Platform Preannouncement Strategies: The Strategic Role of Information in Two-Sided Markets Competition

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Abstract

The release of a new platform version is often preceded by prelaunch activities including a preannouncement of new features, improvements, and other innovations. The information contained within these preannouncements not only shape expectations of distinct but connected sides, e.g., users and developers in a video game platform, but also informs a rival platform in a competitive market. Through a game-theoretic analysis of three different preannouncement strategies (formal, informal, and no-preannouncement) in a duopoly, our research furthers the understanding of externality-related information on expectation formation and the associated competitive dynamics. The literature on the role of information in platform competition is limited, and as the first to model the use of this information (through preannouncements) as a strategic lever, we characterize the firms' equilibrium preannouncement strategies under different market conditions including when agents have an option to switch and/or the ability to multi-home. Our findings show a clear relationship between the equilibrium preannouncement strategies and agents' strength of taste preferences. In markets with weak preferences, firms pursue a no-preannouncement strategy in equilibrium to a formal preannouncement strategy where users and developers have strong taste preferences. Overall, our welfare analyses reveal that in a competitive market, firms will prefer not to pre-announce their platform features even if preannouncement may increase expected network effects. Consumer and social welfare are both higher in multi-homing markets than in single-homing ones.

1. Introduction

In several industries (e.g., automobile, consumer electronics), it is common for firms to preannounce the forthcoming release or launch of their products. Preannouncement is an important part of the pre-launch activities of a firm and can potentially influence both consumers and competitors. While product preannouncements target one group (consumers or users of the product), preannouncements of platforms (e.g., video game consoles, mobile operating systems) are often intended to inform and educate two (or more) distinct groups (e.g., game or application users and developers). Research in IS and Economics have referred to such markets as two-sided markets (Parker and Van Alstyne 2005).

Preannouncements and prelaunch activities contain information that may be critical to both sides of the platforms (and perhaps the competitor) as they help in forming expectations about the forthcoming platform. In addition, many technology-based platforms also have elements to them that create network externalities wherein users may gain more value not only from the increased number of users (called same-side network effects) but also from a greater number of developers (called cross-side network effects) (Eisenmann, Parker et al. 2006). Therefore, one can imagine that preannouncing any such network effects engendering (NEE) aspects in the new version of the platform is an important decision for the firm. More so because expectation formation by all parties (users, developers, and competitors) also needs to take into account the potential future user/developer base of the platform before purchasing the new version.

Extant research describes preannouncement as a *"formal, deliberate communication"* (Eliashberg and Robertson 1988, p.282) that helps a firm to fully inform its existing and potential consumers regarding the details of its future release. Preannouncement activities typically involve several channels including traditional media (television, trade shows, interviews, billboards, special events, etc.) and social media (e.g., Twitch, Facebook, Twitter, and specialized discussion forums).

In fact, a recent survey points out that Facebook has now become the second-most used source for preannouncement behind TV commercials (Schneider 2015). Perhaps, one would think that if firms are adding new NEE elements to their platform, then they should make every effort to transmit this information to the market. However, even if such a full-fledged preannouncement was meaningful from a user/developer point of view, firms still have to incur significant costs in engaging in such prelaunch activities. These costs are not trivial, e.g., setting up a booth at CES[1] and ancillary activities associated with informing the market about a new version of a video gaming console costs millions of dollars[2] even for market leaders such as Microsoft and Sony. Indeed, we observe that not everyone in the industry preannounces or invests in the same fashion.

Sometimes firms do pursue a *formal/full information* preannouncement of the new versions of their platforms thereby informing the market of all their NEE elements. For example, consider Nintendo Wii that came with an advanced motion-controller, which enabled gamers to enjoy group activities such as sports, dance, tournaments, workout, etc. Given the novelty of this feature and its importance to enjoying network effects (primarily with regards to group-related games/activities), prior to releasing Wii, Nintendo made significant investments (Sterlicchi 2013) to ensure that both sides (gamers and developers) of the platform understood the value of the new platform. As a part of its prelaunch activities, Nintendo recruited representatives to provide interactive demos (at home-shows, fitness expos, and major malls) and sponsored "Wii parties" to inform potential consumers regarding the experience and ease of playing games in a group using Wii. By their nature, many NEE aspects exhibit characteristics of experience goods (Yang and Mai 2010), and in the absence of actual consumption, significant investments may be necessary

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[1] Even startups or small sized firms have to invest hundreds of thousands of dollars at CES. https://www.inc.com/ilya-pozin/what-it-costs-to-exhibit-at-ces.html Last accessed on December 25, 2019.
[2] http://www.playstationlifestyle.net/2017/06/01/sony-marketing-budget-was-set-at-13-3-billion-yen-for-marketing-deals-and-advertising-partnerships-in-fy-2016/ Last accessed on December 25, 2019.

for consumers to fully understand and form expectations on the value of the platform (Draganska and Klapper 2007).

Even on the developer side, well before the actual release, Nintendo invested in providing extensive information on the APIs (Application Programming Interface) and toolkits that informed the market about the new NEE aspects through their Nintendo's Developer Portal. Overall, the trade-press attributed such prelaunch initiatives to Wii's success in retaining its user base, capturing new markets of "*alpha moms, pre-teen girls, and senior citizens,*" as well as attracting developers resulting in a number of new games launched on the day of platform release (Sterlicchi 2007).

Interestingly, firms do not always invest in such complete set of prelaunch activities for all their platforms. For instance, many experts attribute Nintendo's struggle with Virtual Boy to its inability to inform the two sides of the market regarding its key NEE aspects despite being ahead in the VR headset trend in the video game industry (Mulkerin 2016). In practice, we do witness situations where firms may not engage in any prelaunch activities at all (called a *no preannouncement* strategy in our paper). Further, there are cases where firms do not want to suffer the full investment in all the prelaunch activities but perhaps incur a part of this cost. The latter case is called *informal/partial preannouncement* in our paper where such a half-measure leads to the market becoming only partly aware of all the NEE aspects of the new platform.

Microsoft's Xbox One preannouncement can be characterized as such a case where not all network effects engendering aspects were fully communicated to the marketplace before launch. For example, while many features of the Xbox One platform, such as hardware specifications and some API support were preannounced, some key features like Xbox Live support and Kinect enhancements that allowed for multiplayer online gaming, were not promoted before the actual

launch. Indeed the industry publications warned that gamers are left with *"far too many unan-swered questions and vague details (regarding Xbox One)"* (Gallaway 2013) suggesting that gamers may not be able to have a full understanding of the network benefits from this platform before its release.

On the other side of the market, however, even with this less-than-a-full prelaunch, Microsoft itself seemed to be sure that game studios and developers who followed their communication on developer forums will understand their preannouncement (Charla 2016). Indeed, there is some evidence that though partial, from information provided in the API support and hardware specifications, developers realized that Microsoft was planning to enhance multi-player experience through NEE aspects of its features. This was borne out by intricate comments in development forums (Staff 2013) that reveal a sophisticated understanding of specific feature-sets likely in the new release (e.g., enhancements made to Kinect for group play, support from Microsoft's Azure for intensive gaming computations for multi-player games). Such observations lead to an understanding that perhaps the two sides of the market have different potentials to form expectations based on the same amount of a firm's investment in prelaunch.

From a managerial perspective, it is indeed important to understand the drivers and implications of preannouncement strategies in a platform setting. How do market characteristics impact preannouncement strategies? What is the impact of a loyal consumer base on preannouncement? How is the pre-launch decision affected by the presence of platform agnostic developers?

Such managerial questions abstract as a significant area of exploration for platform competition. Essentially, it translates into studying the role of information available in the marketplace in the platform competition. While there are a limited number of papers (Suleymanova and Wey 2012, Hagiu and Hałaburda 2014) that have explored this context, there is no research that

has investigated the strategic use of information wherein firms make choices in how they communicate information about their platforms to the marketplace. Combined with elements of price-setting, switching/loyalty aspects in these markets and the possibility of multihoming by developers, our research provides the foundations for a rich understanding of platform competition. Before we develop our model in section 2, we first provide a brief review of literature below.

1.1   Review of relevant literature

We primarily draw upon the following streams of literature in this paper. First, we refer to research on competition in two-sided markets (platforms), particularly those that examine the role of information. Second, we refer to the research on preannouncements that has primarily addressed one-sided markets (products) to motivate the role of information in platform preannouncement. We also refer to literature related to multi-homing and switching to support our modeling extensions in this paper.

In recent years, competition amongst firms in many industries such as video game consoles, mobile communication and personal computers, has evolved from single-sided products to platforms characterized by two-sided markets (Parker and Van Alstyne 2005, Eisenmann, Parker et al. 2006, Eisenmann 2006, Choi 2010, Anderson Jr, Parker et al. 2013, Hagiu and Spulber 2013, Adner, Chen et al. 2016). While product markets have been extensively studied in the context of network effects (Katz and Shapiro 1985) where an agent's utility of a product depends upon its consumption by other agents, in platform settings (Economides and Katsamakas 2006, Zhu and Iansiti 2012), such externalities become even more prominent in the presence of same-side and cross-side network effects.

Rochet and Tirole (2003) and Armstrong (2006) provide an elaborate understanding of outcomes in the platform competition. In modeling competition, both papers incorporate cross-side network effects while considering markets with heterogeneous taste preferences. Through a

stylized Hotelling model, both papers examine the competing platforms' pricing strategies for the two sides of the market. Armstrong (2006) models a duopoly with single-homing agents on either side of the platform and finds that the platform will more aggressively target that side of the market where agents face a lower disutility of moving away from their ideal taste preferences and cause higher cross-side network effect benefits. While we examine similar pricing strategies in our paper, unlike Armstrong (2006), our model also incorporates same-side network effects providing additional insights.

Although Rochet and Tirole (2003) and other authors (Caillaud and Jullien 2003, Choi, Kristiansen et al. 2005, Hagiu 2009, Boudreau 2010) consider that all agents are informed about prices, and therefore its impact on demand. Some other models (Gabszewicz and Wauthy 2014, Hagiu and Hałaburda 2014) have analyzed scenarios where some agents may not be fully informed about prices and form strong expectations that the platform recognizes in its pricing. Further, consumer expectations (Suleymanova and Wey 2012, Hagiu and Hałaburda 2014) about network effects and prices may themselves be dependent upon related information available.

The role of information in platform competition is particularly tricky since it can impact five actors – a firm's users and developers, the competitor, and the competitor's users and developers. In the extant literature, Hagiu and Hałaburda (2014) have considered the partial awareness of certain information (e.g., price) on the part of agents (users and developers), while others (Suleymanova and Wey 2012) have considered this as agents' characteristics where they may form strong or weak expectations. In both these papers, they have observed a lack of full information about some platform characteristics (e.g., price) may lead to very different outcomes compared to traditional platform duopolistic competition.

Through our abstraction of platform preannouncement strategies, we take this investigation of information to the next level by allowing this element to be a part of the firm's strategy

space. In other words, we endogenize the use of this information as a strategic lever to examine optimal behavior and equilibrium outcomes. We believe that this is a significant contribution to both theory and practice.

Product preannouncement has been extensively studied in Economics and Marketing. In particular, *"(preannouncement) creates an awareness of the forthcoming product, spreads information about its characteristics, and enables journalists and opinion leaders to evaluate its performance."* (Le Nagard-Assayag and Manceau 2001, p.206). Preannouncement may include *"information based on the technical attributes and capacities of the new hardware platform, on its quality level and market potential, as well as all the technical information necessary to design compatible programs"* (Le Nagard-Assayag and Manceau 2001, p.206). Particularly, in the context of experience goods that we study, besides advertising (Narayanan, Manchanda et al. 2005), firms may *also* engage in immersive demonstrations, participate in tradeshows, press conferences, interviews, etc.

The extant literature suggests that *"preannouncements play an important role in (consumer's) expectation management"* because consumers making adoption decisions are *"guided not only by a product's current installed base but also by expectations of future installed base."* (Lee and O'Connor 2003, p.244). This work goes on to reiterate that for *"network effect products,"* preannouncing has a positive influence on product's extrinsic (network effects) value perceived by customers. Thus, the primary purpose of a preannouncement is to aid expectation formation of prices, demand, features, etc. of a future version of a product before its actual release (Bayus, Jain et al. 2001, Gerlach 2004).

Preannouncements are routine and prevalent in the technology industry. Choi et al. (2010, p. 314) observe that *"... product preannouncement has been prominent in industries characterized by network effects, such as computer software industry"*. Expectation formation regarding network

effects as a result of a preannouncement enable consumers to *"make a decision before the actual launch, and buy the product as soon as it is available."* (Le Nagard-Assayag and Manceau 2001, p.206). Su and Rao (2010, p.670) emphasize the importance of examining the effect of preannouncement on the demand side and study how *"customers' perceptions, preferences, and choices"* are affected by the *"extent to which the details of new product are revealed"* in the preannouncement. Since a firm's preannouncement to the market is available to its competitors as well, it impacts the firm's choice of the level of information that it provides through the preannouncement strategy.

The preannouncement literature has focused on products, and while this stream of literature has primarily studied monopolies, we begin our analysis by discussing a competitive model for platforms. While not focusing on two-sided markets, another stream of IS literature has focused on emerging business models and optimal pricing strategy in new product introduction (or preannouncement) in the context of versioning of software products (Niculescu and Wu 2014). To the best of our knowledge this is the first paper that addresses the impact of the level of information in platform preannouncement strategies on expectation formation by the two sides of the market, and how firms, in turn, consider this to choose a preannouncement strategy and set competitive prices. Beyond studying the platform preannouncement strategies in a duopoly, we are also interested in examining such strategies in the context of both switching and multi-homing.

The extant literature on two-sided markets, while primarily focused on single-homing agents has also analyzed the impact of multi-homing (by agents in one or both sides of the market) on pricing strategies (Armstrong and Wright 2007, Rasch 2007, Athey, Calvano et al. 2016). Armstrong (2007) finds that 'competitive bottlenecks' arise when the multi-homing side has their network benefits extracted fully while the single-homing side is subsidized to participate in the market. Extant literature is sparse in its analysis of the role of switching of installed bases in

platform competition, although such analysis has been pursued for product competition. In our paper, we also explore the role of switching by the installed base and multi-homing by one-side of the market on equilibrium preannouncement strategies of duopolistic platforms.

2. Model

We consider a duopoly characterized by platform competition where both firms $i, -i$ develop a new version of their two-sided platform such that they acquire revenue from (i) selling to a user side (by charging a price) and by (ii) licensing (by charging a fee) to developers on the other side. For the sake of exposition, we shall develop our model using a gaming platform as an example and hence will alternately refer to one-side as users or gamers and the other-side as developers. We refer to the entire set of consumers of the platform as agents (users and developers). The firms compete in markets where the agents are heterogeneous in their taste preferences; on one-side gamers may differ in their preference for color, design of the product (e.g., console, controller, etc.), while on the other side, developers are heterogeneous in their preferences for programming languages, API management, and other software development environments. Each firm's platform is identical in quality and features but differs in these taste preferences and other horizontally differentiating factors.

We abstract the distribution of these taste preferences on both the user (subscript u) and developer side (subscript d) through a Hotelling line such that the platforms i and $-i$ are horizontally differentiated in their product offering and are located on the extremes. The users and developers are uniformly distributed on their respective taste preferences, and as with extant location models, each point represents the ideal product for the user (developer), and they suffer a disutility tx when obtaining a product that is located some distance x from their ideal point.

In our case, the parameter t $t > 0$, called the transport cost coefficient in location models, captures the strength of taste preferences. In other words, greater this value, stronger is the users' (developers') preference for their ideal product and thus greater is the disutility they suffer when they have to choose a product away from their preferred one.

We develop our base model along the lines of Armstrong (2006) where *both sides* of the platform derive cross-side network effects, i.e., developers gain value from more gamers and gamers gain value from more developers. Similarly, we also assume that there is a same side network effect *only* on the user side, e.g., gamers derive more value as more gamers play the same console. Note that while cross-side externalities are present on both sides, we do not include same-side externalities on the developer side. Even if more developers can create positive externality in the form of potential labor supply, usually such benefits are canceled out due to competitive impacts from more developers. We assume that the cross-side externality coefficient is the same for the user and developer-side and is given by β and a parameter α captures the same-side externality on the user-side. In other words, α abstracts the marginal value of having an addititional gamer to other gamers while β abstracts the marginal value of having an additional developer for gamers and of having an additional gamer for the developers.

We could also think of the above parameters as capturing the strength of network effects in that they determine the network effects that can be enjoyed by an agent for a given network size. An important distinction is that while these parameters are *static* in prior work, our model allows for these parameters to be influenced by the platforms' preannoucement strategy and therefore are part of the strategy space for the platforms. Further, we choose to examine identical firms with limited differentiation on other parameters to isolate and specifically examine heterogeneity in the choice of platform preannouncement strategies.

2.1 Platform preannouncement strategies

Our main aim in this paper is to examine a firm's choice of preannouncement of the new version of its platform. Literature in marketing states that even for products (let alone platforms), in addition to R&D related investments, new product development strategy should also include methods to communicate to the market about the firm's course of action (Eliashberg and Robertson 1988, Le Nagard-Assayag and Manceau 2001, Ofek and Turut 2013). In our paper, we define three preannouncement strategies – a *formal/full strategy,* an *informal/partial strategy* and a *no-preannouncement strategy* as the strategic choice set for a platform. Fundamentally, the strategies capture the *"extent"* of product details (Su and Rao 2010) released to the marketplace. Preannouncement of such NEE aspects of the platform has a positive influence on the platform's network effects value as perceived by consumers (Lee and O'Connor 2003) and enables consumers to "*make a decision before the actual launch, and buy the product as soon as it is available.*" (Le Nagard-Assayag and Manceau 2001, p.217). We specifically model the mechanism through which preannouncements impact platforms with network effects. In our model, the extent and quality of information in the preannouncements help gamers and developers estimate the strength of network effects and thus influence the overall expectation of the total network effects to be enjoyed from purchasing the platform.

2.1.1 Formal (or full) preannouncement strategy

A full/formal preannouncement strategy is one where the firm preannounces the release of its platform with a variety of prelaunch activities wherein it *fully* informs the marketplace about the network effect engendering aspects and other characteristics of the new version *prior* to actual launch. Prelaunch activities may include everything from advertisements to immersive demos of NEE features such as multiplayer gaming, etc. To fully convey information about such NEE elements, the firm has to not only invest in obtaining expensive CES booths and other advertising

channels but may also have to develop demos and giveaways that can be sustained through its partners. We denote the net investment to fully inform the marketplace by a one-time cost c.

While the firm is burdened by this cost upfront, it also stands to benefit from this strategy as this allows both users and developers to fully take into account *all* the NEE aspects of the new version and conditions of the new marketplace, in setting their expectations and allocating their budgets. From a modeling perspective, this strategy implies that when the *full extent* of information about the platform is conveyed, gamers/developers can estimate the full strength of the network effects that the platform can offer.

We commonly observe preannouncements predating new releases during Christmas and other holidays (Dranove and Gandal 2003, Poulter 2013). A key reason is that firms are keen to influence budgetary decisions and other consumer expectations in advance of actual purchase. All activities under this strategy are denoted with a subscript F.

2.1.2 Informal (or partial) preannouncement strategy

We define informal strategy as one where the firm chooses not to fully inform the agents regarding the NEE aspects of its new platform version. In such cases, firms might even eschew the use of traditionally expensive channels (e.g., trade shows with immersive demos) and perhaps largely rely on free/informal channels to transmit information regarding the platform's NEE aspects besides other features. For example, an informal preannouncement may provide such information through pictures, videos and technical details on fan pages, discussion forums, social media channels, etc. instead of an expensive hands-on and immersive experience that characterizes a formal preannouncement (as discussed in Section 1).

Thus, a firm pursuing an informal preannouncement strategy may only incur a lower pre-launch cost in informing the market regarding the NEE aspects of its platform, compared to a formal preannouncement strategy. In our model, we capture this advantage to the firm through

a cost discount parameter k $k \in \begin{bmatrix} 0,1 \end{bmatrix}$ such that the total preannouncement cost incurred in pursuing this strategy is kc.

The second element of this strategy pertains to the expectation formation of the two sides corresponding to the preannouncement. When the platform pursues a partial preannouncement strategy providing less than the full extent of information, agents estimate the strength of network effects to be corresponding to the "*the extent to which the details of new product are revealed*" (Su and Rao 2010, p.670). In other words, as a result of the platform's preannouncement strategy, the agents end up underestimating the strength of network effects that the platform could have provided. This in turn implies that the agents' expectations of the platform's network benefits are also attenuated. At one end, there are cost advantages to this strategy, but it also potentially limits the expected surplus on the agents' side. It is also not clear as to how competition may influence the choice of this strategy and hence further examination is required. All activities under this strategy are denoted with a subscript I.

2.1.3 No-preannouncement (or no information) strategy

We define this strategy as one where the firm chooses not to release any information related to the network effects of the new version of the platform to the gamers or developers – prior to actual release. Not only does the firm not incur any cost in pursuing prelaunch activities but it also provides no new basis for estimating the strength of networks effects in the market. As a result, agents rely purely on the intrinsic value of the platforms in setting their expectations and allocating their budgets for purchase/licensing of the new version of the platform. All activities under this strategy are denoted with a subscript N.

2.2 Relevance of switching and homing

The examination of platform preannouncement strategies will be incomplete without taking into account certain market conditions commonly observed in platform competition. Note that our

investigation seeks to shed light on expectation formation because of platform's externality related information available in the marketplace. In this context, installed base plays an important role if the market conditions do not allow for switching to the other platform when the new version is released. In such markets, the installed base may be considered as loyal agents. However, when the installed base also considers switching they end up affecting agents' expectations regarding total network effects.

Similarly, in platform models of competition, even when defined by Hotelling-type conditions, many authors (Armstrong and Wright 2007, Rasch 2007, Athey, Calvano et al. 2016) have examined markets where some agents end up serving both sides of the market. Commonly known as multi-homing, this refers to situations when developers might find it optimal to develop games for both platforms even if they are positioned at the extremes of the linear market. Without rigorous analysis, it is not clear as to how preannouncement strategies are influenced by such market conditions. In the gaming context, it is rather common to observe multi-homing by some developers who develop games for both consoles, while other developers choose one platform (single-home). For example, when technology or developer's innovation is easily portable between platforms (gaming consoles), then such developers will multi-home. On the other hand, developers may choose to single-home when technology is proprietary (e.g., video games such as NFL, NBA, etc.) and/or porting development to a competing platform is difficult due to technology incompatibility and/or steep learning curve.

To examine preannouncement strategies under market conditions of switching and multi-homing, we first develop the base case where the agents are single-homing and where their installed base does not switch when a new version of a platform is released. We denote this by SH-NSW. Following this base case model, we develop our models for the case, where agents still single-home but where now their installed base considers switching when a new version is released, denoted by

SH-SW. In section 3.2, we introduce the option to multi-home and examine both cases where agents do not switch (MH-NSW) and consider switching (MH-SW).

Independent development of preannouncement strategies in each of the above 4 cases allows us to explicitly isolate the relationship between strategic choices and typical market conditions. Of particular importance to modeling preannouncement is the element of information (Suleymanova and Wey 2012, Gabszewicz and Wauthy 2014, Hagiu and Hałaburda 2014) and when it is available to influence expectation formation. Hence, our choice of the base case, where agents single-home and do not switch, to illustrate the different informational nature of the three preannouncement strategies.

2.3 Timeline when agents do not switch platforms and only single-home (SH-NSW)

To maintain a general understanding of the role of the installed base, we develop the initial model with firm-specific identifiers. However, note that throughout this paper, we shall focus on results for identical firms for two reasons: First, examination of symmetric firms is the norm in platform competition and following this standard allows us to easily compare our results with extant literature. Second, our interests are primarily regarding preannouncement strategies and the role of market conditions such as allowance for switching and multi-homing. However, developing the base model in a generic fashion should allow the reader to see the differential role played by this factor whence switching is allowed and not (it is easy enough to derive closed-form solutions even with this heterogeneity though expressions are unwieldy).

The timeline of the new platform release preceded by prelaunch activities (including preannouncement) is illustrated in Figure 1 and developed as follows:

STAGE 0: Firm i starts with an installed base of gamers/users m_u^i and developers m_d^i of the initial version of its platform that are each normalized to 1, i.e.

$$m_u^i + m_u^{-i} = 1; \quad m_d^i + m_d^{-i} = 1 \tag{1}$$

Stage 0   Stage 1   Stage 2

Two firms have their own versions of the platform and enjoy their own installed base of users and developers.

Firms develop new versions of their platforms that include NEE aspects.

Firms adopt one of three strategies to inform the marketplace of NEE elements.

Agents estimate strength of networks effects in correspondence to the extent of information in the preannouncement strategy.

Agents form expectations of network effects from purchase/licensing of the platform in Stage 2.

Firms set prices/licensing fees to fulfill expectations of users/ developers in Stage 1.

Firms release their respective platforms along with prices/ licensing fees.

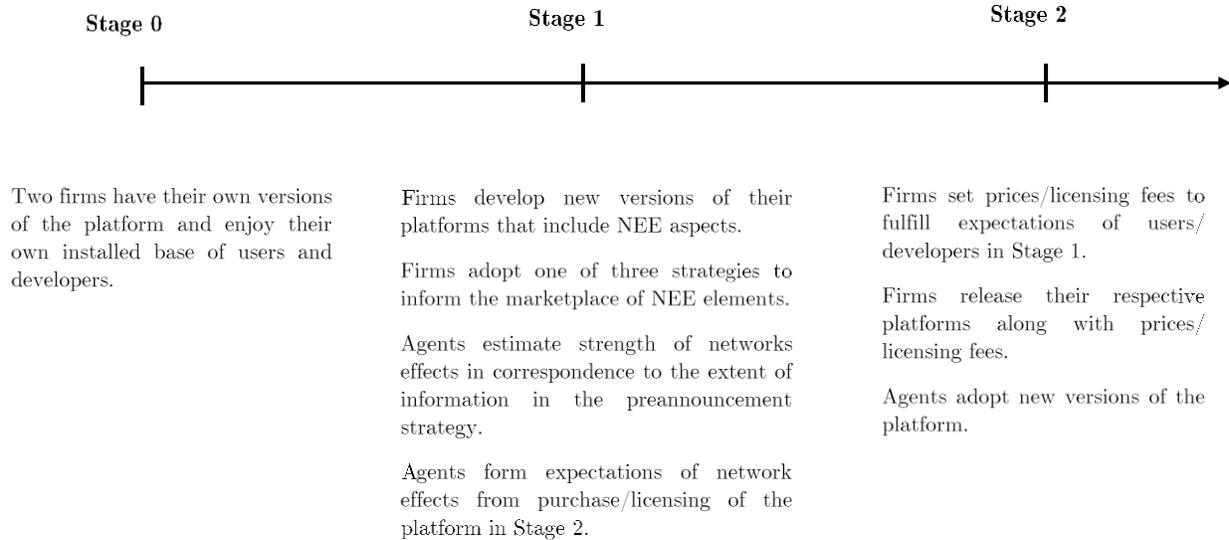Agents adopt new versions of the platform.

Figure 1: Timeline of the preannouncement game.

STAGE 1: In stage 1, both firms develop a version of their platforms with new features including NEE aspects that create and benefit from network effects. We assume that these additional features increase the size of the overall market by bringing in new agents. This assumption captures the fact that many products in the high-tech industry undergo continuous innovation, and improved versions introduce technological advances that bring in a new market of agents. For example, in the video game industry, the market (and the number of games) increased substantially with the introduction of new features like motion sensing, faster CPU, collaborative gaming, etc. (Hall 2015). The proportion of this new market garnered by the firm i can be expressed as

the price/market-dependent user and developer demand functions n_u^i and n_d^i. While the new markets may expand to any arbitrary size, we assume a unit market as given by the following equation:

$$n_u^i + n_u^{-i} = 1; \qquad n_d^i + n_d^{-i} = 1 \tag{2}$$

Further, since these platforms (e.g., video game consoles) have experience-good like qualities, consumers can get an adequate understanding of these new aspects either because: (i) they purchase and experience the product in Stage 2, or (ii) firms have engaged in preannouncement activity in Stage 1 to help the consumers understand as much as possible about these aspects, before the platform is released. As the firms have to set prices *before* agents can purchase/license in Stage 2, the platforms have to make choices regarding their preannoucement strategies here in Stage 1. They can choose from among a formal strategy F, an informal strategy I or a no-preannouncement strategy N, and they incur marketing and preannouncement costs of c, kc and 0 respectively.

Corresponding to the preannoucement strategies (that differ in the level of information released to the market), gamers and developers estimate the strength of network effects, and therefore form expectations regarding the eventual network effects from the new version that would be released in Stage 2.

In related literature that has considered the role of information in expectation formation, typically consumers are *a priori* assumed to vary in their informed-ness of prices (Hagiu and Hałaburda 2014) or possess *weak* or *strong* expectations about market share beforehand (Suleymanova and Wey). In our model, consumers that are homogenous in all aspects may still have different expectations of platforms as a response to the firms' choice of preannouncement strategy. It is therefore important to develop the expected utilities under each strategy separately.

First, let each firm's new version provide some intrinsic or standalone value θ, to the agents, that is independent of network effects (e.g., single player games that may be shipped along with a console). We assume that both firms produce platforms identical in this value as we do not wish to create any bias towards one platform and will be able to fully tease out the differences created by the firm strategies.

The second part of the utility function is the expected value from network effects. Agents making adoption decisions are "*guided not only by a product's current installed base but also by expectations of future installed base*" (Lee and O'Connor 2003, p. 248). We shall first consider the case when agents are single-homing and do not switch (SH-NSW) and hence the installed base of users given in Stage 0 remain with the firm when the new version is released. The network size, therefore, is the sum of the installed based plus any new agents that might arrive with the new version. Note, however, that the estimated strength of network effects is still a function of the platform's preannoucement strategy. In our model, both the installed base and the new market react similarly to the extent of information released during preannoucement. In other words the installed base, even if loyal, is assumed to have no special understanding of the new version's strength of network effects in comparision to the new market.

We first develop the utility function for users and developers under the formal preannouncement strategy case. In case of a formal preannouncement by firm i, the users' utility from purchasing from this platform can be written as

$$U_{u,F}^i = \theta + \alpha \left[m_u^i + n_u^i \left(p^i, p^{-i}, l^i, l^{-i} \right) \right] + \beta \left[m_d^i + n_d^i \left(p^i, p^{-i}, l^i, l^{-i} \right) \right] - p^i \qquad (3)$$

where p^i and l^i are the prices and licensing fees. The second term captures the same-side externality benefits while the third term captures the cross-side benefit as a result of the developer demand. As discussed earlier in this section, α and β are the same-side and cross-side network effect coefficients or the strength of network effects, i.e., they represent the marginal value to a

user from additional user and developer respectively. Also, note that the new demand faced by the firm is a sum of the demand from its installed base as well the new demand introduced in equation (2). This new demand that the firm will acquire is a function of its prices and licensing fees as well those of its competitors. Similarly, we can write the utility of the focal platform's developer as

$$U_{d,F}^i = \theta + \beta\left[m_u^i + n_u^i\left(p^i, p^{-i}, l^i, l^{-i}\right)\right] - l^i \tag{4}$$

Note that the same-side externality is absent from the developer side for reasons discussed earlier.

The "*extent to which the details of new product are revealed*" in a preannouncement is known to influence consumers' response to the new product (Su and Rao, p.670); in the informal or partial preannouncement regime, the limited nature of the preannouncement provides an incomplete understanding of the platforms' NEE aspects to the agents. In our model, we introduce a parameter $\mu \in [0,1]$ that captures the underestimation of the strength of network effects due to the lesser extent of information about NEE in the partial/informal strategy. Thus, the same-side and cross-side strength of network effects become $\alpha\mu$ and $\beta\mu$ respectively, and we can write the total expectation of network effect from the market (of installed base and new consumers) as $\alpha\mu\left[m_u^i + n_u^i\left(p^i, p^{-i}, l^i, l^{-i}\right)\right]$ from the user sided and $\beta\mu\left[m_d^i + n_d^i\left(p^i, p^{-i}, l^i, l^{-i}\right)\right]$ from the developer side. Thus, a user's utility under the informal regime can be written as

$$U_{u,I}^i = \theta + \mu\alpha\left[m_u^i + n_u^i\left(p^i, p^{-i}, l^i, l^{-i}\right)\right] + \mu\beta\left[m_d^i + n_d^i\left(p^i, p^{-i}, l^i, l^{-i}\right)\right] - p^i \tag{5}$$

Similarly, we introduce a parameter $\delta \in [0,1]$ to capture an equivalent understanding on the developer side such that the developers' utility in Stage 1 can be written as

$$U_{d,I}^i = \theta + \delta\beta\left[m_u^i + n_u^i\left(p^i, p^{-i}, l^i, l^{-i}\right)\right] - l^i \tag{6}$$

While not explicitly modeled in this paper, we can easily see that the parameters μ and δ can be thought of as being proportionally related to the discount factor k, i.e., when $k = 1$ or

when the full set of pre-launch activities are pursued (and all of the costs incurred), μ and δ will also converge to 1 thus reducing equations (5) and (6) to equations (3) and (4) respectively. To allow for the fact that developers – a technically advanced and industry-tuned group, understand firms announcements better than end-users, we assume $\delta \geq \mu$.

Following the above discussion, we can see that a no preannouncement strategy corresponds to the situation when k, μ and δ are all zero, i.e., no announcement is made, no cost is incurred and there is no specific understanding of the strength of network effects. Thus, the utilities derived by users and developers can be written as follows:

$$U_{u,N}^i = \theta - p^i \tag{7}$$

$$U_{d,N}^i = \theta - l^i \tag{8}$$

STAGE 2: Stage 2 corresponds to the release of the new version where firms also reveal their prices and licensing fees. Along the lines of literature in economics on network effects, in our model also, agents *"will base their purchase decision on expected network sizes,"* and *"must make their purchase decisions before the actual network sizes are known"* (Katz and Shapiro 1985, p.426). In other words, there is no revision to their expectations formed in Stage 1, and hence firms have to take that into account in setting the prices and licensing fees in Stage 2. Under the fulfilled rational expectations equilibrium, the prices set at this stage should match the expectations of the users and developers in stage 1. All agents adopt the new version released by the platform.

We can now write the objective functions of the firms under the three different preannouncement strategies, formal, informal and no-preannouncement as follows:

$$\max_{p^i, l^i} \pi_F^i = p^i \left[m_u^i + n_u^i \left(p^i, p^{-i}, l^i, l^{-i} \right) \right] + l^i \left[m_d^i + n_d^i \left(p^i, p^{-i}, l^i, l^{-i} \right) \right] - c \tag{9}$$

$$\max_{p^i, l^i} \pi_I^i = p^i \left[m_u^i + n_u^i \left(p^i, p^{-i}, l^i, l^{-i} \right) \right] + l^i \left[m_d^i + n_d^i \left(p^i, p^{-i}, l^i, l^{-i} \right) \right] - kc \tag{10}$$

$$\max_{p^i, l^i} \pi_N^i = p^i \left[m_u^i + n_u^i \left(p^i, p^{-i}, l^i, l^{-i} \right) \right] + l^i \left[m_d^i + n_d^i \left(p^i, p^{-i}, l^i, l^{-i} \right) \right] \tag{11}$$

2.4 The preannouncement game (SH-NSW)

We model the duopoly as a simultaneous move game where a firm i chooses its strategy $S^i = \{F, I, N\}$ in *Stage 1* and sets prices and licensing fees in *Stage 2* taking into account the agents' expectations formed in *Stage 1*. Consistent with the tradition in platform competition literature, we are only interested in pure-strategy subgame perfect Nash equilibria (SPNE) – mixed strategies have limited explanatory ability and managerial meaningfulness.

For the base model, we largely follow Armstrong (2006). Our market is developed as a Hotelling segment such that the users and developers are each uniformly distributed $U \sim \left[0,1\right]$ over a unit line. The firms are located at the extremes (maximally differentiated in their platform offerings), and each agent location represents the ideal platform for that user or developer. Therefore, in using or developing for a platform that is not at the ideal location, the agents suffer a disutility as defined by their transport costs, as a function of how far away they are from the offered platform and the transport cost coefficient t. Throughout the paper, along the lines of extant literature on platform competition (Choi 2010, Hagiu and Lee 2011), we examine a variety of symmetric equilibria for a duopoly of symmetric firms.

2.4.1 When firms engage in formal preannouncement strategies

Consider the case where the firms pursue the strategy of preannouncing their new platform release. To determine the equilibrium prices and licensing fees, we need to first find the price-dependent demand that each firm faces in this market. Given the Hotelling specification, from equation(3) a user located at a distance x from firm i derives a net utility $U_{u,F}^i - tx$. In equilibrium, the indifferent user is located where the market is split between the two firms, and therefore we have

$$U_{u,F}^{i} - tn_{u,F}^{i} = U_{u,F}^{-i} - t\Big[1 - n_{u,F}^{i}\Big]. \tag{12}$$

Now, substituting for the utility functions and denoting a difference in installed bases of users and developers between firms i and $-i$ as Δm_u and Δm_d respectively, we can write the price/licensing fees dependent user demand as

$$n_u^i = \frac{1}{2} + \frac{-t\Big[p^i - p^{-i}\Big] - \beta\Big[l^i - l^{-i}\Big] + \Big[\alpha t + \beta^2\Big]\Delta m_u + \beta t \Delta m_d}{2\Big[t\Big[t - \alpha\Big] - \beta^2\Big]}. \tag{13}$$

Along these same lines, we can also write the specification for the demand function on the developer side of the market as

$$n_d^i = \frac{1}{2} + \frac{-\beta\Big[p^i - p^{-i}\Big] - \Big[t - \alpha\Big]\Big[l^i - l^{-i}\Big] + \beta t \Delta m_u + \beta^2 \Delta m_d}{2\Big[t\Big[t - \alpha\Big] - \beta^2\Big]}. \tag{14}$$

Substituting equations (13) and (14) in the objective function given by equation (9), we can solve for the optimal prices and licensing fees for this case.

2.4.2 When firms engage in informal preannouncement strategies

When the firms pursue an informal strategy in Stage 1, they provide partial information to the market about their platform's NEE aspects. Further, the estimates of the strength of network effects at this stage may be different for the two sides of the platform, as captured by the extent of information μ (for the users) and δ (for the developers) relayed in the informal preannouncement. This eventually affects the expectation of network effects.

Therefore, in Stage 2 when the firm sets prices, it has to take into account this lower extent of information available in the informal preannouncement, its impact on an agent's estimation of strength of network effects and their corresponding expectation of total network effects. Observe that none of the other aspects of the horizontally segmented market are different from the formal preannouncement case, i.e., consumers are single-homing and do not switch. Similar to equation(12), we can find the location of the indifferent user in the informal case as

well. Substituting equation(3) for utilities, we can write the user and developer demand facing

the firm as

$$n^i_{u,\,I,I} = \frac{1}{2} + \frac{-t\big[p^i - p^{-i}\big] - \beta\mu\big[l^i - l^{-i}\big] + \big[\mu\alpha t + \mu\delta\beta^2\big]\Delta m_u + \mu\beta t\Delta m_d}{2\big[t\big[t - \alpha\mu\big] - \beta^2\delta\mu\big]},$$

$$n^i_{d,\{I,I\}} = \frac{1}{2} + \frac{-\beta\delta\big[p^i - p^{-i}\big] - \big[t - \alpha\mu\big]\big[l^i - l^{-i}\big] + \beta\big[\delta t + \big[\delta - \mu\big]\alpha\big]\Delta m_u + \mu\delta\beta^2\Delta m_d}{2\big[t\big[t - \alpha\mu\big] - \beta^2\delta\mu\big]}.$$

(15)

Substituting equation (15) in equation (10) we can solve for optimal prices and licensing fees for

firms with identical installed bases.

2.4.3 When firms engage in no-preannouncement strategies

At the extreme, in the strategy space is the option to not engage in any preannouncement at all.

While a simplistic view is that it saves on the prelaunch costs, we know well that a more significant

impact of this strategy is due to the lack of information regarding the NEE aspects of the new

version of the platform. In the absence of such information, the users and developers cannot form

estimates regarding the strength of network effect α, β and their expected utility from the

platform is strictly confined to the platform's intrinsic benefits. Therefore, along the lines of

sections 2.4.1 and 2.4.2, we can write the agent demands as

$$n^i_{u,\{N,N\}} = \frac{1}{2} - \frac{\big[p^i - p^{-i}\big]}{2t}, \quad n^i_{d,\{N,N\}} = \frac{1}{2} - \frac{\big[l^i - l^{-i}\big]}{2t}.$$

(16)

Substituting these demands into the profit function given in equation (11), we can now derive the

prices and licensing fees for this case.

2.5 Equilibrium outcomes in SH-NSW case

The first step is to derive the optimal prices and licensing fees for a candidate equilibrium strategy

chosen by the firms. To do so, substitute the user and developer demand functions that were

derived from the Hotelling line, in the profit function. Simultaneously solving the first order conditions of the profit function of both firms with respect to p^i and l^i we get the prices and licensing fees as a function of the installed bases. Since our focus is on identical firms, we can get candidate equilibrium prices and licensing fees for the focal firm by setting the installed bases of both firms to be the same $m_u^i = m_u^{-i},\ m_d^i = m_d^{-i}$. Note, however, for these prices and licensing fees to be SPNE, not only should this preannouncement strategy dominate over others, but it should also be feasible in the region as defined by the various parameter relationships. Thus, our candidate equilibrium price-licensing fee pairs are $p_{F,F}^i$, $l_{F,F}^i$ for Formal preannouncement strategy; $p_{I,I}^i$, $l_{I,I}^i$ for Informal preannouncement strategy; and $p_{N,N}^i$, $l_{N,N}^i$ for No-preannouncement strategy.

For any of the above pairs to be SPNE prices and licensing fees, we require the profits from that strategy to be higher than the other two strategies. For example, in the region, where F,F is feasible, $p_{F,F}^i$ and $l_{F,F}^i$ are equilibrium price and licensing fees if and only if $\pi_{F,F}^{i*} > \max\left[\pi_{I,I}^{i*}, \pi_{N,N}^{i*}\right]$ and $\pi_{F,F}^{-i*} > \max\left[\pi_{I,I}^{-i*}, \pi_{N,N}^{-i*}\right]$. Further, we must ensure that various constraints on parameters $\alpha, \beta, \mu, \delta$, etc., are also satisfied besides individual rationality conditions. By imposing all parameters to be non-zero and keeping $\mu, \delta \in\ 0,1$, we now consider other economic constraints and characterize them through the strength of preference parameter t . Such constraints include individual participation constraints of users and developers whereby all agents derive a non-negative utility. Since agent's utilities are decreasing in t, such constraints provide a lower bound for t. An upper bound on t is provided by conditions ensuring that the firms' prices, licensing fees and profits are non-negative, and such profits are concave in prices and

licensing fees. Considering all these constraints together, through reduction, we can characterize the potential bounds where Formal, Informal and No-preannouncement strategies are SPNE.

In our paper, we assume that the intrinsic value θ provided by the platforms is high enough so that certain trivial situations, e.g., where utilities may not be positive, may be dismissed. Through lemmas and propositions below, we examine equilibrium preannouncement strategies and characterize their choice through the strength of preferences in the market. The agents' strength of preferences characterizes different market representations such as in markets where users/gamers are very particular about their tastes and/or where developers are more partial to particular technical product designs (higher values of t). Alternatively, in some markets, agents may have a very minimal attachment to their tastes and be readily willing to consider platforms that are not their ideal ones (low values of t).

Unlike existing work that primarily examines firms' pricing/licensing fees when they engage informed or uninformed consumers (or those that may hold weak vs. strong expectations), our goal in this work is to investigate the feasibility of using information as a strategic tool. Lemmas 1-3 tells us that the optimality of these three different preannouncement strategies can be characterized through the disutility suffered by agents in this markets and hence the strength of preferences therein.

LEMMA 1. *In single-homing markets where the agents do not switch and where they possess strong taste preferences (defined by $t^{*}_{F,F}$), firms will pursue formal preannouncement strategies in SPNE. Equilibrium prices and licensing fees are given by $p^{i*}_{F,F} = t - \alpha - \beta$ and $l^{i*}_{F,F} = t - \beta$* ∎

The prices and licensing fees are decreasing in the strength of network effects even if the utilities of users/developers are increasing in them. This is specific to the fact that this is a competitive model; in a monopoly, strength of network effects serves to increase prices. Further, prices and licensing fees are increasing in the transport cost or taste preferences. This is indeed an artifact of the Hotelling abstraction and is consistent with other works on platform competition as well. We can now contrast our results against other extents of information when firms pursue informal preannouncement or eschew any pre-launch activity.

Lemma 1 refers to markets where agents have very strong preferences for their platforms implying significant disutility costs are incurred by them in consuming/developing for the non-ideal platforms at the extreme. The bounds of these preferences are given by (equation (A5) in the Appendix A)

$$t^*_{F,F} \in \left(\frac{2\theta}{3} + \frac{[\mu + \delta]\beta}{3}, \frac{2\theta}{3} + \frac{2\beta}{3} \right).$$

Our results suggest that the equilibrium strategy is a formal (or full) preannouncement of the new platform for such markets. The economic intuition is provided by the tradeoff between the loss of surplus from high t and the extraction of expected benefits from network effects through a complete understanding of the strength of network effects offered by the platform's new version. In other words, firms need to make a formal preannouncement even if it increases competitive intensity because they have to offset the disutility created by the strong taste preferences.

LEMMA 2. *In single-homing markets where the agents do not switch and where they possess moderate taste preferences (defined by $t^*_{I,I}$), firms will pursue informal preannouncement strategies in SPNE. Equilibrium prices and licensing fees are given by $p^{i^*}_{I,I} = t - \mu\alpha - \delta\beta$ and $l^{i^*}_{I,I} = t - \mu\beta$* ∎

First, note that the prices and licensing fees are higher than those in the formal case. In other words, releasing less than full information about the platforms' NEE aspects lessens the competitive intensity. Not surprisingly, the extent to which prices are higher than those in the informal case is a function of the extent of information that the agents have about the NEE aspects of the forthcoming version of the platform. Lower the extent of this information conveyed through a preannouncement, higher are the prices, suggesting that perhaps eschewing all pre-launch activity might be a better strategy for the firm. However, we know that no-preannouncement is not an equilibrium option for markets whose strength of taste preferences are given by (equation (A6) in the Appendix A)

$$t^*_{I,I} \in \left(\frac{2\theta}{5}, \frac{2\theta}{3} + \frac{[\mu + \delta]\beta}{3} \right).$$

Further, observe that while prices are a function of both extent of information parameters μ, δ , licensing fees is directly a function of the level of understanding on the user-side – the reason being that there are no same-side network effects on the developer side. While a lower extent of information regarding NEE aspects of the platform leads to under-estimation of the strength of network effects, it also attenuates the impact of strength of network effects on the prices and licensing fees.

LEMMA 3. *In single-homing markets where the agents do not switch and where they possess weak taste preferences (defined by $t^{*}_{N,N}$), firms will pursue no preannouncement strategies in SPNE. Equilibrium prices and licensing fees are given by $p^{i*}_{\{N,N\}} = t$ and $l^{i*}_{\{N,N\}} = t$* ∎

Lemma 3 points out that there is a pure-strategy equilibrium where firms eschew preannouncement and where, in the absence of estimates regarding the strength of network effects, agents form expectations based on the platform's intrinsic benefits alone. Thus, there is no impact of the strength of network effects on the prices and licensing fees in this strategy. Also, note that among the three cases, the strategy of no-preannouncement allows the firms to charge the highest prices and licensing fees and therefore the firms also derive higher profits compared to the other two strategies. The bounds on agent's strength of taste preference that characterize such markets are given by (equation (A7) in the Appendix A)

$$t^{*}_{N,N} \in \left(0, \frac{2\theta}{3}\right).$$

The above result echoes recent findings in the economics of two-side platforms wherein firms in a duopoly derive higher profits even when only one side has less information (Hagiu and Hałaburda 2014). In comparing Lemmas 1 through 3, we not only observe that prices and profits are highest when there is no information about the future release, but we also see that the externality benefits from the new features only serve to lower prices for the firms. Earlier work (Armstrong 2006, Hagiu 2009) also alludes to similar results – the general understanding is that a combination of the Hotelling abstraction and competitive dynamics causes this outcome. Note that the agents' surplus is increasing in the strength of network effects. However, the firms are unable to extract this surplus due to competition which in turn is intensified by network effects. Since such network effects are a function of the agents' estimates of strength of network effects which are formed as a result of information about the platform's NEE aspects conveyed through the preannouncement,

the economic intuition behind the superiority of the no-preannouncement strategy becomes evident.

Thus, in markets where the agents are not very particular about their ideal platforms, i.e., where they can consume/develop for a platform other than their ideal ones with little disutility, our results suggest that no-preannouncement is the SPNE. Firms prefer not to preannounce the NEE aspects of their new platform version as this information only serves to increase the competitive intensity and further the firms can charge higher prices/licensing fees when the transport cost parameter t is high. However, we also know that the agents' utility is decreasing in this parameter so there may be markets where such taste preferences are moderately strong enough such that the agents do not derive positive utility. In such markets, our results suggest that the SPNE is informal preannouncement wherein the agents will only have a partial understanding of the new version's NEE aspects. Even though the transportation cost parameter is relatively higher in these markets, equilibrium prices and licensing fees are lower (relative to no preannouncement case) due to the under-estimation of strength of network effects by agents that result in lowered expectation of total network effects. Finally, in markets where agents incur an even higher disutility from moving away from their ideal taste preferences, firms benefit from providing full information (operationalized through a formal preannouncement) regarding their new version to the agents.

In summary, lemmas 1-3 form the crux of our inquiry into platform preannouncement strategies which allows us to conclude that when firms can choose the extent of the information they put out about their platforms, even if the information provides value to the agents, it may not always be optimal to do so in a competitive market.

3. Preannouncement strategies in the case of switching and multi-homing

As a part of our investigation, we are also interested in understanding how the optimality of these preannouncement strategies may be affected by other market settings. In particular, in this section, we relax two major assumptions incorporated in section 2 – those about the actions of the installed base and the option to develop for both platforms. Throughout, we consider SH-NSW (discussed in section 2) as the base case against which we shall first examine the role of loyalty, i.e., what happens when the installed base of agents do not automatically buy their original platform but in-fact also consider the competitor's new version. Following that, in subsection 3.2 we shall examine the case when the developers consider the additional possibility of developing for both platforms as opposed to having to choose between the two. While the former has not been commonly incorporated into the platform competition literature, the latter is called multi-homing and is often examined in the context of such duopolies.

3.1 Single-homing markets where the installed base of agents can switch (SH-SW)

The installed bases of agents for each firm has so far represented a set of loyal agents who always purchase the new version of the platform they were earlier using/developing for. However, akin to the new agents who come into the marketplace as a result of the new platform versions, the installed-base too could re-evaluate their decision to choose a particular firm. To examine this scenario, for brevity, we only develop the informal preannouncement strategy in this section as the other two strategies can easily be understood as extreme cases of this strategy.

We now write the expected utility of a user in this setting as

$$U_{u,I}^i = \theta + \mu\alpha\Big[2n_u^i\big(p^i, p^{-i}, l^i, l^{-i}\big)\Big] + \mu\beta\Big[2\,n_d^i\big(p^i, p^{-i}, l^i, l^{-i}\big)\Big] - p^i \tag{17}$$

Note that in this scenario (SH-SW), *all* users (installed base as well as new users) consider the tradeoff between choosing one platform versus the other. Since the entire market of users is in

play, we ignore the size of the installed bases m_u^i and derive the price-dependent expected demand considering both the old and new market of users due to the new version.

Similar to equation (5), under informal preannouncement strategy in this setting there is only partial information regarding the NEE aspects of the new version of the platform, and therefore unlike the formal strategy where agents estimate the full strength of network effects α, β, agents under-estimate the strength of network effects. This under-estimation of the strength of network effects corresponds to the extent of information regarding NEE aspects in the preannouncement. Thus, users and developers underestimate their corresponding strengths of network effects to be $\mu\alpha$ and $\delta\beta$ respectively, and the developer's expected utility can be written as

$$U_{d,I}^i = \theta + \delta\beta\Big[2\ n_u^i\ \big(p^i, p^{-i}, l^i, l^{-i}\big)\Big] - l^i. \tag{18}$$

As described in the timeline given in section 2.3, agents form rational expectations of the total network effects in Stage 1 and platforms release their versions in Stage 2 by taking into account these expectations. Therefore, we can write the objective function of a platform that engages in information strategy when all its agents single-home but where the installed bases are not loyal when the new version is released, as

$$\max_{p^i, l^i} \pi_I^i = p^i\Big[2n_u^i\ \big(p^i, p^{-i}, l^i, l^{-i}\big)\Big] + l^i\Big[2n_d^i\ \big(p^i, p^{-i}, l^i, l^{-i}\big)\Big] - kc. \tag{19}$$

As before, for this to be a fulfilled expectations equilibria, firms will set prices and licensing fees such that the expectations of the agents are met. Furthermore, we can also develop the other two strategies from equations (17), (18) and (19) by setting parameters μ, δ and k to be 1 (for formal preannouncement) or 0 (for the no-preannouncement strategy). Following the game development in section 2.3, we can also develop prices and licensing fees in this case as given in Lemma 4, following which we present the implications for platform profits in Proposition 1.

LEMMA 4 (SH-SW). *In single-homing markets where agents may switch, firms will pursue a no-preannouncement strategy, an informal preannouncement strategy and a formal preannouncement strategy in markets defined by weak, moderate and strong agent preferences respectively. The corresponding SPNE prices and licensing fees*

$$p^{i^*}_{\{N,N\}} = t \qquad p^{i^*}_{I,I} = t - 2\mu\alpha - 2\delta\beta \qquad p^{i^*}_{F,F} = t - 2\alpha - 2\beta$$
$$l^{i^*}_{\{N,N\}} = t \qquad l^{i^*}_{I,I} = t - 2\mu\beta \qquad l^{i^*}_{F,F} = t - 2\beta$$
∎

PROPOSITION 1. *When platforms choose to preannounce (with a formal or informal preannouncement), platform profits are strictly higher in markets where the installed base of agents does not switch platforms. In this case, both prices and licensing fees are strictly higher than in markets where the installed base can switch platforms.*

First, note that our results show that the appropriateness of the preannouncement strategy is still characterized by the strength of preferences. The bounds on t for formal, informal and no preannouncement strategies are given by equations (B5), (B6) and (B7) in the Online Appendix B. We find that our recommendation from Lemmas 1-3 continues to hold except that the SPNE feasibility regions when installed base is not loyal, are different. From the prices referred to in Lemma 4, we can see that unlike the case where there was no switching, firms are forced to lower their prices in these markets. Given that, we do not allow for subsidies (negative prices) in these models; our results tell us that there is a minimum strength of preference that is required before we can even examine a pure-strategy equilibrium in preannouncements.

Much of the differences between markets with and without switching can be attributed to the increased competitive intensity that switching brings to bear. While firms could comfortably rely on the loyalty of the installed base in the earlier context, with this group also at play, firms

need to lower their prices to be attractive. A second aspect unique to models with network effects stems from the fact that with a loyal installed base, some surplus from network effect is readily built-in for the agents (except in the no-preannouncement strategy) while on the other hand, total network effects expectations are fully price-dependent with switching. Given that prices, licensing fees and profits are always higher with no-preannouncement, in markets where the installed base is not loyal, firms pursue this strategy for even relatively higher values of t compared to markets with the loyal installed base.

Since markets with switching possibilities endow benefits to the agents, it behooves us to examine consumer and social welfare in market settings with and without switching. However, before we do that in section 3.3, we present an analysis of multi-homing markets that are often of great interest to platform researchers.

3.2 Multi-homing markets

Multi-homing, distinct from switching, refers to the situation when an agent develops (or consumes) not just for one but both platforms. In the context of games and other app development, multi-homing is more likely, particularly because many games or apps have embedded intellectual property and they can maximize their return by developing for both parties. Although multi-homing has typically been studied with the assumption that all agents on one side of the market multi-homes (general multi-homing) (Armstrong 2006), there is limited research that has examined this phenomenon particularly where the decision to multi-home itself is endogenized (Rasch 2007, Choi 2010) such that while some may multi-home, others single-home. We follow this approach and endogenize multi-homing as it encompasses the general multi-homing situation. Therefore, in this section, we investigate preannouncement strategies in markets where developers can multi-home – we first examine markets where the installed base is loyal (MH-NSW) followed by the case where both multi-homing and switching is feasible (MH-SW).

Continuing along the lines of the Hoteling abstraction introduced in section 2.4, we now allow for some developers who may potentially develop for platforms at both ends. Not surprisingly, the ones who would consider this opportunity are located in the middle and representative of developers that are more or less equally attracted to platforms at two ends. Unlike the earlier scenarios, we shall first develop the multi-homing agents' utility and then follow up with the single-homing side. Note that we use superscript $i, -i$ to denote the fact that the agents develop for both platforms.

$$U_{d,I}^{i,-i} = \theta + \delta\beta\Big[m_u^i + m_u^{-i} + n_u^i\ \big(p^i, p^{-i}, l^i, l^{-i}\big) + n_u^{-i}\ \big(p^i, p^{-i}, l^i, l^{-i}\big)\Big] - l^i - l^{-i} \qquad (20)$$

Equation (20) captures the fact the multi-homing agent benefits from the installed bases of both platforms $\big(m_u^i, m_u^{-i}\big)$ as well as the expected demand of both platforms from the new version $\big(n_u^i, n_u^{-i}\big)$ and indeed these developers pay the licensing fees of both platforms. On the other hand, the single-homing developer will derive the same utility as in the previous cases, e.g., as in equation (6). Note that since the proportion of single-homing and multi-homing developers is endogenously determined we know the market is split into three types – developers of platform $i\ \big(U_{d,I}^i > \max\big(U_{d,I}^{i,-i}, U_{d,I}^{-i}\big)\big)$, platform $-i\ \big(U_{d,I}^{-i} > \max\big(U_{d,I}^{i,-i}, U_{d,I}^i\big)\big)$, and multi-homing developers $i, -i\ \big(U_{d,I}^{i,-i} > \max\big(U_{d,I}^i, U_{d,I}^{-i}\big)\big)$. In other words, the firms need to take into account this single versus multi-homing decision of the developers in setting their licensing fees.

On the other side, even though a gamer only pays for one platform i, he derives cross-side network effects from both the single-homing developers of platform i as well from the multi-homing developers. Therefore, we can now write the gamer's utility as

$$U_{u,I}^i = \theta + \mu\alpha\Big[m_u^i + n_u^i\ \big(p^i, p^{-i}, l^i, l^{-i}\big)\Big] + \mu\beta\begin{bmatrix} m_d^i + n_d^i\ \big(p^i, p^{-i}, l^i, l^{-i}\big) \\ + n_d^{i,-i}\ \big(p^i, p^{-i}, l^i, l^{-i}\big) \end{bmatrix} - p^i \qquad (21)$$

Note that we also now need to rewrite the profit function as the firm now also gains from the multi-homing developers. Therefore, we have

$$\max_{p^i, l^i} \pi_I^i = p^i \left[m_u^i + n_u^i \left(p^i, p^{-i}, l^i, l^{-i} \right) \right] + l^i \left[m_d^i + n_d^i \left(p^i, p^{-i}, l^i, l^{-i} \right) + n_d^{i,-i} \left(p^i, p^{-i}, l^i, l^{-i} \right) \right] - kc. \quad (22)$$

LEMMA 5 (MH-NSW). *In multi-homing markets where agents do not switch, firms will pursue a no-preannouncement strategy, an informal preannouncement strategy and a formal preannouncement strategy in markets defined by weak, moderate and strong agent preferences respectively. The corresponding SPNE prices and licensing fees are given by*

$$p_{\{N,N\}}^{i*} = 2t \qquad p_{I,I}^{i*} = 2t - 2\mu\alpha - \frac{\delta\beta}{4} - \frac{\delta\left[3\mu + \delta\right]\beta^2}{2t} \qquad p_{F,F}^{i*} = 2t - 2\alpha - \frac{\beta}{4} - \frac{2\beta^2}{t} \qquad \blacksquare$$

$$l_{\{N,N\}}^{i*} = \frac{t}{4} \qquad l_{I,I}^{i*} = \frac{t + 2\left[\delta - \mu\right]\beta}{4} \qquad l_{F,F}^{i*} = \frac{t}{4}$$

Once again, note that even in the case of multi-homing developers, the appropriateness of the preannouncement strategy continues to be characterized by the strength of preferences. The bounds for the strategies are given by equations (B10) and (B11) in the Online Appendix B. We find that our observation from Lemma 1 still holds for this case allowing us to categorically conclude that preannouncement strategies have a consistent impact on the marketplace independent of loyalty of installed bases and/or the opportunity to multi-home. From a theoretical perspective, our findings encompass results from the two extant pieces of literature that has examined the role of information, albeit regarding prices and consumer knowledge (Suleymanova and Wey 2012, Hagiu and Hałaburda 2014). By examining the strategic role of information across several market settings, we can conclude that information increases the competitive intensity leading to lower prices and profits. However, firms end up having to engage in preannouncement strategies (informal/partial or formal/full) and thus providing more information on their forthcoming platforms when they face agents that have strong taste preferences. The

key intuition behind these results continues to be the fact that information that leads to better estimates of the strength of network effects offered by the new version of the platform results in higher expected network effects benefits. Such expectation of network effects increases surplus for the agents but is non-recoverable by firms.

One element stands out in the multi-homing case, i.e., unlike in all the earlier cases licensing fees under the informal preannouncement strategy are weakly *increasing* in the cross-side strength of network effects; in the single-homing cases licensing fees are weakly decreasing in this parameter or independent of it. The intuition behind this result is that multi-homing reduces competitive intensity even if firms lose their monopolistic hold over their developers. A platform obtains licensing fees from a combination of both single-homing and multi-homing developers, and the surplus of these developers are increasing in the cross-side strength of network effect. Unlike earlier (single-homing) when the strictly monopolistic separation of developers intensified competition, multi-homing allows the platforms to enjoy the benefits of the installed base of developers and extract the surplus they may enjoy proportional to the cross-side strength of network effect.

Just like in our analysis of single-homing markets, we also investigate multi-homing markets where the installed base of agents are not loyal and may, therefore, consider switching with the release of the new platform version. As the reader can surmise, the utility functions of the agents, in this case, will be developed along the lines of section 3.1 (SH-SW) and the current discussion on multi-homing. For brevity, we directly write the utilities of the users and both the single and multi-homing developers (for the informal preannouncement case) as follows.

$$
\begin{aligned}
U_{u,I}^i &= \theta + \mu\alpha\Big[2n_u^i\ \Big(p^i,p^{-i},l^i,l^{-i}\ \Big)\Big] + \mu\beta\Big[2\Big(n_d^i\ \big(p^i,p^{-i},l^i,l^{-i}\big)\ + n_d^{i,-i}\ \big(p^i,p^{-i},l^i,l^{-i}\big)\Big)\Big] - p^i \\
U_{d,I}^i &= \theta + \delta\beta\Big[2n_u^i\ \big(p^i,p^{-i},l^i,l^{-i}\big)\ \Big] - l^i \\
U_{d,I}^{i,-i} &= \theta + \delta\beta\Big[2\Big(n_u^i\ \big(p^i,p^{-i},l^i,l^{-i}\big)\ + n_u^{-i}\ \big(p^i,p^{-i},l^i,l^{-i}\big)\Big)\Big] - l^i - l^{-i}
\end{aligned}
\tag{23}
$$

Further, the platform's objective function can be written as

$$\max_{p^i,l^i} \pi_I^i = p^i \left[2n_u^i \left(p^i, p^{-i}, l^i, l^{-i} \right) \right] + l^i \left[2 \left[n_d^i \left(p^i, p^{-i}, l^i, l^{-i} \right) + n_d^{i,-i} \left(p^i, p^{-i}, l^i, l^{-i} \right) \right] \right] - kc. \quad (24)$$

Following approaches similar to the previous cases, we seek to identify SPNE by solving for equilibrium prices and licensing fees. This gives us Proposition 2.

PROPOSITION 2: *When competing firms and their platforms are identical in all aspects, there is no SPNE in preannouncement strategies in multi-homing markets when the installed base of agents can switch platforms.*

As discussed in further detail in the Online Appendix B, multi-homing in a Hotelling model requires certain fundamental assumptions to be satisfied in equilibrium. First, there are the standard conditions of market coverage that is true for both single and multi-homing. Then, there is the specific requirement that there is a non-zero number of multi-homing developers and the sum of developers is equal to the size of the market. In the earlier case where the installed base of agents was loyal, these conditions were met in equilibrium. However, we find that when these agents can switch the conditions for a multi-homing equilibrium are not met. Note that in other works such as Rasch (2007), authors model contexts similar to our switching case and yet find equilibrium multi-homing outcomes. A careful analysis of these models will show that their base setup incorporates some differentiation between either the two platforms in the form of strength of network effects engendered by each and/or differences between the two sides of the markets. In our model, we do not introduce these differences to independently examine the impact of the preannouncement strategies.

We can attribute the non-existence of equilibrium to this lack of differentiation. In other words, when the agents are not loyal and consider switching, they are procurable when the new version of the platform is released. The option to multi-home further removes the possibility of the two platforms to differentiate themselves as their only source of differentiation was by their

location on the Hotelling line. These conditions are not conducive to the existence of a pure-strategy equilibrium. In a similar vein, Choi (2010, p.621) observes, *"Multi-homing has an unintended effect of making consumers more homogeneous,"* supporting our earlier assertion that multi-homing was reducing the one main source of differentiation in our model.

3.3 Welfare analysis

We conclude our examination of preannouncement strategies with an understanding of its implication on consumer and social welfare. In most platform papers, there is always a brief discussion on welfare, but the importance of these analyses is furthermore significant in the context of preannouncement. Since the 1960's, it has been alleged that that *product* preannouncements can potentially be (Gerlach 2004, p.192), *"predatory acts in high-technology industries."* With regards to the role of information itself, Hagiu and Halaburda (2014) observe that all actors in a monopoly – platform, users and developers are all better off in the case of informed users. However, in a competitive model they suggest (p. 30), *"both users and developers prefer the scenario with uninformed users."* It, therefore, behooves us to examine welfare because information in our model is part of firm strategy rather than an exogenous condition. In this paper, not only do we examine welfare in each of the different preannouncement strategies but we also investigate how these might be affected by outside market conditions such as when consumers are not loyal and when developers have the option to multi-home. Therefore, we have Propositions 3 and 4.

PROPOSITION 3: *Consumer (all agents – users and developers) welfare is increasing in information while social welfare is decreasing, i.e., markets with Formal equilibrium outcomes have the highest consumer welfare while markets with No-Preannouncement equilibrium outcomes have the highest social welfare.*

PROPOSITION 4: *Across different types of markets, (i) consumer (social) welfare is higher (lower) in markets that allow for switching than those that do not and (ii) both consumer and social welfare is higher when developers can multi-home than when they only develop for a single platform.*

In our model, consumer welfare refers to the net welfare of *all* agents (users and developers) after the platform is released while social welfare also includes the profits from the two platforms. While firms set equilibrium prices in stage 2 to fulfill consumer expectations, all agents get full information regarding the NEE aspects of the platform upon its release. Thus, in the SH-NSW case when firms made an informal preannouncement in stage 1, by substituting $\mu = 1$ in equation (5) we compute the utility realized by the user after the release of the platform as

$$U_{u,I}^i = \theta + \alpha\left[m_u^i + n_u^i \left(p_{\{I,I\}}^{i*}, p_{\{I,I\}}^{-i*}, l_{\{I,I\}}^{i*}, l_{\{I,I\}}^{-i*}\right)\right] + \beta\left[m_d^i + n_d^i \left(p_{\{I,I\}}^{i*}, p_{\{I,I\}}^{-i*}, l_{\{I,I\}}^{i*}, l_{\{I,I\}}^{-i*}\right)\right] - p_{\{I,I\}}^{i*}.$$

Similarly, if firms made an informal preannouncement, by substituting $\delta = 1$ in equation(6), the developer's realized utility post release of the platform is

$$U_{d,I}^i = \theta + \beta\left[m_u^i + n_u^i \left(p_{\{I,I\}}^{i*}, p_{\{I,I\}}^{-i*}, l_{\{I,I\}}^{i*}, l_{\{I,I\}}^{-i*}\right)\right] - l_{\{I,I\}}^{i*}.$$

Along the same lines, we can compute the realized utilities for different equilibrium strategies in SH-NSW, SH-SW and MH-NSW scenarios.

For the single-homing case, the consumer welfare is given by $w_{s,s} = w_{u,\,s,s} + w_{d,\,s,s}$ where

$$w_{u,\,s,s} = \int_0^x U_{u,s}^i dx + \int_x^1 U_{u,s}^{-i} dx; \qquad w_{d,\,s,s} = \int_0^y U_{d,s}^i dx + \int_y^1 U_{d,s}^{-i} dx \tag{25}$$

with $s \in \{F, I, N\}$ signifying preannouncement strategy, and x, y respectively indicating the user and developer indifferent between the two firms. Therefore, the net social welfare can be written as

$$W_{s,s} = w_{s,s} + \pi_{s,s}^i + \pi_{s,s}^{-i} \tag{26}$$

In the case of multi-homing along the lines of the development in section 3.2, we need to account for the multi-homing developers in both the developer welfare as well as the profit functions of the two firms.

Proposition 3 makes it clear that a full and formal preannouncement, i.e., one where the marketplace has full knowledge of all the NEE aspects of the new version of the platform is the best for all agents. Perhaps this is not surprising in that utilities are increasing in the strength of network effects and it is through formal preannouncement that the agents are enabled to accurately estimate the the strength of network effects. What is interesting is that social welfare is the lowest in this case and is higher in the case of the no-preannouncement equilibrium. This makes it evident that the losses suffered by the platform (as a result of lower prices and licensing fees) in the case of complete information in the marketplace is more than offset by the gains when the agents are making decisions without awareness of the new versions' features. Therefore, it is not a strict transference in surplus. Also, note that this observation about the role of information is true in all markets, those with and without switching and where multi-homing is observed.

Given our analysis of different markets, we can also comment on the impact of the market structures themselves. For example, is switching beneficial? Alternatively, is multi-homing attractive to platform firms? While beyond the scope of this paper, the literature on technology standards (Farrell and Saloner 1986) points out as to how decisions of compatibility can change market conditions, i.e., switching and/or multi-homing themselves can be manipulated by technology firms. Our findings suggest that, not surprisingly, consumer welfare is higher when switching is possible but in this case also it is not a question of simple transference as both firm profits and social welfare are higher when switching is restricted. This once again suggests that the gains made by firms more than overcome the losses by consumers when switching is disallowed thus further emphasizing on loyalty-engendering initiatives on the part of the firms. Proposition 4 also

points to the fact that making one's new platform version to be incompatible with the installed base of the other's is attractive to firms.

In the case of multi-homing, our findings suggest that everyone is better off – consumers as well as firms. Multi-homing is where at least some developers find it optimal to develop for both platforms. This may be due to a variety of reasons including technical compatibility, low licensing fees on both sides and/or limited differentiation between platforms. Whatever the source of multi-homing is, our results show that it is beneficial at large.

4. Conclusion

The analysis in this paper contributes to our understanding of the role of information in preannouncement strategies in the context of two-sided markets (or platforms). Such insights can be leveraged by managers and strategists of platforms in preannouncing their new versions and designing pricing strategies for agents (e.g., users and developers of a video gaming console).

In platforms that are very similar in their intrinsic benefits, platform preannouncement could aid users in forming estimates about the strength of network effects of their new versions. Fully informing the market regarding NEE aspects of a platform is expensive because it involves educating agents about the experiential value derived from such elements of the platform. One may think that such significant investments are necessary for console makers because they influence agents' estimates regarding the strength of network effects and therefore impacts firm's pricing strategies.

Our analysis suggests that while not providing any information regarding NEE elements to the market is most beneficial for the firms, there is a clear relationship between firms' choice of equilibrium preannouncement strategies and differentiation of the platforms from the agent's perspective. When the competing platforms are less differentiated (when agent preferences are weak), the firms will avoid any preannouncement. However, when competing platforms are highly

differentiated (when agent preferences are strong), firms will commit to a formal preannouncement strategy in SPNE. Partial preannouncement is an SPNE strategy for both firms where the platforms are moderately differentiated. Thus, platform owners must understand the impact of market characteristics before identifying a preannouncement strategy.

We extend our analysis to understand the impact of loyalty of the installed base of agents on preannouncement strategies. In markets where the installed base of agents can switch platforms, we find that the ordering of SPNE preannouncement strategies over taste preferences remain the same, but it is clear that prices, licensing fees and firm profits are all higher when agents cannot switch. This insight indicates that platform strategists should not discount the impact of policies such as loyalty programs that discourage the installed base from switching.

Further, investigating these strategies in markets that allow multi-homing offers interesting insights. First, there is no equilibrium outcome in markets where both switching and multi-homing are possible unless the firms are non-identical (e.g., in their stand-alone value). However, when agents do not switch in a multi-homing case, we find that the extent of information in preannouncement plays a similar role as in the single-homing setting.

We also explore the role of information in preannouncement strategy, switching ability of the installed base and multi-homing on consumer and social welfare. Our results indicate that while consumer welfare increases with more information in preannouncement, the social welfare decreases. This is because the increased utility of agents from more information is not offset by the firm's profits due to increased intensity of competition. Hence, a social planner may suggest a ban on preannouncements. We find that the ability of the installed base of agents to switch and the presence of multi-homing developers are both beneficial to consumer welfare. Unlike the switching case, multi-homing developers also increase social welfare irrespective of the extent of

information in the preannouncement strategy. Thus, platform managers in the video game industry have an incentive to enable the developer side to multi-home and port their games easily across the platforms.

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Appendix A

Platform Preannouncement Strategies: The Strategic Role of Information in Two-Sided Markets Competition

Proof of Lemmas 1, 2, and 3

To derive the optimal prices and licensing fees for when firms preannounce formally, we take the user demand function that was derived from the Hotelling line, given by equation (13) and the developer demand function given by equation (14) and substitute them in the profit function given by equation (9). This gives us

$$
\begin{aligned}
\max_{p^i, l^i} \pi_F^i = {} & \\
p^i & \left[m_u^i + \frac{1}{2} + \frac{-t\left[p^i - p^{-i} \right] - \beta\left[l^i - l^{-i} \right] + \left[\alpha t + \beta^2 \right]\left[m_u^i - m_u^{-i} \right] + \beta t \left[m_d^i - m_d^{-i} \right]}{2\left[t\left[t - \alpha \right] - \beta^2 \right]} \right] \\
+ l^i & \left[m_d^i + \frac{1}{2} + \frac{-\beta\left[p^i - p^{-i} \right] - \left[t - \alpha \right]\left[l^i - l^{-i} \right] + t\beta\left[m_u^i - m_u^{-i} \right] + \beta^2\left[m_d^i - m_d^{-i} \right]}{2\left[t\left[t - \alpha \right] - \beta^2 \right]} \right] - c
\end{aligned}
\tag{A1}
$$

To derive the response function for firm i, we differentiate equation (A1) with respect to p^i and l^i. Similarly, we can construct the objective function of the other firm $\max\limits_{p^{-i}, l^{-i}} \pi_F^{-i}$, and differentiating with respect to p^{-i} and l^{-i}, we get its response function. We solve these four first-order conditions simultaneously to get the prices and licensing fees as a function of the installed bases. Since our focus is on identical firms, we can get candidate equilibrium prices $p^i{}_{F,F}$ and licensing fees $l^i{}_{F,F}$ for the focal firm by setting the installed bases of both firms to be the same $m_u^i = m_u^{-i}, \ m_d^i = m_d^{-i}$. Note, however, in order for these prices and licensing fees to be SPNE, not only should this preannouncement strategy dominate over others, but it should also be feasible in the region as defined by the various parameter relationships. In addition, for the existence of our equilibrium solutions to hold true post platform release, it is ensured that the platform i's indifferent consumer's utility continues to be greater than or equal to what he may have derived from the other platform. In other words, to establish that no agent would change their platform adoption decision post platform release, the following condition is ensured to be true: $U_{u,F}^i$ realized $\geq U_{u,F}^{-i}$ realized and $U_{d,F}^i$ realized $\geq U_{d,F}^{-i}$ realized . Note that this only needs to be

checked for this indifferent agent as utilities are strictly increasing away from this user, for other users of the focal platform. Further, since firms are symmetric, the position of the indifferent agent does not change post platform release. In the case of Formal preannouncement strategy,

$$U^i_{u,F} \text{ realized} = U^{-i}_{u,F} \text{ realized} = \theta + \alpha\left[1 + \mu\right] + \beta\left[1 + \delta\right] - \frac{3t}{2}$$

$$U^i_{d,F} \text{ realized} = U^{-i}_{d,F} \text{ realized} = \theta + \beta\left[1 + \mu\right] - \frac{3t}{2}$$

Along the above lines and as developed in section 2.4, we can now develop candidate equilibrium price-licensing pairs for each of the other scenarios[3]. Thus we will have $p^i_{I,I}$, $l^i_{I,I}$ for the Informal case (using equations (15) and (10)) , and $p^i_{N,N}$, $l^i_{N,N}$ (using equations (16) and (11)) for the No-preannouncement case. Now in order for any of the above pairs to be SPNE prices and licensing fees, we require the profits from that strategy to be higher than the other two strategies. Therefore, Formal strategy prices and licensing fees derived earlier are equilibrium prices $p^{i*}_{F,F}$ and licensing fees $l^{i*}_{F,F}$, if and only if

$$\begin{aligned} \pi^{i*}_{F,F} &> \max\left[\pi^{i*}_{I,I}, \pi^{i*}_{N,N}\right] \\ \pi^{-i*}_{F,F} &> \max\left[\pi^{-i*}_{I,I}, \pi^{-i*}_{N,N}\right] \end{aligned} \tag{A2}$$

We can easily see that not only are these conditional on the various constraints on parameters $\alpha, \beta, \mu, \delta$, etc., but they also need to satisfy relationships amongst themselves as imposed by simple individual rationality conditions and other words. In other words, explicitly imposing all parameters to be non-zero and keeping $\mu, \delta \in 0,1$, we now consider other economic constraints and characterize all of them through t . Once again, we develop these only for the Formal case.

From the Hotelling model, we require that all agents derive non-negative utilities (they will not participate otherwise). Ensuring this for the indifferent agent suffices and therefore substituting the utility function (equation(3)) and user demand (equation (13)) in the net utility (equation(12)), we can derive the condition for non-negative net utility of user as

$$t \leq \frac{2\left[\theta + 2\alpha + 2\beta\right]}{3}$$

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[3] Note that to avoid redundancies, we explicitly derive and develop prices and licensing fees and corresponding conditions only for the formal case. The techniques to do so are the same for other cases as well.

Along the same lines, using equations(4) and (14), the condition necessary for non-negative net utility of the developer can be given as

$$t \leq \frac{2\left[\theta + 2\beta\right]}{3}$$

We also require that profits are non-negative, which yields us the condition

$$t \geq \frac{c + \alpha + 2\beta}{2}$$

And that the profit function is concave in the equilibrium prices and licensing fees which yields us conditions

$$t > \alpha \ \text{ and } \ t\left[t - \alpha\right] > \beta^2$$

Finally, since we do not consider subsidies in our paper, all equilibrium prices and licensing fees must be positive. This yields us the conditions

$$t > \alpha + \beta, \ t > \beta$$

Considering all these constraints together, through reduction, we can characterize the potential bounds where FF is SPNE to be defined as:

$$t_{F,F} \ \in \left(\max\left[\alpha + \beta, \ \frac{\alpha + 2\beta + c}{2}\right], \frac{2\theta}{3} + \frac{2\beta}{3}\right) \tag{A3}$$

Similarly, considering the utility functions, profit functions concavity conditions and others, we can have the potential bounds for the other two cases as:

$$t_{I,I} \ \in \left(\max\left[\mu\alpha + \delta\beta, \ \frac{\mu\left[\alpha + \beta\right] + \delta\beta + kc}{2}\right], \ \frac{2\theta}{3} + \frac{\left[\mu + \delta\right]\beta}{3}\right)$$
$$t_{N,N} \ \in \left(0, \frac{2\theta}{3}\right) \tag{A4}$$

However note that in order for these bounds to be SPNE regions, we need to ensure that equation (A2) (and its counterparts for other equilibrium solutions II and NN)) is also satisfied along with equations (A3) and (A4). Thus, the Formal strategy equilibrium bounds characterized over t is

$$t^{*}_{F,F} \ \in \left(\frac{2\theta}{3} + \frac{\left[\mu + \delta\right]\beta}{3}, \frac{2\theta}{3} + \frac{2\beta}{3}\right) \tag{A5}$$

Similarly, we can derive the bounds for the other two equilibrium outcomes as

$$t^*_{I,I} \in \left(\frac{2\theta}{5}, \frac{2\theta}{3} + \frac{\left[\mu + \delta\right]\beta}{3} \right) \tag{A6}$$

$$t^*_{N,N} \in \left(0, \frac{2\theta}{3} \right) \tag{A7}$$

Therefore, we have Lemmas 1, 2 and 3.

REST OF THE OF PROOFS ARE AVAILABLE IN THE ONLINE APPENDIX

****Insert Link here ****