross-platform technology experience obtained by the agents.

The paper is structured as follows: in §2 we describe the basic model. In §3 we analyze a monopoly scenario. In §4 we extend it to open duopoly competition with no sharing between platforms. The results in §3 and §4 serve as baseline comparisons for the analysis in §5 and §6, where we study incentives for strategic partnership between rival platforms through network sharing, and technology licensing, respectively. §7 discusses the main results and concludes.

2. The basic model

Consider a two-sided market with heterogeneous customers on both sides. For ease of exposition we’ll refer to the customers on one side as sellers and the other as buyers. Transactions between buyers and sellers are facilitated by one or more platforms (we use the term transaction to generically represent many possible types of interactions including, but not limited to, matching, trade, information transmission, etc.). The platforms are independently owned, and serve as both platform sponsors and providers.

Sellers and buyers are denoted respectively by their types $\theta_s$ and $\theta_b$ respectively. A customer’s type represents the ability of that customer to extract value from a transaction, and customers are assumed to be heterogeneous in this regard. For instance, in the context of the Google advertising platform, different advertisers may have different click-through rates and conversion ratios, and hence derive different values from an ad. We assume that $\theta_s$ and $\theta_b$ are uniformly distributed over $[0,1]$. We further assume there are $N_s$ sellers and $N_b$ buyers.

The net utility to a customer on side $i = \{s,b\}$, from joining a platform $j = \{1, 2\}$ is given by the following reduced form utility function:

$$U_{ij}(\theta_i; n_{ij}) = \theta_i \tau_i n_{ij} - p_{ij}$$

where $n_{ij}$ is the number of customers joining platform $j$ on side $i = \{s,b\}; \ i \neq 1; \ p_{ij}$ is the membership price charged by platform $j$ to customers on side $i$, and $\tau_i$ is the level of technology provided by platform $j$. The customers do not incur any other costs beyond the price of membership and platforms
have zero marginal costs associated with serving customers. The utility function reflects the presence of cross-market network effects, i.e., each customer’s utility is affected by the number of members on the “other” side of the platform. Moreover, the multiplicative form of the utility function implies that network effects are both type and technology dependent. Note that typically, the level of a platform’s technology may not only influence the customers’ network value, but their standalone value as well. To account for this, an additional additive term can be added to the above utility function. We have ignored the standalone value to squarely focus on the network effects. Adding the standalone utility (for instance similar to that in [15]) will somewhat moderate our results.

3. Monopoly

The monopoly scenario serves as a baseline for comparing the competitive results that follow. We consider a monopoly platform, with a technology level $t$. The structure of the game is as follows: In stage 1, given the level of platform technology, the monopolist chooses prices for both sides of the market and the customers form rational expectations about the platform’s equilibrium network sizes on both sides. In stage 2, the customers make their membership decisions based on their expectations on network sizes and the monopoly prices. The expectations are assumed to be fulfilled in equilibrium. The equilibrium concept used is therefore the fulfilled expectations equilibrium (FEE). While this definition of fulfilled expectations is standard in the literature [10], some authors do use other variations of these assumptions. Some of these are briefly discussed later in this section.

Let $n^e_b$ and $n^e_s$ respectively be the buyers’ and sellers’ expectations about how many customers from the other side join the platform. Customers join the platform if their net surplus, given the expectations, is non-negative. The monopolist’s choice problem is therefore,

$$\max_{p_b, p_s} \pi_M = p_b D_b(p_b, p_s; n^e_b, n^e_s, t) + p_s D_s(p_b, p_s; n^e_b, n^e_s, t)$$

where $D_b$ and $D_s$ are respectively the demands (realized network sizes), and $p_b$ and $p_s$ are respectively the prices charged on the buyer and seller sides. The following lemma establishes the monopoly outcomes

**Lemma 1:** Optimal monopoly prices, demands, and overall platform profit are given by:

$$p^*_b = \frac{tN_s}{4}; \quad p^*_s = \frac{tN_b}{4}; \quad D_b = \frac{N_b}{2}; \quad D_s = \frac{N_s}{2};$$

$$\pi^*_M = \frac{tN_b N_s}{4}$$

(Proofs have been excluded due to the page limitations. They are available upon request.)

Note that, in addition to the above equilibrium, a second “pessimistic” equilibrium also exists, where consumers expect equilibrium network sizes to be zero, and these expectations are in turn fulfilled in equilibrium. We ignore this trivial equilibrium and focus on the equilibrium with positive demands characterized in Lemma 1.

From Lemma 1 it is clear that the price on each side depends on the size of the network on the other, which follows from the presence of the cross-market network effects. Further, while the price structure is generally asymmetric, the monopoly platform otherwise behaves similar to a regular monopolist in a non-network market, covering half the market on each side. It is somewhat surprising that an effort to internalize the cross-platform externality does not lead the monopolist to cover a larger share of the market. However, this is largely a consequence of the rationality assumptions of the model, where the monopolist is assumed to set the profit maximizing price, given the customers’ expectations.

A slightly different assumption that is sometimes made in the literature has the monopolist actively setting the expectations of the customers with respect to equilibrium network sizes. In this game structure, the monopolist “announces” targeted network sizes, the customers believe the announcement and make decisions accordingly, and the monopolist chooses prices to expressly fulfill the expectations. The resulting monopoly outcomes turn out to be:

$$p^*_b = \frac{2tN_s}{9}; \quad p^*_s = \frac{2tN_b}{9}; \quad D_b = \frac{2N_b}{3}; \quad D_s = \frac{2N_s}{3};$$

$$\pi^*_M = \frac{8tN_b N_s}{27}$$

While the monopoly profits in this case are higher, the problem with this assumption is that the monopolist’s announcement needs to be credible. If the customers blindly believe the monopolist’s announcement, then the monopolist has an incentive to choose prices where the expectations are not fulfilled in equilibrium. Moreover, the active setting of expectations is less likely possible in a competitive
Improvements in the platform technology increase prices and monopoly profits, but do not affect equilibrium network sizes.

4. Open duopoly competition with no sharing

Here we consider open competition between two platforms, characterized by technology levels \( t_1 \) and \( t_2 \), respectively. Without loss of generality, we assume \( t_1 > t_2 \), that is, platform 1’s technology is superior to platform 2’s. We further assume that the technologies employed by the two platforms are proprietary, and there is no collaboration of any form between the platforms. We also assume that the customers single-home, that is, they join no more than one platform. Therefore, transactions between members of rival platforms are not possible.

The structure of the game is very similar to the monopoly case. Given complete knowledge of the technologies of the two platforms, the two platforms simultaneously choose membership prices, and customers form expectations about the equilibrium network sizes of the two platforms. Based on their expectations and platform prices, customers decide which, if any, platform to join. In equilibrium, the expectations are fulfilled. Finally, when faced with multiple equilibria, we choose the stable, non-trivial equilibrium outcome. In this case, the unique non-trivial FEE involves the superior technology platform serving the higher end customers on both sides of the market, while the inferior technology platform serves the customers with lower values.

**Lemma 2:** Under open duopoly competition with no sharing, the equilibrium platform prices and demands for side \( i \), \( i \in \{ b, s \}; i \neq l \), and overall platform profits are given by:

\[
\begin{align*}
\pi_1^* &= \frac{8N_bN_s(t_1^2+t_2^2)}{(8t_1-t_2)^2}; \\
\pi_2^* &= \frac{2(N_b+N_s)t_1t_2(2t_1-t_2)}{(8t_1-t_2)^2}.
\end{align*}
\]

The platform with the superior technology charges much higher prices to both sides than the prices charged by inferior technology platform \( (p_{11}^*/p_{12}^* = 4t_1/t_2) \), but still has twice the market share of the inferior technology platform, and makes substantially more profits \( (\pi_1^*/\pi_2^* = 8t_1/t_2) \). Thus, while the outcome may not be a “winner-take-all” in terms of market shares, it is perilously close to that in terms of profit shares. Not surprisingly, the overall market coverage is higher than the monopoly case \( (D_{11} + D_{12} > D_{1M}) \), and the overall combined platform profit is lower \( (\pi_1^* + \pi_2^* < \pi_M) \).

Comparative statics of market shares, equilibrium prices, and profits are described in the following proposition.

**Proposition 2:** Under open competition with no sharing, the technological advantage of the superior platform erodes, that is, as \( t_2/t_1 \) increases,

a) Both platforms expand their market coverage on both sides of the market. In the limit, as \( t_2 \to t_1 \), the total coverage approaches 6/7th of the total market, but the relative market shares remain unchanged.

b) The membership prices go down for the superior platform, while they increase for the inferior platform.

c) The profits decrease for the superior platform, while they increase for the inferior platform. Despite the decrease in the profits, the superior platform continues to capture a significant fraction of the overall industry profits. In the limit, as \( t_2 \to t_1 \), the superior platform’s profit share is approximately 8/9th of the total duopoly profit and about 3/4th of the monopoly profit.

The results in the proposition are illustrated in Figure 1, which depicts the equilibrium market shares and prices on both sides, and overall profits as the ratio of the lower to higher technologies \( (t_2/t_1) \) is varied from zero to one. (However, note that the point \( (t_2/t_1) = 0 \) or \( (t_2/t_1) = 1 \) do not meaningfully exist, \( (t_2/t_1) = 0 \) contradicts the existence of two platforms and \( (t_2/t_1) = 1 \) contradicts the assumption on the heterogeneity in platform technology. All sensitivity analysis are essentially valid for the open
interval \((t_2/t_1) \in (0,1)\) Interestingly, as the inferior technology improves, both platforms cover a larger share of the market, and the number of customers left unserved comes down. When \((t_2/t_1)\) increases, platform 2 increases its prices, and platform 1 reacts by lowering its price on both sides. The increased market coverage by platform 1 is an indirect response motivated by the desire to maintain differentiation with platform 2, as the improvement in platform 2’s technology reduces the differentiation along the technology dimension. In the limit, as \(t_2 \to t_1\), the total market coverage approaches \(6/7\)th of the total market.

Figure 1 shows that a relative improvement in platform 2’s technology improves its own profits, but hurts platform 1’s profits. It decreases the difference in profits between the two platforms. However, the difference continues to be large, and platform 1’s profit share remains \(8/9\)th of the total platform profit even when \(t_2 \to t_1\). Further, as \(t_2 \to t_1\), \(\pi^*_1/\pi^*_M \to \frac{256}{343} \approx 0.7464\), that is, even when the difference in the two platform technologies is negligible, the ‘superior’ platform makes almost 75% of the profits of a monopoly platform.

The comparative statics in profits are interesting for two reasons. First, in a standard (non-network) market with quality differentiation, a decrease in technology differentiation decreases the profits for both products, but in our case, only platform 1’s profits decline. The difference is due to the fact that there is a second endogenous source of differentiation which arises from the different network sizes, which helps platform 2 avoid profit erosion. The second interesting observation is the relative resilience of the superior platform’s profits to changes in the inferior platform’s technology. When \(t_2 \to t_1\), the two platforms are more or less homogeneous from a technological perspective, but are at the same time, differentiated due to the endogenous difference in network sizes. This difference enables the superior platform to convert a very small technological advantage into a dramatic asymmetry in profit shares. This result is consistent with similar observations in the literature of one-sided network markets [3], and highlights the importance of managing expectations in network markets. With very similar technologies, the platform with a slight technological advantage, which can credibly create expectations of a larger network, ends up dominating the market and captures the bulk of the profits. In fact, as the proposition shows, in this case, the dominant duopoly platform is not much worse off than it would be in the absence of competition.

5. Collaboration through network sharing

In this section, we consider the case of network sharing/interconnection where members of one platform can access members of the second. For instance, in 2009, Microsoft and Yahoo reached an agreement to share their advertising platforms. Advertisers on each site can access the other’s properties. (They also agreed that Bing, which had the superior search technology at that point, would serve as the search service provider for the Yahoo site as well, but we’ll consider technology sharing in the next section). For now, the technologies of the two platforms still remain independent.

In the absence of an external mandate, interconnection will generally require the consent of both platforms. Here we start by assuming that the platforms are interconnected, and analyze the
resulting equilibrium in order to identify conditions under which platforms have an incentive to interconnect. With interconnection, while the utility from a transaction between two members of the same platform remains the same, the utility for a cross-platform transaction (i.e., transaction between members of different platforms), may in general depend on the technologies of both platforms. In particular, we use \( y_1(t_1, t_2) \) and \( y_2(t_1, t_2) \) to represent the “effective” cross-platform technologies experienced by members of platforms 1 and 2, respectively. The utility to a customer on side i on platform \( j \) is then given by:

\[
U_{ij}(\theta_1; n_{1i}, n_{2j}) = \theta_1 n_{1i} + \theta_2 y_1(t_1, t_2) n_{2j} - \rho_{ij}
\]

Lemma 3 characterizes the equilibrium outcomes assuming that the platforms are interconnected. Note that \( y_1(t_1, t_2) \) and \( y_2(t_1, t_2) \) have been shortened here to \( y_1 \) and \( y_2 \) respectively to simplify notation.

**Lemma 3:** When the platforms are interconnected, the equilibrium prices and demands for side i, \((i, \bar{i} = \{b, s\}; i \neq \bar{i})\), and overall platform profits are given by:

\[
p_{11}^* = \frac{2N_b(2t_1 + y_1)^2(2t_1 - t_2 + y_1 - 2y_2)}{(8t_1 - t_2 + 4y_1 - 2y_2)^2};
\]

\[
P_{11} = \frac{2N_b(2t_1 + y_1)^2}{(8t_1 - t_2 + 4y_1 - 2y_2)^2};
\]

\[
P_{12} = \frac{(N_1)(2t_1 + y_1)^2}{(8t_1 - t_2 + 4y_1 - 2y_2)^2};
\]

\[
\pi_1 = \frac{2N_bN_2(2t_1 + y_1)^2(2t_1 - t_2 + y_1 - 2y_2)}{(8t_1 - t_2 + 4y_1 - 2y_2)^3};
\]

\[
\pi_2 = \frac{2N_bN_2(2t_1 + y_1)^2(2t_1 - t_2 + y_1 - 2y_2)}{(8t_1 - t_2 + 4y_1 - 2y_2)^3};
\]

Lemma 3 establishes that, in equilibrium, the platform with the superior technology continues to serve a larger share of the market (directly) than the inferior platform (\( D_{11} = 2D_{12} \)), sets a higher price \( (p_{11}^* / p_{12}^* = 2(2t_1 + y_1)/(2y_2 + t_2) > 1 \) unless \( y_1 \ll y_2 \), and earns a larger profit \( (\pi_1 / \pi_2 = 4(2t_1 + y_1)/(2y_2 + t_2) > 1 \) unless \( y_1 \ll y_2 \). Going forward, in Section 5.1, we analyze one extreme case in which buyers (sellers) of one platform can access the sellers (buyers) of the other platform, directly. For example, this would be the case if Yahoo and Microsoft were to share with each other their advertisers’ network and the content providers’ network, but, they did not share the technology that matches the advertisement with the content site or any other technology related to contextual advertising. In this case, customers on either platform have access to customers on the other platform but their utility is not affected by the technology of the other platform. This scenario is equivalent to interconnected platforms with \( y_j(t_1, t_2) = t_j \) for \( j = 1, 2 \).

**Lemma 4:** When the customers of each platform have direct access to the customers of the other platform, the equilibrium prices and demands for side i, \((i, \bar{i} = \{b, s\}; i \neq \bar{i})\), and overall platform profits are given by:

\[
p_{11}^* = \frac{6N_b t_1^2(t_1-t_2)}{4(t_1-t_2)^2};
\]

\[
P_{11} = \frac{2N_t t_1}{(4t_1-t_2)^2};
\]

\[
P_{12} = \frac{3N_b t_1^2(t_1-t_2)}{4(t_1-t_2)^2};
\]

\[
\pi_1 = \frac{24N_b N t_1^2(t_1-t_2)}{(4t_1-t_2)^3};
\]

\[
\pi_2 = \frac{6N_t N t_1^2(t_1-t_2)}{(4t_1-t_2)^3}
\]

**Proposition 3:** When the customers of each platform have direct access to the customers of the other, a
relative improvement in the technology of the inferior platform, that is, an increase in $t_2/t_1$, results in
(a) Both platforms expanding market coverage on both sides of the market.
(b) The membership price decreases for the superior platform, while it is non-monotonic for the inferior platform. Price for the inferior platform initially increases, but declines thereafter.
(c) Profit for the inferior platform is non-monotonic. It initially increases, but declines thereafter.

Figure 2 depicts the equilibrium demands, prices, and profits as the ratio of the lower to higher technologies $(t_2/t_1)$ is varied from zero to one. The increase in demand for both platforms that follows a reduction in the technological asymmetry is consistent with the case of open competition between the platforms without network sharing, and is driven by the same factors. However, the price and profit trajectories are different in this case. This is not surprising since, with interconnection, the two platforms are once again undifferentiated in terms of network sizes. That leaves technology as the only differentiator. When technologies of the two platforms are equal, it leads to undifferentiated Bertrand competition causing the prices to fall to their marginal costs, i.e., zero. Therefore, as the inferior platform improves its technology relative to the superior one, at some point, the gain in price due to improved quality is overpowered by the pricing pressure due to reduced differentiation, leading platform 2’s price and profit to be non-monotonic.

The following lemma derives the parameter values where sharing is possible. For the purposes of this lemma, $t_1$ is fixed at 1 and $t_2$ is varied between 0 and 1.

**Lemma 5:** When the customers of each platform have direct access to the customers of the other,
(a) Sharing is pareto optimal, even without side payments, when $(t_2/t_1) \in (0,0.66]$
(b) Network sharing is possible with side payments from platform 2 to platform 1 when $(t_2/t_1) \in [0.66,0.71]$
(c) Network sharing is not possible, even with side payments, when $(t_2/t_1) \in [0.71,1]$
[Note the boundaries of the intervals above are precise up to 2 decimal points]

Figure 3 (next page) depicts, for comparison, the corresponding platform profits with and without direct network sharing. The comparative statics with respect to profit here are very interesting, and are our primary focus here. As the technological asymmetry between the platforms decreases, the inferior platform’s profit increases initially. Unlike the case of open competition, here the platforms are substitutes as well as complements.

![Figure 2. Market shares, prices, and profits with direct access to each other’s’ networks](image-url)
understand the possibility of sharing in region 2, we examine whether total profits of the two platforms with sharing are higher than the corresponding profits without sharing. In region 2A, the total profit is indeed higher. This implies that in region 2A, sharing can arise as an equilibrium outcome where platform 2 uses part of its incremental profits to compensate platform 1 for its loss. Details of the side payments, and their effect on the equilibrium would depend on whether the payments are structured as a fixed fee or a per-user fee. In region 2B, platform 2’s incremental profit is not large enough to compensate for the incremental loss of platform 1. Therefore voluntary sharing in region 2B is not likely. So the only possibility for cross-network access in this case is if the inferior platform were to unilaterally build a converter of some kind, but this generally poses both technological and legal (related to intellectual property) problems as noted earlier. In region 3, both platforms’ profits under sharing are lower than their corresponding profits under open competition and therefore not sharing is a dominant strategy here for both platforms.

In summary, network sharing is most feasible when the two degree of asymmetry between the technologies is high. In industries where the technology is maturing, the leader might find it difficult to sustain a significant superiority. Therefore in such industries, network sharing might be time limited.

5.2 Platforms interconnect — indirect access to network

We now turn to the case where the platforms interconnect, but do not allow the members of one platform to access the others’ members directly. The consequence is that the utility of agents on either platform depends not only on the level of technology of their own platform but also on the level of technology of the other platform. We conduct the analysis using three different forms of $Y_j(t_1, t_2)$ to mimic three different types of realization of cross-platform technology experience. We rule out the possibility of the cross-platform technology realization being any better than the superior technology or any worse than the inferior technology. We consider the following three cases:

\[
Y_j(t_1, t_2) = \begin{cases} 
\min(t_1, t_2) \\
\text{Avg}(t_1, t_2) \\
\max(t_1, t_2)
\end{cases}
\]

Figure 3. Profit comparison — with and without network sharing

We identify conditions for interconnection for the above examples numerically. As in Lemma 5, the value of $t_1$ is fixed at 1 and $t_2$ varied over (0,1) here. The results are summarized in the Lemma below.

Lemma 6: When the platforms are interconnected, and the customers of each platform indirectly access the customers of the other platform,

(a) Interconnection is pareto optimal, even without side payment, when 
\[
\begin{align*}
(t_2/t_1) &\in (0, 0.30] & \text{when } Y_j(t_1, t_2) = \min(t_1, t_2) \\
(t_2/t_1) &\in (0.09, 0.30] & \text{when } Y_j(t_1, t_2) = \text{Avg}(t_1, t_2)
\end{align*}
\]

(b) Interconnection is possible with side payment, when 
\[
\begin{align*}
(t_2/t_1) &\in (0.30, 0.45] & \text{when } Y_j(t_1, t_2) = \min(t_1, t_2) \\
(t_2/t_1) &\in (0.09, 0.30] & \text{when } Y_j(t_1, t_2) = \text{Avg}(t_1, t_2) \\
(t_2/t_1) &\in (0.01, 0.09] & \text{when } Y_j(t_1, t_2) = \max(t_1, t_2)
\end{align*}
\]
Improvements in the cross-platform utilities, through changes in cross-platform technology integration, shift the boundaries between the regions in Figure 3. A higher level of cross-platform technology experience for platform 1 shifts the boundaries to the right, making interconnection more likely, while an increase in the cross-platform technology experience for platform 2 shifts them to the left, making interconnection less likely.

6. Platforms share technology only – technology licensing

Finally, we consider the case where platforms do not share their networks but share their technologies only. This scenario can also be labeled as technology licensing by the superior platform. The customers of both platforms experience the better of the two technologies, but can only interact with customers on their own platform. The equilibrium outcomes can be obtained by evaluating the equilibrium outcomes of the “open competition without technology sharing” case assuming $t_2 \rightarrow t_1$.

**Lemma 7:** When platforms do not share their networks and the superior platform shares its technology with the inferior platform, the equilibrium platform prices and demands for side $i$, $(i, i = \{b, s\}; i \neq i)$, and the overall platform profits are given by:

- $p_{11}^* = \frac{8 N_1 t_1}{49}$; $D_{11} = \frac{4 N_1}{7}$; $\pi_1 = \frac{64 N_b N_s t_1}{343}$
- $p_{12}^* = \frac{2 N_1 t_1}{49}$; $D_{12} = \frac{2 N_1}{7}$; $\pi_2 = \frac{8 N_b N_s t_1}{343}$

The equilibrium outcomes are similar to the case of open competition with no network sharing, except for the fact that both platforms enjoy the better of the two technologies. Note that even though both platforms have identical technologies, the outcome is not symmetric. This is because, although there is no ex-ante (exogenous) differentiation between the two platforms, the different network sizes (driven by different expectations) create an endogenous source of differentiation. To derive the results here, it is assumed that Platform 1, which owns the better technology, is expected (by consumers) to have the larger network leading to an asymmetric outcome.

To check for the possibility of a technology licensing agreement of this sort, we compare the total profits of the two platforms with technology licensing and the total profits without it.

**Proposition 4:** Technology licensing alone is not optimal in duopoly competition between platforms.

The comparative statics are depicted in Figure 4.

![Figure 4. Total Profits of platforms 1 and 2, with and without technology licensing](image)

The sum of profits of the two platforms with technology licensing is lower than the sum of profits without it throughout the interval $(t_2/t_1) \in (0,1)$. This implies that partnership is not possible, even with side payments, solely on the basis of technology sharing.

7. Conclusion

In two-sided markets with technology-enabled intermediaries (such as Google, Yahoo, and Microsoft in search advertising, Amazon and eBay in electronic marketplace, etc.), the technology of the platform plays a significant role in driving the utility of the agents on both sides of the platform. The technology of the platform can improve network effects experienced by the agents, by increasing the number of successful transactions, and by improving the quality of each transaction.

In this paper, we have focused on the role that such technology plays in shaping competition between platforms, and their incentives for collaboration. Under open competition, while multiple platforms can coexist, generally the superior technology platform significantly outperforms the inferior platform with respect to profitability. In fact, the superior technology platform captures about 7/8th of the total industry profits and almost 75% of the monopoly profits and the extent of technological asymmetry between the platforms does not have a significant effect on this profit structure.
Cooperation between the platforms in the form of direct or indirect network sharing can spontaneously emerge, with or without side payments between them, and the resulting expansion in market coverage can simultaneously improve platform profits. Platforms don’t benefit from sharing their technology alone with their rivals; however, sharing each other’s member networks, with or without side payments, can be pareto optimal. The likelihood of partnership is driven by platforms’ relative strengths in technology as well as the cross-platform experience of the agents. The partnership is most likely when platforms directly share their network with each other without sharing the technology.

While the results are interesting, we should also acknowledge some limitations of our analysis. We currently consider pure membership pricing only. The work can be extended to analyze platforms that adopt transaction pricing. The model can also be extended to study platforms where agents can multihome. Finally, making platforms’ technology decision endogenous can give further insights into the dynamics of competition between platforms.

8. References