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Platform-based information goods: The economics of exclusivity

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ABSTRACT

This paper explores the role of exclusive contracting between vendors of platforms (such as video game consoles) and vendors of complements (such as video games). The main questions of interest are: When do we observe complement exclusivity, and what is the impact of exclusive contracting on prices, profits and efficiency? We answer these questions by developing a model of competition between platforms in an industry with indirect network effects, and deriving some insightful analytical and numerical results. While complement vendors have natural incentives to be available on all platforms, we establish conditions under which they can be contracted for exclusive supply on a single platform. Exclusivity eases competition in the platform market and can significantly help increase a platform's adoption. However, exclusivity choice presents a key trade-off for the complement vendor—a larger platform offers access to a larger market, but also more competition, as compared to a smaller platform. We find that exclusivity is more likely in the nascent and very mature stages of the platform market, whereas non-exclusivity is more likely in the intermediate stages. Interestingly, our numerical analysis suggests that a complement vendor might sometimes prefer being exclusive on the smaller platform, rather than the larger one.

1. Introduction and motivation

Several information goods industries are structured as systems comprising of platforms and complementary products. Customers typically derive greater benefit from joining a platform that has a greater variety and quality of compatible complementary products available, which in turn often depends on the size of the platform's customer base. This leads to the creation of complementary or indirect network effects [8,9], which significantly alters customer behavior and has important implications for managers of information goods [2]. Examples of platforms and complements include video games consoles and video games; operating systems platforms and software applications; cellular service providers and mobile devices; and DVD formats (Blue-ray/HDDVD) and titles.

In systems markets such as those discussed above, a platform's portfolio of complements generally constitutes its core value proposition as well as the basis of differentiation. Vendors of platforms, who have to rely on third party firms to develop complements often seek exclusive contracts with them. For instance, AT&T Wireless entered into a multi-year exclusive deal with Apple to provide cellular phone services to users of its iPhone. Similarly, Major League Baseball (MLB) signed an exclusive deal with DirecTV forgoing non-exclusive deals with other satellite and cable services. Such practices are even more prominent in the market for console-based video game platforms, where exclusive titles are widely considered the most important drivers of adoption and determinants of success in the console market. Therefore all major console brands feature exclusive games. For example, about one-third (150 of 450) of PlayStation 3 games, and about one-sixth (110 of 620) of Xbox 360 games are exclusive. This research attempts to understand the forces that determine exclusivity, and describe its effect on prices, profits and efficiency. As such the video game market can be considered a good example to motivate, and understand the results of, the problem analyzed here.

Our work in this paper adds to a rich stream of recent work on the economics of information goods, which has analyzed bundling [15], pricing [4], upgrade pricing [20], services such as content delivery networks [16], Internet inter-connection [22] and the role of network externalities [5,23,24]. In particular, we extend the last set by examining the strategic use of complement exclusivity in platform industries with indirect network effects.

Despite the ubiquity of exclusive contracts in many hi-tech industries, there has been very little research addressing this phenomenon in network markets.[1] Most existing research on competition in network industries has instead focused on issues

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[1] Exclusivity has been studied in the context of supply chain relationships, mainly focusing on the relationship between manufacturers and retailers (see for instance [6]), but the issues there are quite different.

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such as the impact of network effects on switching costs and lock-in [14,19], technology adoption [17], choice of compatibility [13,18], and pricing in two-sided markets [3]. This last set of papers on two-sided platforms also consider exclusivity, but their focus is on a more macro level and on pricing, and they do not delve into the contractual arrangements firms make to influence exclusivity choices of complementary products, which is the focus of our paper. We build on the basic concepts of indirect network effects and platform lock-in as presented in this literature, and develop a model that enables us to analyze exclusivity choices in a simple, but rich setting.

The objective of our analysis is two-fold. First, to examine the conditions under which exclusive relationships between platforms and complement developers arise as equilibria, and second, to analyze their impact on competition, profitability and economic efficiency. We start by developing a generic model of platform competition in the presence of third party complements, and analytically establish a number of results relating to the equilibrium exclusivity regimes, and the corresponding profits. We then analyze a specific form for the consumer utility function and numerically explore the parameter space to more clearly delineate the conditions under which the outcomes are exclusive and non-exclusive, and the corresponding effect on demands, prices, profits and profit shares.

Our results suggest that the stage of platform market maturity (the level of total platform penetration) and the asymmetry between the installed bases of platforms are critical determinants of exclusivity. Exclusivity is much more likely both in the nascent and mature stages of the platform market, but non-exclusivity is the dominant outcome in the intermediate stages. In the nascent stages, the bigger platform secures exclusivity. However, in the mature stages, interestingly there exist conditions (derived numerically) under which the smaller platform is able to secure exclusivity. The stage of the platform market maturity, platform asymmetry, and the quality of the complement also have a critical impact on the division of surplus between platforms and complement developers.

The rest of the paper is structured as follows. Section 2 presents our basic model of platform competition and derives the demand for complements. Section 3 analytically specifies a set of results that are central to determining the equilibrium exclusivity regimes and the associated market outcomes. Section 4 describes the results from an extensive numerical analysis performed to gain additional insight. Finally, Section 5 concludes and discusses the managerial implications of our findings. While the analysis in Sections 2 and 3 is conducted using a fairly general utility function for consumers, the online appendix provides more detailed results using a specific form of the utility function and forms the basis for the discussion in Section 4. Pseudocode and parameter values for the numerical analysis are also provided in the Online Appendix.

2. A model of competition between platforms

We model competition between two platforms A and B with installed bases n_A and n_B respectively.[2] There is a third segment of customers, numbering n_N, who are not currently members of either platform, but who can potentially join one of them. This third segment is labeled the *new segmen*t. We assume, without loss of generality, that $n_A \geq n_B$ and refer to A as the bigger/larger platform. Each platform currently has a set of complements available for it. The greater the number of complements, the larger the variety that customers of the platform can choose from. The platforms are assumed to be incompatible in the sense that complements developed for one platform cannot directly be used on the other platform. However, complement developers can choose to port a complement developed for one platform onto the second platform at an additional cost.

We assume that the number of complements currently available for a platform is a *monotonically increasing function of the size of its installed base*. For instance, this is reflected in the console-based video game industry, where Nintendo Wii has an installed base of 50 million and 940 games; Microsoft Xbox360 has installed base of 28 million and 620 games; and Sony PlayStation3 has installed base of 21 million and 455 games[3] (see also [10]).This reflects the presence of *indirect network effects* [9] in this market—complement developers generally have a greater incentive to develop products for the larger platform and members of the larger platform, in turn, benefit from the greater variety.

Each platform is interested in potentially adding a new complement G to its existing portfolio of complements. To sharpen focus on the exclusivity choices of a single complement developer, we assume that all complements, with the exception of G, are supplied by non-strategic players and the number of complements available on each platform is common knowledge. Non-strategic here implies that the platform choices of these complements are not made strategically within the context of the game we analyze. It is possible that these choices were made prior to the introduction of G, and for ease of exposition, we'll refer to these non-strategic complements as "existing" complements, while referring to G as the "new" complement. The strategic developer G takes into consideration each platform's installed base, the number of existing complements available for each platform, and the contractual terms offered by the platform owners in deciding whether to develop its product exclusively for a single platform or non-exclusively for both platforms.

2.1. Payoffs and game structure

The broad structure of interaction between players is as follows. A strategic developer chooses to develop a new complement of some exogenously endowed quality for one or both platforms depending upon the contractual terms offered by the platform owners. Once developed, units of the complement will be sold directly to the customers. When the developer chooses to make the new complement available on only a single platform, we call this outcome the *Exclusive regime*, and when it is made available on both platforms, we call it the *Non-Exclusive* (or *Common*) *regime*.

2.1.1. Revenues

The platform owners have two sources of revenue. First, new customers pay a price p_k for platform membership if they join platform k. This price is endogenously chosen by the platform owners. Second, the platform owners receive a per unit *license fee* on the complements sold by the complement developers.[4]

The complement developers have a single source of revenue that comes from selling units of the complement to end customers. The selling price of complements (p) is exogenously fixed, but the strategic developer chooses which platform(s) to supply the new complement for. A part of this sales revenue is then passed on to the platform owners as license fees.

2.1.2. Costs

We assume that both platforms are produced/supplied at a symmetric constant marginal cost $c \geq 0$. In general, in addition to the marginal costs, there will be fixed costs associated with the development and marketing of platforms. Often these costs are quite high. However, we ignore these costs because they can be considered sunk under the current set-up and therefore do not affect the results.

[2] Installed bases are the numbers of customers who are currently members of the platforms.

[3] Numbers as of Summer 2009.

[4] Although we treat the license fee as a payment per unit of the complement sold, the analysis and results carry over to a situation where the payments are lump sum rather than prorated. We chose the prorated route because it is more consistent with current practice in the industries we are modeling.

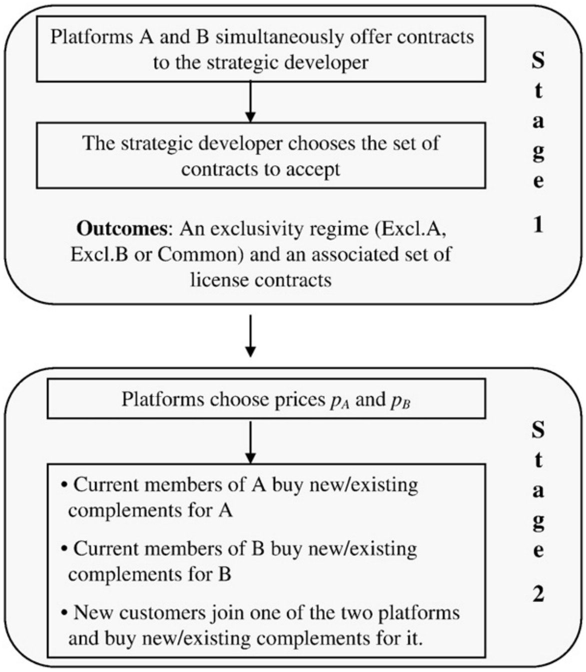

Fig. 1. Structure of the game.

The costs for the strategic developer depend on the exclusivity regime chosen. We assume that the developer incurs an initial fixed investment of F_1 for designing, developing and marketing the product for one of the platforms. If the developer wishes to supply both platforms, then it will have to incur an additional fixed porting and marketing cost, bringing the total fixed cost to F_2 ($F_2 > F_1$). Typically $F_2 < 2F_1$ as porting generally involves only re-coding, re-formatting or minor changes in product design, but not new concept or product development. The *marginal costs* of production/sale for the new complement are assumed to be zero.[5] Finally, costs associated with existing complements are ignored as these do not affect the analysis or results.

2.1.3. Game structure

The interaction between the platforms and the strategic developer is modeled as a two-stage game of complete information (See Fig. 1). In the first stage, the developer seeks offers for exclusive and non-exclusive licensing from the two platforms. In response, both platforms simultaneously offer a set of take-it-or-leave-it contingent contracts to the strategic developer which specifies the license fees that the developer will have to pay to the platform owners under the exclusive and non-exclusive regimes. These license fees—l_{kk} in the exclusive case and l_{kC} in the non-exclusive (or common) case (for platform k), are specified as a fraction of the selling price p of the complement. Although the other existing complement developers do not actively make any strategic decisions, it is assumed that they make a license payment of L (as a fraction of the complement's selling price p) per unit of their complement sold. At the end of stage one, the strategic developer decides which license(s) to accept and invests accordingly to produce either one or two versions of the new complement.

Given the set of complements (new and existing) available for each platform, the platform owners simultaneously choose platform prices p_k in the second stage. As discussed earlier, prices for the complements are exogenously fixed. Given the set of complements and prices, new customers then join one of the two platforms, and all customers (old and new) purchase a bundle of complements for their platform. The two-stage structure of the game reflects the fact that information on the availability of complements is often known in advance to the consumers, and it is taken into account in their choices of platforms and complements, as well as in the strategic decisions of the vendors themselves.

2.2. Customer utility and choice

As discussed earlier, there are three segments of customers in the market—current members of platforms A and B, and new customers. Becoming a ‘member’ of a platform typically involves a commitment in terms of a fixed (and sunk) payment by the customer e.g. buying a video game console or signing a long-term contract with a wireless or television service provider. Since the platforms are substitutes (albeit imperfect), we assume that customers do not seek multiple platform memberships. This is a reasonable assumption here because customers who join a platform are (for the most part) locked in because of the high cost of the platform, the learning involved in using a platform effectively, and often by the library of complements acquired for that platform.[6]

We take a representative consumer approach [12] to modeling the consumption preferences of customers in each of the three segments. The aggregate preferences of customers in each segment are assumed to be characterized by the utility of a separate representative consumer, each with the following additive form of utility.

$$V(x_0, u) = x_0 + u \tag{1}$$

where x_0 is the quantity of a numeraire good, and u is the utility that the representative consumer receives from being a member of one of the two platforms and consuming some of the compatible complements. It is assumed that platform membership by itself does not provide any utility to the customers. Rather, the utility from membership accrues from being able to buy and consume the complements available for the platform.[7]

In modeling the products, the set of existing complements available for a particular platform will be treated as a single *composite product H* [11], whose “quality” is increasing in the number of complements available for that platform. While this is an obvious simplification, it enables us to abstract away from considerations of how consumption may be split among the existing complements and focus on the interaction between the new complement and the “set” of existing complements.[8] The utility that a representative consumer receives from a particular platform can now be defined as:

$$u = U(x_g, x_h) \tag{2}$$

where $x_g, x_h \in R_+$ represent *quantities* of the new and existing complements consumed by the representative consumer in each

[5] Assuming an exogenous, constant marginal cost does not qualitatively affect the analysis.

[6] According to a March 2008 survey by NPD Group, only 3% of all consumers own two of the three main consoles, and only 2% own all three consoles (http://www.gamasutra.com/php-bin/news_index.php?story=18107). Similarly multi-homing is also rare in other platform markets such as television and wireless services. Additionally, multi-homing by current customers doesn't change our results so long as they buy complements for both platforms, since the market size number for the current platform members (n_A and n_B) could potentially include some customers who are members of both. Multi-homing by new customers (n_N) cannot be analyzed in the current set-up because our demand curves / utility functions are represented at the aggregate level. Allowing a subset of new customers to multi-home will require additional parameters and makes the analysis intractable.

[7] Note that it is not strictly necessary to assume that customers receive no utility from the platform itself. The analysis (and results) remains similar if customers receive a positive utility from the platforms. However the analysis would change significantly if one were to assume heterogeneity in valuation for the platforms (beyond the heterogeneity that comes from differing utilities from the corresponding complements).

[8] As the following discussion will make clear, this treatment of existing complements still preserves the essential effects that the variety of complements available on a particular platform has on utility and competition, while affording better tractability.

segment. We make the following assumptions about the utility function $U()$.

A1. Utility is non-negative. It is zero only when both quantities are zero. $U \geq 0$, $U = 0 \Leftrightarrow x_g, x_h = 0$.

A2. Utility is twice continuously differentiable, increasing and concave in quantities. $\frac{\partial U}{\partial x_i} > 0, \frac{\partial^2 U}{\partial x_i^2} < 0$, $i = g, h$. Further, $\frac{\partial U}{\partial x_i}$ is finite at $x_i = 0$.

A3. The products are strategic substitutes [7], $\frac{\partial^2 U}{\partial x_g \partial x_h} < 0$. i.e. a higher quantity of one product reduces the marginal utility to having the other product. Further, $\frac{\partial^2 U}{\partial x_i^2} < \frac{\partial^2 U}{\partial x_g \partial x_h} < 0$, $i = g, h$; which indicates a preference for variety. In the representative consumer approach, since $U()$ represents the aggregate preferences of all customers in the segment, this assumption therefore implies that customers in a segment spread consumption over different complements, or in other words, their preferences are heterogeneous.

Each complement has a "quality" associated with it. This quality, labeled $\alpha_i (i = g, h)$, captures the desirability of the complement to the customers. The higher the quality, the higher the utility to customers from consuming that complement. Quality of the new complement (α_g) is assumed to be exogenous in the sense that it is endowed on the strategic developer and cannot be chosen by it. The quality of the composite product (α_h) reflects the variety of existing complements available for a particular platform as well as their inherent qualities. Since the variety of complements available for a platform depends on the size of its installed base (leading to indirect network effects), we have $\alpha_{hA} > \alpha_{hB}$. Therefore, although we've modeled the set of existing complements as a single composite product, the utility enhancement arising out of increased variety is indirectly captured through an increase in its "quality" α_h. Based on this definition of quality, we impose the following additional properties on the utility function $U()$.

A4. Utility and marginal utility are increasing in quality. $\frac{\partial U}{\partial \alpha_i} > 0$, $\frac{\partial^2 U}{\partial x_i \partial \alpha_i} > 0$; $i = g, h$. Further, $\frac{\partial^2 U}{\partial x_i \partial \alpha_j} = 0$; $i, j = g, h$; $i \neq j$. The second part of this assumption implies that the quality of a complement does not affect the marginal utility of the *other* complement directly.[9] In particular this assumption ensures that if a complement is not being consumed at all, then any change in its quality does not affect the consumer's utility.

The representative consumer for each segment chooses a consumption bundle (x_0, x_g, x_h) to maximize the utility $V()$ defined in Eq. (1) subject to a budget constraint given by:

$$x_0 + x_g p + x_h p \leq y \tag{3}$$

where y is the available disposable income and p is the price per unit of the complements (both new and existing). For customers in segments A and B, the disposable income y equals Y, the common endowment of the numeraire (wealth). For new customers (those in segment n_N), $y = Y - p_k$, where p_k is the price of membership for platform $k = A, B$, depending on which platform they choose to join.

2.3. Demand for complements

This section establishes some basic properties related to demand for the complements. These properties provide the basis for the analysis in the rest of the paper and are also helpful in gaining intuition about the results.

Demand for complements G and H in each segment is derived by maximizing the utility function of the corresponding representative consumer (1) subject to the budget constraint (3). Consumers in segments A and B are already members of a platform, so they simply choose the quantities x_g, x_h while consumers in the new segment choose a platform k and some quantities of the corresponding new and existing complements. From Eq. (3) we have $x_0 = y - p(x_g + x_h)$. Substituting this into Eq. (1), the respresentative consumer's choice problem in its generic form becomes,

$$Max_{\{x_g, x_h, k\}} \quad V(x_g, x_h) = U(x_g, x_h) + y - p(x_g + x_h) \tag{4}$$

From Eq. (4), it is straightfoward to see that all the properties imposed on $U()$ via assumptions A1 through A4 hold for $V()$ as well. Let X_g and X_h be the solutions to the representative consumer's maximization problem in Eq. (4) i.e. $(X_g, X_h) = \arg\max V(x_g, x_h)$. We can think of X_g and X_h as the *per capita demands* for complements G and H. The total demand for complement i from segment k will be given by $n_k X_i$ where $i = g, h$ and $k = A, B$ or N.[10] It is clear from Eq. (4) that the analytical expressions specifying quantities X_g and X_h chosen by the representative consumer are independent of the segment to which the consumer belongs as long as $y > 0$. Going forward, we assume that the income endowment Y is large enough to satisfy this condition.

The solutions X_g and X_h will in general be interior ones. We'll label these interior solutions X_g^I, X_h^I where they exist. Let X_g^0 and X_h^0 represent the two boundary solutions to the maximization problem in Eq. (4), where an interior solution does not exist. Boundary solutions may arise for two reasons: (i) When the new complement is not available for a particular platform (and hence its consumption is zero by definition); and (ii) When it is optimal for the consumer to allocate the entire expenditure to either the new or the existing complement. The following lemmas establish some useful properties related to demand for a complement when it is non-zero. (All proofs are in the Appendix).

Lemma 1. *The demand for a complement is increasing in its own quality i.e.* $\frac{dX_i}{d\alpha_i} > 0$.

Lemma 2. *Demand for a complement is decreasing in the other complement's quality i.e.* $\frac{dX_i}{d\alpha_j} < 0$.

Recall that $\alpha_{hA} > \alpha_{hB}$. Lemma 2 then implies that the new complement receives a lower per capita demand on the larger platform as compared to the smaller platform. This presents a key trade-off for the developer of the new complement. If the developer develops the complement for the larger platform, then it can potentially reach a larger audience since $n_A > n_B$. However, the per capita demand on the larger platform is lower due to the higher intensity of competition it faces from other (existing) complements. Total demand for the new complement ($n_k X_{gk}$) may therefore be higher on either platform depending upon the relative values of n_k and X_{gk}.

Lemma 2 also raises the possibility that the new complement may have no demand on a platform if the variety of existing complements available on that platform (represented by α_h) is sufficiently high. This is indeed true and is formalized in the following proposition.

Proposition 1. *For each platform, there may exist a threshold quality for the new complement below which the new complement has no demand. Moreover, this threshold, when it exists, is higher for the larger platform.*

Proposition 1 implies that it may not be possible to profitably launch new complements with very low qualities into the market-place. This is especially true when α_h is high, or in other words, when a

[9] There could still be an indirect effect through a change in the consumption quantities, which is discussed later.

[10] We assume that all customers in the new segment join one of the two platforms. This is clearly a simplification, but numerical analysis revealed that the results remain qualitatively similar when only a fraction of the new customers adopt a platform.

platform has a high variety of existing complements. Thus over time, as the variety of complements available for a platform goes up, it becomes increasingly difficult to profitably bring a new complement into the market. More importantly, the second part of the proposition implies that, for complements with quality endowments in some intermediate range, the only option may be to go with the smaller platform, but not the larger one. The higher intensity of competition on the larger platform makes it impossible for lower quality complements to get a foothold on it, while the lower intensity on the smaller platform might enable it to realize some demand and make some profit. In these cases, the new complement *will de-facto be exclusive to the smaller platform*. While interesting, this constitutes a special case and therefore going forward, we'll assume that the quality endowment of the new complement is high enough to obtain positive demand on both platforms.

Having examined how the variety of the existing complements affects demand for the new complement, it is instructive to also see how the addition of the new complement impacts the overall demand for complements on a platform. Lemma 3 describes this effect.

Lemma 3. (a) *The availability of the new complement for a platform expands its overall demand for complements i.e.* $X_g^I + X_h^I > X_h^0$.
(b) *The new complement also cannibalizes some of the demand for the existing complements i.e.* $X_h^I < X_h^0$.

Table 1 summarizes the main notation used in the paper, some of which will be introduced later.

3. Specification of equilibrium outcomes

This section provides a generic specification of the players' profits under different exclusivity regimes and establishes some analytical results that provide the basis for the identification of equilibrium exclusivity regimes and the corresponding platform membership prices. These results are then used in Section 4 to numerically specify the equilibrium outcomes.

3.1. Player profits and incremental value of the new complement

A precise specification of the players' profits requires knowledge of which platform the new customers join in the second stage of the game. This requires further analysis and is therefore deferred to Section 3.3 and the Appendix. Here we employ two indicator variables I_A and I_B that take a value of 1 if the new customers adopt the corresponding platform and 0 otherwise. The players' profits can then be specified as follows.

3.1.1. When G is available on both platforms (Regime C: non-exclusive/common)

The profits of platform k $(k = A,B)$ and complement developer G are respectively given by:

$$\begin{aligned}\pi_{kC} &= p(n_k + I_{kC} n_N)(LX_{hk} + l_{kC} X_{gk}) + I_{kC} n_N (p_{kC} - c)\\ \pi_{GC} &= p((n_A + I_{AC} n_N)(1 - l_{AC}) X_{gA} + (n_B + I_{BC} n_N)(1 - l_{BC}) X_{gB}) - F_2\end{aligned} \tag{5}$$

3.1.2. When G is available only on one platform (Regimes XA and XB: exclusive)

Assume G is exclusive to platform k i.e. regime is Xk. The profits of platforms k, k' $(k' \neq k)$ and complement developer G are respectively given by:

$$\begin{aligned}\pi_{kk} &= p(n_k + I_{kk} n_N)(LX_{hk} + l_{kk} X_{gk}) + I_{kk} n_N (p_{kk} - c)\\ \pi_{k'k} &= p(n_{k'} + I_{k'k} n_N) LX_{hk'} + I_{k'k} n_N (p_{k'k} - c)\\ \pi_{Gk} &= p(n_k + I_{kk} n_N)(1 - l_{kk}) X_{gk} - F_1\end{aligned} \tag{6}$$

In expressions (5) and (6), the first letter in the subscript denotes the player whose profits are being specified, while the second letter denotes the equilibrium regime (C,A and B for regimes C,XA and XB respectively). Similar notation is employed for the platform prices, license fees and the indicator variables, and this notation will be preserved throughout the paper. As described earlier, profits for the platforms accrue from two sources—license fees from existing/new complements given by the first term in expressions (5) and (6) and from sales of platform memberships, given by the second term.

The specification of exclusive profits in Eq. (6) can now be used to define two *incremental value* variables, δ_A and δ_B, which play a key role in the identification of the equilibrium exclusivity regimes as well as the characterization of equilibrium profits. Before doing so, it'll be useful to first define some intermediate "revenue" variables that are then used to specify δ_A and δ_B.

Definition $R_{kk0} = \pi_{kk} + \pi_{Gk}$, $k = A,B$ assuming $I_{kk} = 0$.
Definition $R_{kk1} = \pi_{kk} + \pi_{Gk}$, $k = A,B$ assuming $I_{kk} = 1$.
Definition $R_{kk'0} = \pi_{kk'}$, $k = A,B$; $k' \neq k$ assuming $I_{kk'} = 0$.
Definition $R_{kk'1} = \pi_{kk'}$, $k = A,B$; $k' \neq k$ assuming $I_{kk'} = 1$.

Table 2 provides a more elaborate depiction of these definitions. Here R_{kk1} denotes the total profits accruing to the platform k plus the strategic developer G when the new complement is exclusive to platform k, assuming that new members join platform k (i.e. $I_{kk} = 1$). R_{kk1} includes the platform's profit from membership fees, the *total* revenue from the sale of the new complement on platform k (which is shared between platform k and developer G), and the *license* revenue to platform k from the existing complements sold for the platform (to both new and current members). Thus R_{kk1} is the total profit generated by the partnership of platform k and developer G, when G is exclusive to k. It does not explicitly consider how this profit is

Table 1
Summary of notation used in the paper.

Notation	Description
k,k'	Indices for platforms (and the corresponding segments). $k,k' = A,B$; $k' \neq k$
n_k	Number of customers in segment k, $k = A,B,N$
$U(.),V(.)$	Utility functions for representative consumer
x_g,x_h	Quantities of the new and existing complements consumed by the representative consumer
X_g,X_h	Per-capita demand for new and existing complements
δ_A,δ_B	Incremental value to platforms A,B from the new complement
α_g,α_{hk}	Quality parameters for the new and existing complements respectively on platform k
π_A,π_B,π_G	Profits of platform A, platform B and the strategic developer G
p_k	Price of platform membership for platform k
p	Price of complements—assumed equal for all complements
L,l	License fee as percentage of complement price paid by the existing and new complements respectively
F_1,F_2	Fixed cost of development for strategic complement when it is exclusive and non-exclusive respectively
c	Constant marginal cost of platforms—assumed symmetric for both A, B
γ	Degree of substitutability between the new complement and existing complements (used in Section 4 and the Appendix)

Table 2
Descriptions of the R terms.

	G is exclusive to A		G is exclusive to B	
	New customers join A	New customers join B	New customers join A	New customers join B
Total profits to A (and G)	R_{AA1}	R_{AA0}	R_{AB1}	R_{AB0}
Total profits to B (and G)	R_{BA0}	R_{BA1}	R_{BB0}	R_{BB1}

shared between the platform and the complement developer G. The assumption that new customers join platform k is equivalent to assuming that platform k will charge a sufficiently low membership price (p_{kk}) such that the new customers find it optimal to join platform k. When this is not true, R_{kk0} provides the total profit to the platform and the strategic developer G when platform k does not serve the new customer segment despite G being exclusive to it.

The $R_{kk'1}$ and $R_{kk'0}$ terms denote the profits to platform k when the new complement G is exclusive to the other platform (k'), assuming new customers join platform k and k' respectively. These include profits to k from new platform memberships (if $I_{kk'}=1$) and the license fees from existing complements, but do not include the profits for G as it is not available on platform k.

In general, a platform will choose to recruit the new customers or not, depending on which option results in higher profits. This is reflected in the following definitions for the incremental value variables δ_A and δ_B.

Definition $\delta_A = R_{AA} - R_{AB}$ where $R_{AA} = \text{Max}(R_{AA0}, R_{AA1})$ and $R_{AB} = \text{Max}(R_{AB0}, R_{AB1})$

Definition $\delta_B = R_{BB} - R_{BA}$ where $R_{BB} = \text{Max}(R_{BB0}, R_{BB1})$ and $R_{BA} = \text{Max}(R_{BA0}, R_{BA1})$.

The δ_k terms are crucial to our analysis and are the primary drivers of results. They denote the *incremental total profit* created on a platform k by G when it is exclusive to k, as compared to a situation when G is exclusive to the other platform (k'). The δ_k terms can be thought of as a measure of the "value at risk" that the platforms face in this situation i.e. how much does a platform stand to lose if the new complement enters into an exclusive relationship with the *other* platform? Hence the values of δ_k determine how much the platform would be willing to share with the new complement G to avoid being left out.

3.2. Equilibrium regimes and profits

The incremental value variables (δ_A and δ_B) defined in the previous subsection are now used to derive some results related to the equilibrium exclusivity regimes and the associated profits. Proposition 2 below is central to identifying the equilibrium outcomes and its proof provides valuable intuition about the derivation of these outcomes. Hence the proof is included here in the main body instead of the Appendix.

Proposition 2. *If $\delta_k > \delta_{k'}$, then platform k cannot be excluded from the new complement in any subgame perfect equilibrium of the game.*

Proof. Let $\delta_k > \delta_{k'}$, but assume that the subgame perfect equilibrium involves G being exclusive on platform k'. Also assume, without loss of generality, that the revenues from the sale of complements directly accrue to the platforms, which then transfer the revenues less any license fees to the complement developers (This assumption is purely for clarity of exposition and the arguments presented are not affected by whether the platform collects the revenues and transfers a part of them to the complement developers or the other way around).

Now, let platform k make the following offer to G: Platform k will pay G an amount equal to δ_k if G switches loyalties and goes exclusive with platform k instead of platform k'. If G accepts the offer and switches, then platform k will be no worse off than before because the difference between the total profits in the two cases for platform k is exactly δ_k. Also note that platform k' cannot make an acceptable counter-offer to G because the maximum total amount that platform k' would be willing to give up to retain G would be $\delta_{k'}$ (which includes any amount it was paying G in the first place) which is less than δ_k. Therefore G will accept platform k's offer and switch. Therefore, any equilibrium of this game cannot exclude platform k.

According to Proposition 2 the new complement G will always be available on the platform with the higher incremental value, though the regime may be exclusive or common. For example, if $\delta_B > \delta_A$, then the equilibrium outcome will have either G non-exclusive (regime C), or G available only on B (regime XB). The opposite is true when $\delta_A > \delta_B$. The arguments presented in the proof of Proposition 2 also make it clear that when $\delta_k > \delta_{k'}$, platform k can unilaterally exclude platform k', if it so wishes, through an appropriate offer of contractual terms to G.

Since the platform with the higher δ controls the equilibrium exclusivity regime, we'll refer to it as the *dominant* platform and the other one as the *dominated* platform. Under different conditions, the larger or the smaller platform may be the dominant one. Dominance does not imply that the platform is able to appropriate a significant portion of the profits created on the platform. Indeed as we will discuss later, a dominant platform may need to surrender most of the surplus to the strategic complement developer to avoid getting into an unfavorable exclusivity regime. Also, while the dominant platform can make G exclusive to it, it may in fact prefer to use this leverage to extract additional rents without excluding the other platform from the new complement. Thus, the dominant platform compares its potential net profits under the *exclusive* and *common* regimes to structure a set of contracts that drive the outcome towards its preferred exclusivity regime.

Having discussed the equilibrium exclusivity regimes, we now turn our attention to the associated profits. The next two propositions specify the equilibrium profits of the complement developer and the dominated platform respectively. First, considering the complement developer, note that a contractual offer that leaves G with retained gross profits (after paying license fees, but before accounting for the fixed development expenses) of $\geq \delta_{k'}$ is *necessary* and *sufficient* for the dominant platform k to make the complement exclusive, or non-exclusive, at its choice because platform k' will not be able to make a superior counter-offer. The following proposition formalizes this assertion.

Proposition 3. *If $\delta_k > \delta_{k'}$, then the strategic developer G makes a net profit equal to $\delta_{k'} - F_1$ in any subgame perfect equilibrium.*

Proposition 3 implies that the strategic developer's net profit does not depend on the equilibrium exclusivity regime that arises as the outcome. Rather, it depends on the *incremental value* it brings to the *dominated* platform, and remains the same whether the equilibrium regime involves exclusivity or non-exclusivity. Proposition 3 should not be construed to mean that the developer G has no strategic power. In fact, the strategic developer has a great deal of bargaining power due to the incremental value it creates for the dominated platform and, as will be evident from the discussion in Section 4, often ends up capturing the lion's share of the profits. Going forward, we'll assume that $\min(\delta_A, \delta_B) > F_1$, meaning the strategic developer's individual rationality constraint is satisfied at least for exclusive supply on one platform. Satisfaction of this condition is necessary for the new complement to be introduced into the market in the first place and therefore making this assumption a priori obviates the necessity to repeat the condition every time. The next proposition specifies the equilibrium profits of the dominated platform.

Proposition 4. *If $\delta_k > \delta_{k'}$, then in any subgame perfect equilbrium, $\pi_{k'} = R_{k'k}$.*

Following our earlier definition, $R_{k'k}$ denotes the profit accruing to platform k' when the new complement G is exclusive to platform k. Proposition 4 thus implies that in any subgame perfect equilibrium of the game, the dominated platform is left with a net profit that is exactly equal to its profit in a scenario where the new complement G is exclusive to the dominant platform. The notable aspect of Proposition 4 is that it *does not require* exclusivity; it is true whether G is exclusive to the dominant platform or non-exclusive. This suggests that if additional surplus can be created on the dominated platform through a non-exclusive supply of G, then this surplus would be extracted away by either the strategic developer G or the dominant platform k. In fact Proposition 3 implies that this additional surplus is completely extracted away by the dominant platform (indirectly in the form of higher license payments from G). This sometimes provides an incentive for the dominant platform to choose a common regime instead of an exclusive regime. However, non-exclusivity offers a trade-off—between higher license fee revenues and higher revenues through platform membership fees. When the new complement is exclusive, it increases the degree of differentiation between the platforms, thereby relieving price pressure in the membership market. Further, exclusivity may also strongly influence a platform's ability to successfully recruit the new customers.

Propositions 3 and 4 are also important because they provide us with a way to identify an equilibrium set of license contracts that will satisfy the strategic developer's and the dominated platform's individual rationality and incentive compatibility constraints. Further, it is evident from the foregoing discussion that, even when the equilibrium outcome is a common regime, the profits of the players are strongly influenced by which platform is the dominant one. Therefore to further distinguish the dominant platform in a common regime, we'll use CA and CB to represent the common regimes when A and B are the dominant platforms respectively. So when the equilibrium regime is common, the outcomes will take three subscripts instead of the usual two. For instance, π_{GCB} will represent the net profit of the strategic developer G when the regime is CB (Common dominated by B); l_{ACA} will represent the license fee that G pays to platform A under a CA (Common dominated by A) regime, and so on.

3.3. Platform pricing and membership choice

We now turn to platform prices and platform choice by new customers. The crucial insights required to understand the incentives driving the pricing choices of platforms in the second stage of the game are provided in the following remarks.

Remark 1. Given the exclusivity regime and the corresponding license fees determined in the first stage, the second stage [platform] pricing choices of the platforms do not affect their revenues (or profits) from their current members.

Remark 2. The lowest membership price that a platform is willing to charge will exactly equate its total profits on the new customer segment to zero. Note that this minimum price is below the platform's marginal cost (c), as the customers also buy complements from which the platform derives license fees.

It is easy to understand why the first remark should hold. The membership prices of the platforms in the second stage only affect the platform and complement choices of the new customers, but do not affect the complement choices of the platform's current members. The only factors that affect complement revenues from current members are the selection of complements available and the complement prices, which are all determined before the second stage. The second remark follows from the first. If the platforms' second stage actions on the new customer segment do not affect their profits from current members, then any price that yields some net profit to the platform will be preferred to not recruiting the customers in the new segment (which would yield a net profit of zero from this segment). Therefore the minimum price will exactly equate the profits on the new segment to zero. However, this does not imply that the platform will always charge this minimum price. It simply implies that, at any price above this minimum, the platform has an incentive to undercut its competitor's price (in a Bertrand fashion) if required, in order to recruit the new customers.

Now turning to the platform choices of customers in the new segment, the following lemma specifies these choices in cases where the equilibrium outcome regime is exclusive.

Lemma 4. *Under any subgame perfect equilibrium that corresponds to an exclusive regime (XA or XB), new members join the dominant platform.*

The generic platform choices of new customers in cases where the equilibrium outcome is non-exclusive are not possible to specify analytically.[11] Lemma 4 along with Remarks 1 and 2 can be used to specify the second stage equilibrium prices associated with any *exclusive* equilibrium regime. This is done in two simple steps.

1. Equate the total net profit of the dominated platform on the new customer segment to zero. This provides the price of the dominated platform in terms of the known second stage complement demand (which are independent of the platform price) and the license fee that it obtains from existing complements (which is an exogenous parameter).
2. Equate the net utility $(V(X_{gk},X_{hk})-p_k)$ that the representative consumer for the new segment derives from both platforms and solve for the price of the dominant platform. Lemma 4 ensures that the dominant platform will find it profitable to recruit the new customers at this platform price.

These two steps, along with the results in Propositions 2 through 4, will be used to characterize the equilibrium outcomes in the next section.

4. Equilibrium regimes, prices and profits

This section discusses the outcome of an extensive numerical analysis conducted based on the analytical results derived in Sections 2 and 3. The results discussed relate primarily to the conditions under which different exclusivity regimes arise as equilibria and the associated prices, profits and division of surplus.

For this analysis, we assume the following quadratic specification for the representative consumers' utility function [21]:

$$U(x_g,x_{hk}) = \alpha_g x_g + \alpha_h x_{hk} - \frac{1}{2}(x_g^2 + x_{hk}^2) - \gamma x_g x_{hk}$$
$$\gamma \in (0,1); \quad k = A,B$$

Here, γ is the degree of substitutability between the existing complements and the new complement. The rest of the parameters are identical to those discussed in the previous sections. The higher the value of γ, the closer the new complement is to the existing set of complements. Therefore, given the consumers' desire for variety (assumption A3), the higher the value of γ, the lower the *incremental* value we would expect the new complement to add to a platform. Analytical details of this analysis are provided in the Appendix. Here we focus on the results of a numerical analysis conducted using this specification.

A thorough exploration of the parameter space established that the most insightful way to frame the outcomes is in terms of two variables that describe the *current state* and *structure* of the platform market. First is the *current level of total penetration* in the platform market. This is defined as the fraction of total customers that have currently adopted one of the two platforms. Algebraically, it is specified as $(n_A+n_B)/(n_A+n_B+n_N)$. This is depicted along the *x-axis* in all the figures in this section. The second variable used for framing the outcomes is the *degree of asymmetry* in the platform market. This is defined as the ratio of the installed base of the smaller platform to

[11] Our numerical analysis (in Section 4) revealed that the dominant platform continues to recruit new customers in most cases even under a non-exclusive equilibrium regime.

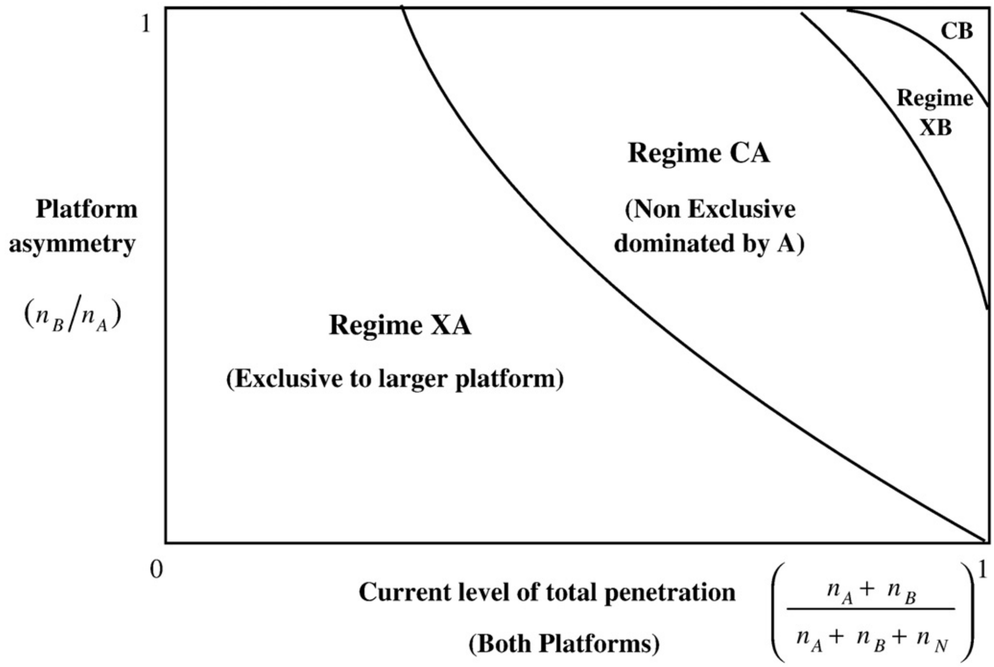

Fig. 2. Equilibrium exclusivity regimes.

that of the larger platform i.e. n_B/n_A. This is depicted along the *y-axis* in Fig. 2. Values of n_B/n_A near zero imply that the smaller platform has an installed base which is insignificant compared to the larger platform, while values near 1 imply that the platforms are of similar size.

4.1. Equilibrium exclusivity regimes

Fig. 2 depicts the exclusivity regimes that arise as subgame perfect equilibria of the two-stage game we have analyzed. For most of the parameter space, the larger platform is dominant, though *G* faces stronger competition from existing complements on *A*. When market penetration is low, the dominant Platform A exclusively secures the new complement. However, with higher market penetration, there are fewer and fewer new customers, and Platform *A* prefers not to exclusively secure the new complement.

Fig. 2 further reveals that under some conditions the smaller platform can dominate. This happens when the two platforms are of roughly similar size and the market penetration is relatively high. Further, for the smaller platform B to dominate, two other special conditions need to be satisfied. First, the larger platform, perhaps as a consequence of its being the early leader, should maintain an advantage in terms of the number of existing complements available for it, even if the smaller platform catches up with it in terms of installed base. Second, the new complement has to be sufficiently similar to the existing complements (i.e. γ needs to be sufficiently high[12]), such that significant demand for the new complement comes from cannibalization of existing complements, rather than a net expansion in the overall complement demand. If these two conditions are not satisfied, then the larger platform continues to dominate even when the platform market has achieved a high level of penetration. While it is interesting that sometimes the smaller platform can take a larger platform head-on in a fight for complement exclusivity and win, it's appeal is somewhat limited by the fact that this happens at a high level of platform penetration. Consequently, going forward we'll focus our analysis on the set of parameter values for which the larger platform is always the dominant one.

4.2. Economic efficiency

Since the marginal costs of the complements are zero, it is economically efficient to supply the complement non-exclusively to consumers of both platforms as long as the porting costs $(F_2 - F_1)$ are not very high. If this is true, then any form of exclusivity strictly creates a dead weight loss. However, as seen in Fig. 2, deadweight loss due to exclusivity on Platform A (the dominant platform) is limited, since the number of people denied access to the new complement is relatively small: exclusivity arises at comparatively low levels of total penetration and when the installed base of the excluded platform (Platform *B*) is relatively small. On the other hand, the exclusivity on Platform *B*, which sometimes arises as the outcome when total market penetrations are high, can lead to a much higher deadweight loss as almost half the market is shut out in this case. However, recall that one of the conditions for this outcome to result is that much of the demand for the new complement is obtained through cannibalization of demand for existing complements, rather than through an expansion of the market. As a consequence, the actual efficiency losses even in this case are milder than they might first seem.

4.3. Equilibrium demand and prices

The rest of this section presents equilibrium demands, prices and profits for the players. In doing so, we'll focus our presentation on a fixed level of platform asymmetry (essentially at a fixed level along the *y-axis* in Fig. 2) and discuss the outcomes at two different levels of total market penetration—At a *low level*, *where the equilibrium outcome is Exclusive A* and *at a higher level where the equilibrium outcome is Non-exclusive*, but still dominated by *A*. For comparison, we also sometimes present the equilibrium results (for the same parameter values) arising out of the analysis under a different assumption—the assumption that exclusive contracting is not possible/allowed. This "exclusive contracting not possible" case is modeled in a fashion similar to our analysis thus far, the one difference being that the new complement is also considered non-strategic in this case,

[12] In our numerical analysis, we observed this equilibrium only for values of $\gamma > 0.5$.

i.e. it also pays the same license fee (L) as the existing complements. Therefore there is no explicit endogenous contracting between the complement developer and the platforms. This effectively implies that the game analyzed becomes a single stage game (only the second stage of the game analyzed in Sections 2, 3, and 4). The analysis is fairly straightfoward and the details are hence excluded for reasons of brevity.

Fig. 3 depicts the equilibrium per capita demand for the new complement at two different levels of total platform penetration. At low levels of total penetration, G is exclusive to Platform A and hence the demand on Platform B is zero. At high levels of penetration, the resulting equilibrium is a common regime, and the new complement has positive demands on both platforms. In this case, the per capita demand for G is higher on the smaller platform. This is due to the fact that it faces less competition from existing complements on the smaller platform (recall that the number of other complements increases with the installed base due to indirect network effects). This is also the reason why the per capita demand for the complement on the bigger platform is more at lower levels of penetration than at higher levels.

The platform price for A (the platform which sells to the new customers) at two different levels of total penetration is depicted in Fig. 4 . The corresponding prices under the situation where exclusive contracting is not permitted are also depicted for comparison. There are two things of note about these prices. First, the prices for Platform A are much higher under the exclusive regime than the non-exclusive one. This is not surprising since platforms are less differentiated in the non-exclusive regime, and this increases price competition. Second, the price in a situation where exclusive licensing is permitted is higher than the price when it is not permitted. This is especially true at low levels of penetration where exclusivity is the equilibrium outcome, and the resulting differentiation confers platform A with more pricing power as compared to the no-contracting case where the new complement is non-exclusive. What is surprising, however, is that even under the common equilibrium regime, the price is higher when exclusive contracting is permitted as compared to when it is not. This clearly cannot be explained by differentiation as both platforms have the new complement available in the common regime (both when exclusive contracting is possible and not possible). The reason for the higher price of A here is more involved, and arises from the fact that platform A can indirectly cause platform B's equilibrium price to increase, and can therefore increase its own price. The ability to set license fees strategically, along with its dominance, enables platform A to cause a reduction in the license fees that G pays to platform B below the no-contracting level (i.e. $l_{BCA}<L$). This reduction in license revenue causes B to increase its platform price, thereby enabling A to respond in a like fashion. Thus, the fact that A can force an exclusive regime, if it so wishes, confers power to A even when the equilibrium regime is non-exclusive.

The demands in Fig. 3 as well as the prices in Fig. 4 were depicted at a fixed level of asymmetry between the two platforms. As the two platforms become more symmetric in terms of installed bases (i.e. as n_B/n_A goes up) the non-exclusive equilibrium becomes a lot more likely. Further, platform prices go down due to decreased differentiation between the two platforms. Therefore if increased penetration of the platform market is accompanied by a reduction in asymmetry, then the prices in the market may very well go down (as compared to going up as discussed in the previous paragraph).

4.4. Profits

Fig. 5 depicts the total profits for the three strategic players (A,B and G), as well as the net profits of the complement developer (G) alone, in situations where exclusive contracting is possible and not possible. The figure shows that total industry profits are lower when total penetration is high (and the equilibrium is non-exclusive) as compared to when the penetration is low (and the equilibrium is exclusive). This is somewhat surprising because, at higher levels of penetration, more complements are available for each platform (due to the larger size of their installed bases) and this should result in an increase in industry revenues. Indeed this does happen. However, this increase is dominated by a larger drop in platform profits from new customer memberships, caused by two factors (i) As discussed with Fig. 4 the platform prices are significantly lower in the common regime at high penetration levels; (ii) At high levels of penetration, there are also fewer new customers to recruit.

Now turning to the profits of the strategic complement developer (G), Fig. 5 shows that in the case with exclusive contracting, the profits go down from low levels of total penetration to high levels of total penetration. This is despite the fact that at high levels of penetration, the complement is non-exclusive and serves members of both platforms, while at low levels, it is exclusive and serves only one

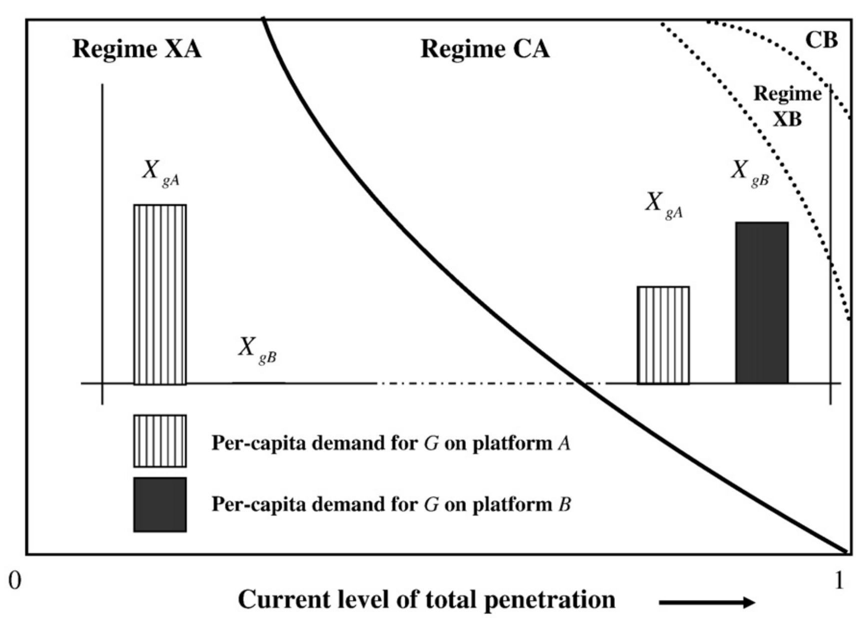

Fig. 3. Equilibrium demand for the new complement.

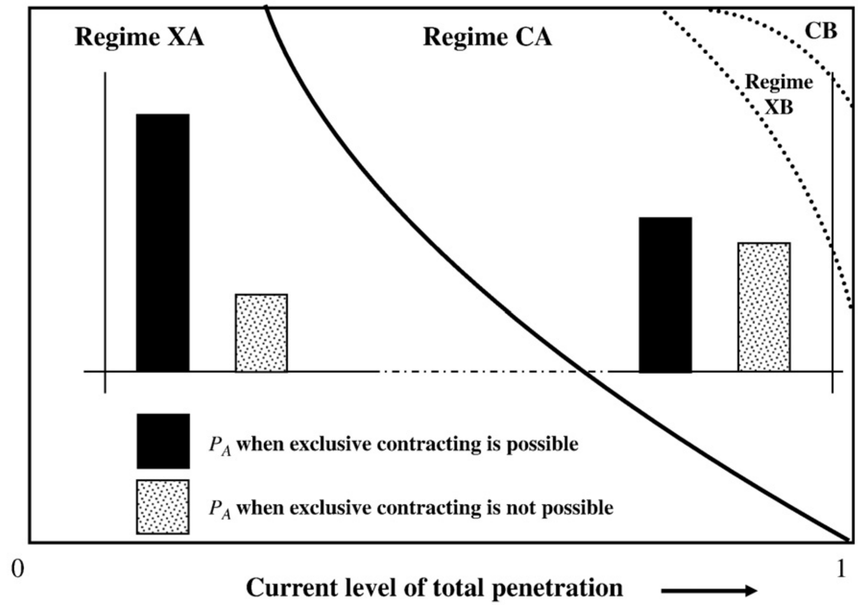

Fig. 4. Equilibrium price for Platform A with and without the possibility of exclusive contracting.

platform. The drop in profits is due to two reasons. First, as the level of total current penetration increases, the extent of competition from other complements goes up and as a consequence, demand for the new complement goes down. The second reason is more indirect. As the market penetration increases, there are few new customers. Therefore *the ability of the strategic complement to influence platform profits* is also lower. Therefore, in addition to the total industry profits shrinking, the share of profits obtained by the strategic complement will also go down (which is discussed in more detail below).

4.5. Profit shares

It is also interesting to examine how the total industry profits (for the strategic players) are split between *A*,*B* and *G*. Based on our analysis, we find that in the absence of exclusive contracting, the larger platform always earns the biggest share of the profits. However when platforms compete to make the strategic complement exclusive, the winning platform (in this case Platform *A*) will need to give up a significant fraction of the surplus in order to obtain exclusivity. For instance, a closer examination of Fig. 5 reveals that the complement developer *G* corners more than half the total industry profits generated at low levels of total penetration, where the outcome is an exclusive equilibrium. However, this does not necessarily mean that Platform *A* is worse off in a situation where exclusive contracting is feasible. To see this, recollect from Fig. 5 that the total industry profits at low levels of penetration in the presence of exclusive contracting are much higher than in its absence. Therefore a smaller share of a larger pie might still result in higher profits for *A*, and this is indeed often the case.

However, there are exceptions to this. If the intensity of competition between the platforms is very high, then the larger platform, even when it wins exclusivity, might suffer from a sort of

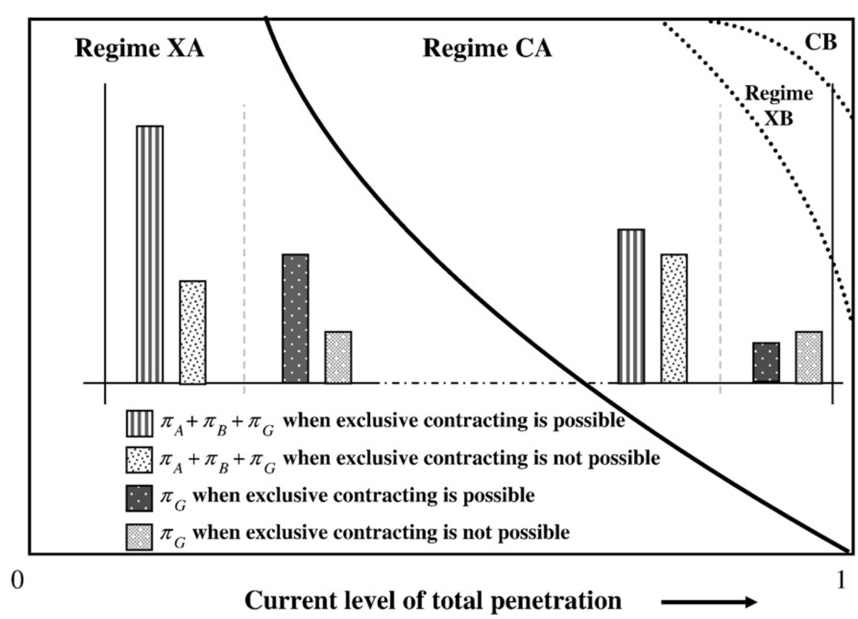

Fig. 5. Total industry (A + B + G) and complement developer (G only) profits with and without exclusive contracting.

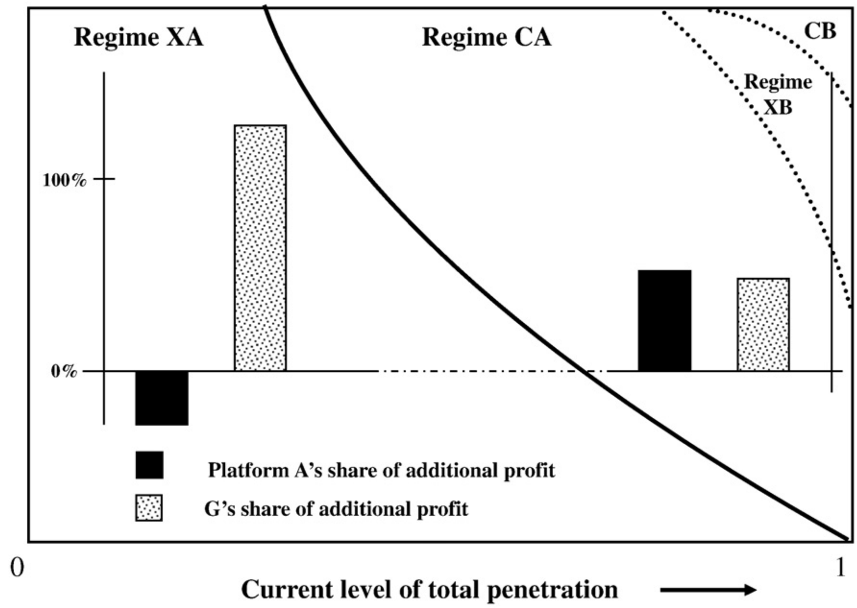

Fig. 6. Shows the split of the additional industry profits between Platform A and Developer G.

“winner's curse”, wherein the resulting exclusive profits are lower than they would be in a case where the new complement were not available in the market at all. This usually happens at low levels of total penetration, when the platforms are of roughly equal size (i.e. a low degree of asymmetry) and the new complement is of high quality (α_G is high). Fig. 6 illustrates one such instance. It shows how the additional industry profits created by the new complement are split between the dominant platform and the complement developer. By additional profits, here we mean the total industry profits of the three strategic players (*A*, *B* and *G*) in the presence of the new complement minus the total profits (of *A* and *B*) without the complement. It is a measure of how much the new complement expands the industry pie. What is striking about Fig. 6 is that, under these conditions, the strategic complement might appropriate more surplus than it creates. Notice that at low levels of platform market penetration, the share of additional profit cornered by *G* is more than 100%, while the corresponding share for *A* is negative. Thus Platform *A* in this case is worse off because of the availability of the new complement than it was before. Essentially, the new complement here is very influential in swinging the new customers from one platform to the other and therefore the platforms compete bitterly for it. Having the complement available on their platform becomes a strategic necessity and as a consequence, Platform *A* ends up sacrificing a great deal of profit in order to prevent the smaller platform *B* from locking up the complement. Interestingly, Platform *A* would not have to face this dilemma if exclusive contracting were not feasible at all, in which case, introducing the new complement would always be unambiguously better for the larger platform.

Summarizing, the presence of exclusive contracting almost always applies a squeeze on the profits of the smaller platform. For the larger platform, as well as for the complement developer, exclusive contracting can cut both ways. Under conditions where a high quality complement becomes a strategic necessity (generally at low levels of total penetration, and low levels of asymmetry), the complement developer gains disproportionately at the cost of the larger platform as compared to a scenario where exclusive contracting is not possible. However, at higher levels of penetration or at higher levels of platform asymmetry, the ability to write exclusive contracts enables the larger platform to appropriate a large fraction of the surplus applying a squeeze on both the complement developer and the smaller platform.

5. Conclusions and discussion

In the current paper, we have developed and analyzed a formal model of competition between platforms that depend on third party developers to supply valuable complements for their platforms. We applied this model to study exclusive contracting between strategic complement developers and platforms and derived some interesting results. Our results show that the possibility of exclusive contracting has differential effects at different levels of platform market maturity. We now summarize and discuss the main results and highlight their managerial implications for platform vendors and complement developers.

5.1. Exclusivity is often the outcome in the nascent stages of the platform market

Complement developers are naturally reluctant to enter into exclusivity arrangements since it closes out a subset of the customers to them. Despite this reluctance, our results indicate that the outcomes in the nascent stages of the platform markets are often exclusive. This comports well with the empirical observation that platforms such as game consoles often seek exclusive complements in the early stages, and our results suggest that complement developers may in fact make higher profits by negotiating favorable terms in exchange for exclusivity, rather than insist on non-exclusivity.

Exclusivity in the nascent stages also implies that early leads can become self sustaining. Leadership in installed base makes a platform dominant in terms of securing exclusivity, which can then be used to catapult it further ahead. This partially explains why platform vendors such as console manufacturers place a great deal of emphasis on being the first to the market.

5.2. Exclusivity is sometimes necessary to capture new customers, but may come at a price

Our analysis indicates that complement exclusivity is often necessary for platforms to attract new members. This is especially true when the platforms are relatively symmetric in terms of installed bases and each of them is relatively small i.e. in the early stages. In these cases, while obtaining exclusivity enables a platform to recruit new customers, the pursuit of such an outcome comes at a significant sacrifice of revenues, exposing it to a kind of winner's curse. Therefore platform owners need to be careful about aggressive pursuit of exclusivity strategies, especially if such pursuit triggers quid pro quo reactions from competitors.

5.3. New complements face a quality hurdle

Our analysis indicates that there is a threshold level of complement quality for each platform below which it will not be viable to introduce a new complement. Further, this threshold level for quality is higher for the larger platform and at the later stages of the platform market. Therefore complements which do not meet the higher threshold for the larger platform in the market, might end up being developed exclusively for the smaller platform by default. A further implication for complement developers is that they may be better off waiting for the [early stage of] the next generation platform market, rather than introducing their complements into a mature market.

5.4. Non-exclusivity is usually the outcome in the mature phase

Our analysis indicates that non-exclusivity is most likely to be the outcome in the intermediate to later stages of the platform market. The reason for this non-exclusivity is the fact that exclusivity may not be very valuable to a platform at this stage and therefore it prefers to leave a complement non-exclusive and harvest it for higher rents in the form of license fees. The resulting outcome could be considered a win–win situation for all parties—the smaller platform has access to high quality complements, the customers have more choice, and the complement developer can potentially serve the entire market.

5.5. The efficiency distortion from exclusivity is limited

From a social perspective, exclusivity always results in a loss of surplus because some of the customers who derive value from the complement are excluded from it because of their platform ownership. However, given the nature of our results, where exclusivity most often results in the early stages while non-exclusivity is more common in the later stages, the losses arising from permitting exclusive contracting are relatively mild. However, this does not imply that consumers are not hurt. Exclusivity results in a significant transfer of surplus from customers to the industry players.

5.6. Exclusivity dampens price competition in the platform market

While the most important reason for pursuing exclusivity is a desire on the part of the platform owners to grow their installed base, this is not the only reason. Exclusivity might sometimes be pursued even if it does not add substantially to a platform's membership growth. This is because the presence of exclusive complements serves to differentiate the platforms thereby dampening the intensity of price competition between them.[13] A common strategy in platform markets is to use them as loss leaders, and make up the lost revenues through complement licensing. While we do observe below cost pricing in our analysis, the subsidy given by the platforms is much lower than would be the case if exclusive contracting were not feasible.

5.7. Under some conditions, the smaller platform dominates

While the larger platform is dominant in most cases, our numerical analysis suggests that the smaller platform dominates when (i) the market penetration is high, and the difference in installed base between the two is platforms is not significant; and (ii) the new complement would face significant competition from existing complements on the larger platform, sufficient to over-turn the benefit of the larger market size offered on the larger platform.

While the results we have derived are quite interesting, a significant limitation of our analysis is that we have used a single period, cross-sectional model to study the changes in industry outcomes at different stages of evolution of the platform market, which is essentially a dynamic/longitudinal phenomenon. An obvious extension would be to extend the model to a truly dynamic setting, where the evolution of the installed base is explicitly modeled over time. Unfortunately, tractability precludes our being able to do so in the current set-up. However, the installed bases of the platforms and the size of the new customer segment serve as useful state variables allowing us to interpret the model as one stage of a state dependent dynamic model without uncertainty, thereby allowing us to gain valuable insights into the possible outcomes in a dynamic case. Given the absence of research in this area, we believe that this is a reasonable compromise and a good starting point.

Another modeling choice we have made in the interest of tractability is to treat the platforms themselves as homogenous, with any heterogeneity arising solely from the differential supply of complements. This is an obvious simplification, but it is an assumption we are relatively comfortable with as far as the insights from the analysis go. This is because the most basic effect of any inherent differentiation among platforms will be to mitigate the level of competitive intensity between the platforms, thereby decreasing the importance of complements and consequently the effect of exclusive licensing. Beyond this moderation of the results, we conjecture that there is little qualitative difference. Future research could explicitly model heterogeneity among platforms which offer an intrinsically different experience (e.g. Nintendo Wii, with its three-dimensional movement detection), in addition to the heterogeneity arising from the available complements. Multi-homing of platforms, though not widely prevalent in the video game industry, is possible in other platform-based goods, and is also worth exploring in future research.

Finally, while the primary results we have derived in the paper are consistent with anecdotal evidence, it will be interesting to subject them to rigorous empirical scrutiny. Organizations such as the NPD group regularly collect data on the sales and prices of video games and consoles. Access to this data will enable one to test whether the exclusivity regimes evolve over a platform generation in the manner suggested by our results. However, results related to license fees cannot be tested without access to confidential data available to the platform and complement vendors.

Appendix A. Proofs

Lemma 1. Assumption A4 along with the respresentative consumer's utility in (4) implies that $\frac{\partial^2 V}{\partial x_i \partial \alpha_i} > 0$ $i = g, h$. Therefore the consumer's utility function has increasing differences in a complement's quantity and quality. Theorem 2 from [1] then implies that $\frac{dX_i}{d\alpha_i} > 0$.

Lemma 2. Assumption A3 implies that the complements are strategic substitutes. Therefore an increase in the demand for one complement decreases the demand for the other i.e. $\frac{dX_i}{dX_j} < 0$. From lemma 1, $\frac{dX_j}{d\alpha_j} > 0$. Therefore $\frac{dX_i}{d\alpha_j} = \frac{dX_i}{dX_j}\frac{dX_j}{d\alpha_j} < 0$.

Proposition 1. Consumer's utility maximization problem in (4) implies that demand for the strategic product will be zero if $\frac{dU}{dx_g} < p$ for all $x_g \geq 0$. (Note that the Hessian for the problem in (4) is negative definite and hence the FOCs are sufficient). From, assumption A3 we have $\frac{\partial^2 U}{\partial x_g \partial x_h} < 0$ and from assumption A2, $\frac{dU}{dx_g}$ is finite at $x_g = 0$. Therefore for *sufficiently high* values of x_h, we'll have $\frac{dU}{dx_g} < p$ for all $x_g \geq 0$ and the

[13] The platform with the exclusive complement is more valuable and does not have to compete as strongly on price.

demand for the new complement (X_g) equals zero. However, is X_h high enough for this to happen?

For a given value of α_g, let $\overline{x_h}$ be such that for all $x_h \geq \overline{x_h}, X_g = 0$. Is $X_h \geq x_h$? The answer depends on the values of the other parameters—in particular, α_h. From Lemma 1, we have $\frac{dX_h}{d\alpha_h} > 0$. Therefore, for sufficiently high values of α_h, we'll have $X_h \geq \overline{x_h}$ and X_g will be zero. Further, since $\frac{dX_h}{d\alpha_g} < 0$ (from Lemma 2), a sufficient increase in α_g will cause X_h to fall below $\overline{x_h}$ and X_g becomes positive. Therefore for each value of α_h, there exists a threshold quality level α_g below which X_g is zero and above which X_g is positive. Using similar arguments based on lemmas 1 and 2, it is easy to see that the threshold quality level is higher for higher values of α_h or in other words, for the bigger platform.

Lemma 3. Part (a). We need to show that $X_g^I + X_h^I > X_h^0$ or alternatively, $X_g^I > X_h^0 - X_h^I$. Assume instead that the opposite is true. Then from assumption A3 ($\frac{\partial^2 U}{\partial x_g \partial x_h} < 0$) and the FOC for (4) we have, $\frac{\partial U(X_h^0 - X_h^I, X_h^I)}{\partial x_h} \leq \frac{\partial U(X_g^I, X_h^I)}{\partial x_h} = p$. The second part of assumption A3 ($\frac{\partial^2 U}{\partial x_i^2} < \frac{\partial^2 U}{\partial x_i \partial x_j}$) then implies that $\frac{\partial U(X_h^0 - X_h^I, X_h^I)}{\partial x_h} > \frac{\partial U((X_h^0 - X_h^I) - (X_h^0 - X_h^I), X_h^I + (X_h^0 - X_h^I))}{\partial x_h} = \frac{\partial U(0, X_h^0)}{\partial x_h}$. However the RHS of this inequality equals p from the FOC of (4) when the strategic complement is not available. Therefore we have a contradition, implying $X_g^I + X_h^I > X_h^0$.

Part(b). We need to show $X_h^0 > X_h^I$. Assume instead that the opposite is true. Based on assumption A3, this implies that $\frac{\partial U(X_g^I, X_h^I)}{\partial x_h} \leq \frac{\partial U(X_g^I, X_h^0)}{\partial x_h} < \frac{\partial U(0, X_h^0)}{\partial x_h}$. However the first and third terms of this inequality are both equal to p from the FOCs of (4) when the strategic complement is available and not available respectively. Therefore we have a contradiction, implying $X_h^0 > X_h^I$.

Proposition 2. Proof included in the main body of the paper.

Proposition 3. Assume that the dominant platform k offers G an exclusive licensing contract that leaves G with an equilibrium *gross* profit of $\delta_{k'}$. Since the net profit $\pi_G = \delta_{k'} - F_1 \geq 0$, the strategic developer's individual rationality constraint is satisfied for exclusive supply to the dominant platform. Further, since any exclusive offer from platform k' to G cannot provide it with a gross profit higher than $\delta_{k'}$, the strategic developer prefers the exclusive contract by the dominant platform to any exclusive offer made by the dominated platform. Now assume that the dominant platform makes a non-exclusive license offer, that leaves G with the same net surplus ($= \delta_{k'} - F_1$), G will be indifferent between the two offers. Therefore, the dominant platform can impose the equilibrium regime (exclusive or non-exclusive) of its choice by structuring license contracts such that G receives a net profit of $\delta_{k'} - F_1$ in either case.

Proposition 4. Since k is the dominant platform, the only two exclusivity regimes that can arise as equilibria are Xk or C (Proposition 2). When the resulting equilibrium is of type Xk, then $\pi_{k'} = R_{k'k}$ by definition and this forms the individual rationality constraint for platform k' to enter into any contracting relationship with the complement developer G. Further, in this case, the net profit to G would be $\pi_G = \delta_{k'} - F_1$, which will also be its net profit if the equilibrium regime is C (Proposition 3).

Now consider the case when the resulting equilibrium is of type C and assume that the license contracts are such that platform k' makes a net profit $\pi_{k'} = R_{k'k} + \Delta$ (where $\Delta > 0$). This cannot be an equilibrium because, in this case, the dominant platform k can increase its own profit by increasing the total license fee that it charges G by an amount Δ leaving G with a non-exclusive net profit equal to $\delta_{k'} - F_1 - \Delta$. Given this offer, G will prefer an Exclusive k contract to a non-exclusive contract with both k and k' unless k' surrenders the surplus Δ.

Lemma 4. Assume that the outcome exclusivity regime is Xk, but the dominant platform finds it optimal not to recruit the new customers. In this case, the dominant platform k will be strictly better off by making the equilibrium regime into a non-exclusive one and setting a platform price high enough (say $p_k = c$) at which the new customers join the dominated platform. This is because, in both cases it receives no revenues/profits from the new customer segment. But in the latter case, it can charge a higher license fee from G on existing customers, because G's total profit remains the same whether or not the outcome is exclusive (Proposition 3), and under non-exclusivity, G receives a part of its profit from complement sales on the dominated platform. Therefore any outcome where G is exclusive to k, but in which platform k does not recruit new customers, cannot arise as an equilibrium.

Appendix B. Supplementary data

Supplementary data associated with this article can be found, in the online version, at doi:10.1016/j.dss.2010.07.004.

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