In-house Publishing and Competition in the Video Game Industry *

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Abstract

This paper analyzes two-sided competition in the video game industry. Video game platforms compete for software publishers and gamers and may invest into in-house publishing of own software (games) before they enter competition. Such investments affect the strength of the indirect network externalities between gamers and publishers in equilibrium. If publishers multihome, i.e., if they can release games for multiple platforms, and gamers singlehome, i.e., if they use only a single platform, in-house games reduce the profits obtained by platforms in equilibrium. Consequently, one may suppose that they refrain from investing into in-house games. However, the analysis reveals that an equilibrium where platforms credibly commit to do so cannot be sustained, transforming the game into a prisoner’s dilemma. This no longer holds if gamers also multihome, granting monopoly power to platforms on both sides of the market. The benefit obtained by gamers and the level of social welfare are always enhanced with in-house publishing.

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1 Introduction

Video games are software products published for use on video game consoles (e.g., Microsoft’s Xbox 360, Sony’s Playstation 3 or Nintendo’s Wii). Video game consoles are platforms offered by hardware manufacturers dealing with software publishers and gamers. The industry exhibits strong two-sided indirect network effects. Both software publishers and gamers obtain value from interacting with each other. The publishers’ incentives to port a game to a particular console increase with the number of gamers who use this console. Likewise, the wider the variety of games available on a console, the more attractive it becomes for gamers to use it.

All console manufacturers develop and publish own in-house games. Such ‘first-party titles’ attract more gamers, which, in turn, increases the value to software publishers of porting games to the respective consoles.\(^1\) By contrast, independent publishers can choose between porting a game exclusively to a single console or to port it to multiple consoles. For example, Electronic Arts redesigned its *FIFA* video game series to make it compatible with multiple consoles, while there are other publishers which ported games exclusively to a single platform.\(^2\)

This paper aims to analyze the importance of indirect network externalities in the provision of in-house games and exclusive games in the video game industry in more detail. Video game console platforms engage in duopolistic competition in the spirit of Armstrong’s (2006) two-sided market framework.\(^3\) It is assumed that they can invest into in-house games before entering competition. Such investments allow a platform to gain a competitive advantage over its rival due to the presence of strong cross-group externalities between gamers and publishers. The model helps to understand the effects of in-house publishing on the strength of network externalities and the resulting price strategies of the platforms. It explores the implications for publishers, gamers and for social welfare in general. The paper also analyzes how the equilibrium outcome depends on gamer singlehoming, that is, it shows how the results change if not only publishers...
can deal with multiple platforms, but also gamers.

The model comprises three types of agents. Video game console platforms charge a license fee to publishers and a fee (i.e., the retail price for the console) to gamers. The platforms balance these fees to maximize combined profits from both sides of the market. The literature on two-sided markets (e.g., Caillaud and Jullien (2003), Hagiu (2006) and Rochet and Tirole (2003) and (2006)) emphasizes the importance of indirect network effects as driver of pricing decisions. The model provides a setting where console manufacturers can strengthen the indirect network externalities by investing into first-party titles before entering competition. Thereby, the paper contributes to the literature on investment decisions in two-sided markets. For example, Belleflamme and Peitz (2010) examine the role of network externalities in investment decisions in a model of platform intermediation between buyers and sellers. They assume that sellers can make investments (e.g., into innovation activities) before joining a platform and investigate the effects of for-profit intermediation on sellers’ investment incentives. One further important determinant of pricing decisions in two-sided markets is whether agents singlehome or multihome (see, e.g., Armstrong (2006) and Choi (2010)). The model deals with this issue by differentiating between two market configurations. First, a set-up of duopolistic platform competition is provided where gamers singlehome, i.e., they use a single console, while publishers multihome, i.e., they may release games for both consoles. Given that the gamer market is covered and cannot be extended, this case represents a competitive bottleneck. This implies that a platform immediately captures demand from the rival by either decreasing the price or increasing the variety of games if the rival does not react to these changes. This business stealing effect is not present on the publisher side of the market. The decision of publishers to port games to a console is independent of the decision also to port them to the rival console. This form of multihoming implies a structure of overlapping market shares, granting monopoly power to platforms on the publisher side of the market. In the second configuration, the set-up is modified so that both sides of the market are allowed to multihome in this way. Regarding the video game industry, a scenario with multihoming gamers is particularly relevant for the recent console generations. The emergence of new digital services has made it easier for platforms to differentiate themselves from competitors and to induce gamers to access and use multiple platforms. Therefore, some gamers may choose to own more than only one console (see, e.g., Belleflamme and Peitz (2010)).

Turning to the results, the analysis reveals that platforms will choose a strategy of first-stage in-house publishing in both market configurations, leading to an increase in the level of both
consumer surplus and social welfare. This result is noteworthy because platforms only benefit from offering first-party content if they have monopoly power on the gamer side of the market. If this is not the case, i.e., if gamers singlehome, platforms fiercely compete for them and investing into in-house games reduces platform profits in the symmetric equilibrium. Therefore, one might conjecture that platforms refrain from in-house publishing. However, this ignores the business stealing effect on the gamer side of the market resulting from the presence of the cross-group externality. As a result, an equilibrium where platforms credibly commit to refrain from in-house publishing is not sustainable because each platform would have a large deviation incentive. This transforms the game into a prisoner’s dilemma.

This no longer holds if gamers can multihome. In this case, platforms have monopoly power on both sides of the market and investments into in-house games increase the gamer demand without stealing business from the rival. Consequently, first-stage in-house publishing is a profitable strategy for platforms. In addition, the aggregate surpluses of gamers and publishers and the social welfare are strictly increased.

The reminder of the paper is organized as follows. Section 2 briefly provides background information on the video game industry and discusses related empirical studies. Section 3 sets up the model and studies the duopoly with singlehoming gamers and multihoming publishers. Section 4 explores the model with multihoming on both sides of the market. Finally, Section 5 concludes.

2 Industry background and empirical evidence

This paper aims to analyze the effects of in-house publishing of software in the video game industry. The results suggest that indirect network externalities are an important determinant of the competitive environment in this industry. From this point of view, the paper is closely related to a handful of empirical studies.

A first empirical study analyzing the importance of indirect network externalities in the video game market is conducted by Clements and Ohashi (2005). They use data from the U.S. market in the period from 1994 to 2001 and estimate the effects of console price and game variety on the elasticity of demand over a console’s product cycle. They find that the competitive effect of the strength of the indirect network externality is particularly important towards the end of the product cycle.
Regarding publishers, the trend in the industry is towards making games non-exclusive (Reimer (2005)). Clements and Ohashi (2005), state that only 17% of the games were available on multiple platforms in the period of their study. Since then the share has tended to increase. Publishers look for multiple revenue sources, and in case the profits from porting the game to an additional platform exceed the porting and development costs, they will choose to make the game available on that platform. The model may help to explain this trend. It shows that the share of non-exclusive games increases if the installed base of a platform becomes larger. Corts and Lederman (2009) study the trend towards non-exclusive games empirically. In accordance with the results derived in this paper, they find that an exogenous increase of exclusive games on one platform, i.e., in-house published games, leads to an immediate business stealing effect. They refer to this as "indirect network effects lead the strong to get stronger and the weak to get weaker". In addition, they find that the effect on gamer demand of an exclusive game is slightly more than two times as large as the one of a game that is compatible with all platforms. Their empirical results support the conjecture that exclusive games are an effective means to gain competitive advantage.

A study particularly focusing on in-house published games is provided by Cenamor et al. (2013). They use data from a panel for the period between 1989 and 2011 and find that a larger number of in-house published games stimulates platform adoption by gamers. This effect is amplified if a larger share of gamers use the in-house published titles. Clements and Ohashi (2005) find that the share of in-house published games was on average 26.6% six years after the console release for the period of their study. These days, all three main players still have strong first-party development portfolios (Greenspan (2013)). For example, in 2012, the three console manufacturers Microsoft, Nintendo and Sony were also among the top 7 game publishers. The model of this paper predicts that in-house publishing is profitable if it does not imply a business stealing effect, i.e., if gamers multihome. Indeed, console manufacturers increasingly target different consumer segments and according to a recent survey provided by Nielsen, the current trend in gamer behavior is towards an overlap in the use of consoles.

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4Nintendo’s market share in the publishing market was 10.8%, while those of Microsoft and Sony were 5% and 3.5% respectively, see http://www.gamesindustry.biz/articles/2013-05-16-activisions-market-share-climbed-to-almost-20-percent-in-2012.

5In their recent marketing campaigns, Microsoft advertises its Xbox One as multi-purpose de-
3 Singlehoming gamers and multihoming publishers

This section sets up a two-sided market model to examine the impact of investments into in-house game publishing by video game console platforms along the lines of Armstrong (2006) and Belleflamme and Peitz (2010).

Consider first the case where publishers are not restricted to devote to a single platform, while gamers only use a single platform. Suppose that there are two competing profit-maximizing platforms, each denoted by $P_i$, $i = A, B$, which are horizontally differentiated for both gamers and publishers. Both sides of the market are modeled as a circular city à la Salop (1979) with a unit mass of gamers and publishers. In the case of duopolistic competition, platforms symmetrically locate in equilibrium, that is, $P_A$ is located at 0 and $P_B$ at 1/2 on both sides of the market (see, e.g., Economides (1989) or Dewan et al. (2003)). A representative platform $P_i$ generates profits from both sides of the market by simultaneously charging gamers a price $p_i$ and publishers a license fee $w_i$. Platforms have neither marginal nor fixed costs when setting up and running their business. The game is two-stage. Before entering the competition stage, $P_i$ decides whether or not to invest into in-house publishing, where the resulting number of in-house published games is $f_i$. When doing so, $P_i$ faces quadratic costs, e.g., to conduct in-house development or to contract with an external development studio. It is assumed that platforms earn an expected amount of $\delta$ from each gamer per in-house published game.

Gamers are heterogeneous and uniformly distributed along the circular city, reflecting their differentiated needs and preferences with respect to the games on the platforms. A gamer located at point $x_\eta$ on the right side of the circular city faces costs of accessing $P_A$ that are given by

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It is assumed that platforms set fees for gamers and publishers simultaneously. In case of video game consoles, simultaneity in price setting is used by, e.g., Belleflamme and Peitz (2010) and Rasch and Wenzel (2013). However, Hagiu (2006) argues that in the video game industry, access fees may be set sequentially. Consider for example that a producer of a console may announce a low price for the console in advance of the release. This makes the console attractive to gamers and incentivizes publishers to make their games compatible with it.

It can be easily justified that platforms face costs when they decide to apply a strategy of in-house publishing. They need to set up costly development divisions or they must buy games from external development studios. Organizational diseconomies of scale may arise because the console manufacturers are also among the largest publishers, while independent development teams often enjoy benefits from specialization and comparative advantages.
$p_A + tx_\eta$. These costs are comprised of $P_A$’s gamer price and costs arising from the difference to the gamer’s most preferred specification of games that linearly increase at rate $t$. The gamer benefits from the number of games $q_A$ available on $P_A$, encompassing both in-house developed games and games ported to $P_A$ by independent publishers in the second stage. The utility gain from each additional game obtained by gamers is $\gamma$. Thus, the gamer at position $x_\eta$ on the right side of the circular city receives a net utility from using $P_A$ that is given by

$$U_\eta^A = R_A + \gamma q_A - tx_\eta - p_A,$$

(1)

where $R_A$ is the intrinsic value attributed to gamers if they chose to access $P_A$.\(^8\) It is assumed that $R_i$, $i = A, B$, is sufficiently large, so that each gamer chooses to access one of the two platforms. Analogously, this gamer’s net utility from using $P_B$ is

$$U_\eta^B = R_B + \gamma q_B - t \left( \frac{1}{2} - x_\eta \right) - p_B.$$  

(2)

Using (1) and (2) gives the definition of the locations where gamers are indifferent between using $P_A$ and $P_B$:

$$\hat{x}^r = \left( \frac{1}{4} + \frac{R_A - R_B + p_B - p_A + \gamma (q_A - q_B)}{2t} \right)$$  
on the right side of the circle

and

$$\hat{x}^l = \left( \frac{3}{4} + \frac{R_B - R_A + p_A - p_B + \gamma (q_B - q_A)}{2t} \right)$$  
on the left side of the circle.

Turning to the other side of the market, each publisher is assumed to have exactly one game. Without loss of generality, it is assumed that publishers have already developed the basic design of the game and now must choose between porting it to either one or both platforms. It is natural to assume that ”porting games to different platforms can be expensive and time-consuming” (Reimer (2005)). Therefore, publishers are uniformly distributed along their circular market, reflecting that games are heterogeneous with respect to porting costs (see, e.g., Corts and Lederman (2009)).

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\(^8\)The intrinsic value may be based on features offered by the platforms such as online multiplayer gaming.
Porting costs may originate from high levels of complexity and product innovation of video game consoles. In general, the systems strongly differ in technology and product features. This applies to the hardware (e.g., Sony’s PlayStation 3 has a Blu-ray drive, while the Xbox 360 originally had an HD-DVD add-on drive) and to the programming and scripting languages. In addition, a tremendous technological progress has taken place. Video game consoles have increasingly become multi-purpose systems over the past years, and there is a permanent challenge between hardware platforms to come up with more innovative products (Almirall and Casadesus-Masanell (2010)). In case a game is developed to run on several platforms, the developing process requires programmers with specialized knowledge about the technology and the engine architecture of the respective platforms. Additionally, format testers who monitor a game’s cross-platform compatibility are needed (Novak (2008)). This implies that much knowledge is specific to the process of porting a particular game to a particular console that cannot be transferred costlessly to port this particular game to another console.

Apart from the above-mentioned technology-specific costs, heterogeneity in the publishers’ costs of releasing a game for a particular console may also arise from the targeting of marketing activities. As outlined in section 2, video game consoles are increasingly differentiated with respect to their targeted consumer segments. This implies that publishers have to launch different marketing campaigns when releasing a game for different consoles. In addition, contracts are usually written so that publishers are required to pay the license fees in advance and to produce a minimum quantity. Thus, publishers may also have heterogeneous costs of inventory risk when releasing a game for a particular console because they often bear all risk if the game fails in the market (Epstein and Politano (2014)).

Turning back to the model, multihoming of publishers implies that there may be up to three segments on each side of the circular market. Consider for example a publisher at point \( y_\sigma \) on the right side of the circular city which is closest to \( P_A \). If platforms are symmetric, this publisher can decide to release the game for \( P_A \) and, independent of this decision, to additionally release it for the rival \( P_B \). The costs faced by the publisher of releasing its game for \( P_A \) are

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9As a result, the size of game development teams has continuously increased. While, in the early years, a team typically consisted of two people, today up to 400 developers are involved in the development of a game (Claussen et al. (2012)). Thus, it is not surprising that game development costs have also risen significantly from each generation to the next (Corts and Lederman (2009)).
given by $w_A + \tau y_0$, where $w_A$ is the license fee and the term $\tau y_0$ reflects the porting costs that linearly increase at rate $\tau$. Analogously, the costs of additionally releasing the game for $P_B$ are $w_B + \tau (1/2 - y_0)$. Like platforms, publishers generate an expected amount of $\delta$ from each gamer on a platform. Hence, the net utility of the publisher at position $y_0$ from releasing the game exclusively for $P_A$ is given by

$$w'_A = \delta x_A - w_A - \tau y_0,$$

where $x_A$ is the number of gamers using $P_A$. Porting a game to a platform has no intrinsic value to publishers. Equivalently, the net utility of a publisher at position $y_\kappa$ on the right side of the circular city, which is closer to $P_B$, from releasing the game exclusively for $P_B$ is

$$w'_B = \delta x_B - w_B - \tau \left(\frac{1}{2} - y_\kappa\right),$$

where $x_B$ is the number of gamers on $P_B$. When releasing the game for both platforms, each publisher obtains a net utility given by

$$u_b = \delta (x_B + x_A) - w_B - w_A - \frac{\tau}{2}.$$

Thus, the definition of the locations where publishers are indifferent between porting their game to $P_A$ and porting it to both platforms are

$$\hat{y}_{Ab} = \frac{1}{2} - \frac{\delta x_B - w_B}{\tau} \quad \text{on the right side of the circle}$$

and

$$\hat{y}_{Ab}^l = \frac{1}{2} + \frac{\delta x_B - w_B}{\tau} \quad \text{on the left side of the circle}.$$

Equivalently, the definition of the locations where publishers are indifferent between porting their game to $P_B$ and porting it to both platforms are

$$\hat{y}_{Bb} = \frac{\delta x_A - w_A}{\tau} \quad \text{on the right side of the circle}$$

and

$$\hat{y}_{Bb}^l = 1 - \frac{\delta x_A - w_A}{\tau} \quad \text{on the left side of the circle}.$$
Figure 1 illustrates the set-up with singlehoming gamers and multihoming publishers.

Figure 1: Set-up with multihoming publishers and singlehoming gamers

It is now possible to determine the number of gamers and publishers on each platform. Gamers singlehome and thus split into two groups where one group accesses $P_A$, while the other accesses $P_B$. The number of gamers on a representative platform $P_i$ is given by

$$x_i = 2 \left[ \frac{1}{4} + \frac{p_j - p_i + \gamma (q_i - q_j)}{2t} \right], \quad i = A, B. \quad (3)$$

Publishers may multihome, that is, they can release their game for both platforms. The number of games ported to both platforms is determined by $q_b = (\hat{y}^r_{Bb} - \hat{y}^r_{Ab}) + (\hat{y}^l_{Ab} - \hat{y}^l_{Bb})$. Inserting the expressions for the locations of the respective indifferent publishers yields

$$q_b = 2 \frac{[\delta x_i + x_j - w_i - w_j]}{\tau}, \quad i = A, B. \quad (4)$$

In contrast, the number of publishers releasing only for $P_A$ is determined by $q^*_A = \hat{y}^r_{Ab} + (1 - \hat{y}^l_{Ab})$ and the number of those releasing only for $P_B$ is determined by $q^*_B = \hat{y}^l_{Bb} - \hat{y}^r_{Bb}$. Thus, the number of games that publishers port exclusively to a representative platform $P_i$ is given by

$$q^*_i = 1 - \frac{2 (\delta x_j - w_j)}{\tau}, \quad i = A, B. \quad (5)$$

Both platforms are monopolies with overlapping market shares on the publisher side of the
market because a publisher’s decision to release its game for a platform is independent of the decision to release it for the rival platform. Let \( q_i \) be the total number of games on \( P_i \) that accounts for the strength of the positive externality exerted by the variety of games on gamers.

The total number of games on \( P_i \) is given by the sum of the number of \( P_i \)'s in-house games in addition to the number of both exclusive and non-exclusive games ported to \( P_i \) by independent publishers, that is, \( q_i = q_b + q_i^s + f_i \). Inserting (4) and (5) yields

\[
q_i = \frac{2(\delta x_i - w_i)}{\tau} + f_i, \quad i = A, B. \tag{6}
\]

It is now possible to solve the system of the four equations (3) - (6). From (6), \( P_i \)'s market share on the gamer side of the market can then be formulated as follows:

\[
x_i = \frac{1}{2} + \frac{4\gamma(w_j - w_i) + 2\tau(p_j - p_i + \gamma(f_i - f_j))}{2t\tau - 8\delta\gamma}, \quad i = A, B.
\]

On the publisher side of the market, the number of games ported to \( P_i \) by independent publishers is given by the sum of (4) and (5). Using (3) and (6), one obtains

\[
q_b + q_i^s = \frac{\delta - (w_i + w_j)}{\tau} + \frac{t(w_j - w_i) + 2\delta(p_j - p_i + \gamma(f_i - f_j))}{t\tau - 4\delta}, \quad i = A, B.
\]

The model is solved by backward induction, starting with the pricing stage. Before analyzing the platforms’ pricing decisions, the following assumption is made:

**A1.** \( 2t\tau > \gamma^2 + 6\delta\gamma + \delta^2 \).

The assumption states that the indirect network effect must be relatively small compared to the degree of horizontal differentiation on both sides of the markets. This assumption is standard in two-sided market models with cross-group externalities and is needed to ensure concavity of the platforms’ profit functions.

In the second stage of the game, each platform chooses the license fee and the gamer price to maximize its profit. Thus, \( P_i \) solves the program

\[
\max_{(p_i, w_i)} \pi_i = (p_i + \delta f_i) x_i + w_i (q_b + q_i^s).
\]
Consider for simplicity that $R_i = R_j$. The first-order condition with respect to the optimal license fee can be formulated as $P_i$'s best-reaction function on the publisher side of the market, which is given by

$$w_i(p, w_j, f_j) = \frac{\delta(t \tau - 4\gamma \delta) + 2\gamma (2\delta w_j + p_i \tau) + 2\delta \tau (p_j - p_i) - 2\gamma \delta \tau f_j}{4t \tau - 8\gamma \delta}, \quad i = A, B,$$

where $p = (p_i, p_j)$. Analogously, $P_i$'s best-reaction function on the gamer side of the market becomes

$$p_i(p_j, w, f) = \frac{t}{4} + \frac{1}{2} (p_j + \gamma (f_i - f_j)) + \frac{1}{\tau} (\gamma (w_j - w_i) - \delta (w_i + \gamma)) - \frac{\delta f_i}{2}, \quad i = A, B,$$

where $w = (w_i, w_j)$ and $f = (f_i, f_j)$. Solving the system of best-reaction functions (7) - (8), one obtains the license fee and the gamer price chosen in the equilibrium of the second stage:

$$w_i^*(f) = \frac{\delta - \gamma}{4} + \frac{2(\delta - \gamma) ((\delta + \gamma) \tau (f_i - f_j) - 4\delta \gamma)}{4 (3t \tau - 2(\delta^2 + 4\delta \gamma + \gamma^2)), \quad i = A, B, (9)$$

and

$$p_i^*(f) = \frac{(t \tau - \delta (\delta + 3\gamma))} {2\tau} + \frac{\gamma (f_i - f_j)}{3} - \frac{(\delta - \gamma)(\delta + \gamma) (\delta + 2\gamma)(f_i - f_j)} {3(3t \tau - 2(\gamma^2 + 4\gamma \delta + \delta^2))}, \quad i = A, B. \quad (10)$$

Consider that both platforms are symmetric in their first-stage investments, i.e., $f_i = f_j = f^*$. In this case, the equilibrium license fee becomes $w^* = \frac{\delta - \gamma}{4}$. Because of the monopoly power platforms have on the publisher side of the market and the linearity of the model, $w^*$ is independent of the publishers’ transportation costs $\tau$. It is straightforward that this expression increases in the network externality exerted by gamers on publishers and decreases in the network externality exerted by the variety of games on gamers. Moreover, if $\gamma > \delta$, the optimal licensee fee becomes negative, that is, platforms subsidize publishers. In this case, competition is fierce, such that platforms choose a strategy of paying publishers to make their game compatible with their console, which, in turn, allows platforms to gain competitive advantage over the rival on the gamer side of the market. The equilibrium gamer price with symmetric first-stage investments is $p^* = t/2 - \frac{\delta (\delta + 3\gamma)}{2\tau} - \delta f^*$, which, without network effects, equals the one of the standard Salop (1979) model with two firms, i.e., $p^* = t/2$. This term is adjusted downwards by a platform’s external benefit from attracting one additional gamer, which is determined by
\[
\frac{\partial (q_i + q_s)}{\partial x_i} (w^* + \gamma) + \delta f^*, \text{ where } i = A, B. \]

The term \((w^* + \gamma)\) is the benefit realized by a platform from the increase in the number of publishers. The platform gets the license fee \(w^*\) from the additional publishers and extracts an additional benefit \(\gamma\) from gamers per each additional publisher. Using (6) and the equilibrium fee for publishers with symmetric in-house publishing \(w^*\) gives the linear expression \(\frac{\delta (2\gamma + 3\gamma)}{2\tau}\). Moreover, each additional gamer allows a platform to earn an extra revenue of \(\delta\) per in-house game.

Using (9) and (10), one obtains the platforms’ equilibrium profit in the second stage of the game, which is given by

\[
\pi^*_i(f) = \frac{(2t\tau - (\gamma^2 + 6\gamma\delta + \delta^2))(3t\tau + 2\tau(\delta + \gamma)(f_i - f_j) - 2(\gamma^2 + 4\gamma\delta + \delta^2))^2}{8\tau (3t\tau - 2(\gamma^2 + 4\gamma\delta + \delta^2))^2}, \quad i = A, B.
\]

Consider now that platforms are asymmetric in the second stage, for example, that \(P_i\) made larger investments into in-house games than \(P_j\) in the first stage. In this case, \(P_i\) has a competitive advantage over \(P_j\) because, due to the positive externality, larger investments lead to an increase in the gamers’ benefit from accessing \(P_i\). This, in turn, makes it more attractive for publishers to port games to \(P_i\). Consequently, \(P_i\) can charge higher equilibrium fees than \(P_j\) for both gamers and publishers, resulting in an increase of its equilibrium profit. Therefore, each platform would always choose to publish the largest possible number of in-house games.

However, first-stage in-house publishing is costly to platforms. It is assumed that platforms face a quadratic investment cost function \(C(f_i) = \phi f_i^2\) to publish \(f_i\) games in-house, where \(\phi\) is a constant parameter. The following parameter restriction ensures concavity of the platforms’ profit functions in the first stage of the game:

**A2.** \(2\phi > \frac{(2\tau(\delta + \gamma))^2(2\tau - (\gamma^2 + 6\gamma\delta + \delta^2))}{(3\tau - 2(\gamma^2 + 4\gamma\delta + \delta^2))^2}\).

Each platform anticipates the outcome of the second stage and chooses its optimal first-stage investment. The outcome of the equilibrium of the first-stage game is as follows:

**Proposition 1.** The number of games published in-house by each platform in the first stage is given by

\[
f^* = \frac{(\delta + \gamma)(2t\tau - (\gamma^2 + 6\gamma\delta + \delta^2))}{4\phi (3t\tau - 2(\gamma^2 + 4\gamma\delta + \delta^2))}.
\]
If both platforms could commit to refrain from investing into in-house games in the first stage, each of them would earn strictly higher equilibrium profits. In the limit, as $\phi \to \infty$, the equilibrium profits with investments into in-house games converge to those without.

**Proof.** See Appendix.

Proposition 1 states that platforms are strictly better off if both commit to refrain from in-house publishing in the symmetric equilibrium. Although platforms generate a benefit of $\delta$ from each gamer per in-house published game, this positive effect is completely outweighed by the negative effect that stems from the more intense competition for gamers due to the increased strength of the indirect network externality. Hence, the set-up where gamers singlehome and publishers multihome transforms the game into a typical prisoner’s dilemma. Investing into own games in the first stage is a dominant strategy for platforms. This is due to the business stealing effect on the gamer side of the market. If one platform increases its investments to publish more games in-house, it immediately wins gamers away from the rival. This makes a situation impossible where a commitment between platforms to abstain from publishing games in-house is supported. Moreover, in order not to lose competitive advantage, platforms cannot balance their costly first-stage investment by increasing the equilibrium fees in the second stage. To see this formally, consider that $\phi$ decreases. It is easily seen that platforms optimally react by increasing the number of in-house games because from (11) it follows that $\partial f^*/\partial \phi < 0$ by virtue of $A1$. As a consequence, competition for gamers becomes even more aggressive, which can be shown by means of the equilibrium gamer price. Inserting (11) into (10) gives

$$p^* = \frac{1}{2} \left( t - \frac{\delta(\delta + 3\gamma)}{\tau} - \frac{\delta(\delta + \gamma) \left( 2t \tau - (\gamma^2 + 6\gamma \delta + \delta^2) \right)}{2\phi \left( 3t \tau - 2(\gamma^2 + 4\gamma \delta + \delta^2) \right)} \right).$$

If $A1$ is satisfied, it follows that $\partial p^*/\partial \phi > 0$. Thus, if $\phi$ decreases, platforms increase the number of in-house games, but the generated profits are passed on to gamers in the form of a decrease in the price. Paradoxically, for the same reason, an increase in the cost parameter $\phi$ leads to higher profits obtained by platforms in the symmetric equilibrium.

### 3.1 Welfare implications

This subsection aims to explore the effects of first-stage investments into in-house games on gamer and publisher surplus and on social welfare in general. In the set-up with singlehoming
gamers and multihoming publishers, the aggregate surplus obtained by gamers is determined by

\[
GS = \int_0^{\hat{x}} (R_A + \gamma q_A - p_A - tx) \, dx + \int_{\hat{x}}^1 (R_A + \gamma q_A - p_A - t(1 - x)) \, dx \\
+ \int_{\frac{1}{2}}^{\hat{x}} (R_B + \gamma q_B - p_B - t \left( x - \frac{1}{2} \right)) \, dx + \int_{\frac{1}{2}}^{\hat{x}} (R_B + \gamma q_B - p_B - t \left( 1 - x \right)) \, dx.
\] (12)

Consider that \( R_i = R_j = R \). First inserting the equilibrium expressions for the pricing variables (9) and (10) into (12) and then inserting the equilibrium expression for the number of in-house games (11) into the resulting expression gives

\[
GS^* = R - \frac{5t}{8} + \frac{\delta^2 + 4\delta\gamma + \gamma^2}{2\tau} + \frac{(\delta + \gamma)^2 \left( 2t\tau - (\gamma^2 + 6\gamma\delta + \delta^2) \right)}{4\phi (3t\tau - 2 (\gamma^2 + 4\gamma\delta + \delta^2))}. \tag{13}
\]

From (13), it is easily seen that gamers benefit (suffer) from larger (lower) investments into in-house publishing. Consider that \( \phi \) decreases. From (11), it follows that platforms optimally increase the equilibrium level of in-house games. This positively affects the gamer surplus in two ways. First, gamers benefit due to the increased strength of the positive externality. Second, as shown in the analysis above, this leads to an exacerbation of platform competition for gamers, resulting in a decrease in the equilibrium price.

Turning to the other side of the market, the aggregate surplus obtained by publishers is determined by

\[
PS = \int_0^{\hat{y}} (\delta x_A - w_A - \tau y) \, dy + \int_{\hat{y}}^1 (\delta x_A - w_A - \tau (1 - y)) \, dy \\
+ \int_{\frac{1}{2}}^{\hat{y}} (\delta x_B - w_B - \tau \left( \frac{1}{2} - y \right)) \, dy + \int_{\frac{1}{2}}^{\hat{y}} (\delta x_B - w_B - \tau \left( y - \frac{1}{2} \right)) \, dy.
\] (14)

Proceeding as in the derivation of (13), the level of (14) in the symmetric equilibrium becomes

\[
PS^* = \frac{(\delta + \gamma)^2}{8\tau}.
\]

It can be easily seen that the aggregate publisher surplus is unaffected by changes in the level of in-house games. The reason for this is that an adjustment in the level of in-house games in the symmetric equilibrium does not affect the market share on the gamer side of the market. Therefore, publishers neither enjoy benefits from the positive externality nor suffer from a positive change in the license fee.
The social welfare in the symmetric duopoly is defined as the unweighted sum of the aggregate surpluses obtained by gamers, publishers and both platforms in equilibrium:

\[
W^* = R - \frac{t}{\delta} + \frac{3(\delta + \gamma)^2}{8\tau} + \frac{(\delta + \gamma)^2(4t\tau - (\delta + 3\gamma)(3\delta + \gamma))(2t\tau - (\gamma^2 + 6\gamma\delta + \delta^2))}{8\phi(3t\tau - 2(\gamma^2 + 4\gamma\delta + \delta^2))^2}.
\]

The following proposition analyzes the impact of first-stage in-house publishing on social welfare.

**Proposition 2.** The aggregate surplus of gamers and the level of social welfare are larger if platforms invest into in-house games in the first stage. Therefore, an increase in the cost parameter \( \phi \) harms gamers and reduces social welfare.

**Proof.** If both platforms abstain from publishing own games in the first stage, the aggregate gamer surplus and the level of social welfare in the symmetric equilibrium are given by (13) and (15), respectively, reduced by the last term in both expressions. Both of these terms are strictly positive by virtue of A1.\(^{10}\) It follows that the gamer surplus and the social welfare in the symmetric equilibrium are strictly larger with first-stage in-house publishing. Consequently, \( \partial GS^*/\partial \phi < 0 \) and \( \partial W^*/\partial \phi < 0 \) hold if A1 and A2 are satisfied. □

To summarize the findings of this section, in-house publishing turns out to be a dominant strategy for platforms, leading to an exacerbation of competition for gamers. Because in-house publishing does not result in an increase in the market share on the gamer side of the market, platforms earn strictly lower profits when doing so in the symmetric equilibrium. This result is mainly driven by the fact that the gamer market is covered and cannot be extended. This implies that an increase in in-house publishing by only one platform results in a business stealing effect due to the existence of cross-group externalities. Hence, platforms cannot credibly commit to refrain from publishing first-party titles, finding themselves in a prisoner’s dilemma. As a consequence, first-stage in-house publishing only benefits gamers, while the aggregate surplus of publishers is unaffected. In terms of social welfare, this gain in the gamer surplus completely outweighs the platforms’ losses.

\(^{10}\)A1 imposes a restriction on the relation between the transport cost parameters and the network externality parameters which is stronger than \( 3t\tau > 2\left(\gamma^2 + 4\gamma\delta + \delta^2\right) \) and \( 4t\tau > (\delta + 3\gamma)(3\delta + \gamma) \).
This section is devoted to the analysis of the set-up with multihoming on both sides of the market, that is, gamers may also choose to use both platforms. This set-up is chosen as a benchmark to investigate how the results derived in the previous section are affected if platforms have monopoly power on both sides of the market.

If gamers can choose to multihome, there are also up to three market segments on each side of their circular market. The previous section with singlehoming gamers demonstrated that a gamer at location $x_\eta$, which is closest to $P_A$ on the right side of the circular market, only accesses $P_A$ in the symmetric equilibrium. In this case, the gamer’s net utility from using $P_A$ is defined by (1). Consider now that this gamer can choose to additionally access $P_B$. When doing so, the gamer realizes a net utility from multihoming that is given by

$U^\eta_b = R_A + R_B + \gamma (q_A + q_B) - p_A - p_B - t$ \hspace{1cm} (16)

Using (1) and (16), one obtains the locations where gamers are indifferent between $P_A$ and both platforms:

$\hat{x}^r_{Ab} = \frac{1}{2} \left( R_B + \frac{\gamma q_B - p_B}{t} \right)$ on the right side of the circle

and

$\hat{x}^l_{Ab} = \frac{1}{2} + \frac{R_B + \gamma q_B - p_B}{t}$ on the left side of the circle.

Similarly, the locations where gamers are indifferent between $P_B$ and both platforms are given by

$\hat{x}^r_{Bb} = \frac{R_A + \gamma q_A - p_A}{t}$ on the right side of the circle

and

$\hat{x}^l_{Bb} = \frac{R_A + \gamma q_A - p_A}{t}$ on the left side of the circle.

The number of multihoming gamers is determined by $x_b = (\hat{x}^r_{Bb} - \hat{x}^r_{Ab}) + (\hat{x}^l_{Ab} - \hat{x}^l_{Bb})$, while the number of those who use a single platform is $x^*_A = \hat{x}^r_{Ab} + (1 - \hat{x}^l_{Ab})$ for $P_A$ and $x^*_B = \hat{x}^l_{Bb} - \hat{x}^r_{Bb}$ for $P_B$. Hence, a representative platform $P_i$’s market share on the gamer side of the market is now determined by the sum of the number of gamers who singlehome on $P_i$ and the number of those who multihome on both platforms:
This set-up implies that a gamer makes the decision to use a platform independently from the decision to use the rival platform. Because publishers continue to multihome, platforms have monopoly power on both sides of the market. Solving the system given by (4), (5), (6) and (17) yields the number of gamers on $P_i$, which is given by

$$x_i = \frac{2(R_i + \gamma q_i - p_i) - \gamma f_i}{t - 4\delta}$$

and the number of publishers releasing their game for $P_i$, which becomes

$$q_i = \frac{2(2\gamma(R_i + \gamma f_i - p_i) - \gamma f_i)}{t - 4\delta}.$$ 

Before turning to the analysis of the platforms’ pricing decisions, the following parameter restriction is imposed to ensure concavity of the platforms’ second-stage profits:

**A3.** $t \tau > (\gamma + \delta)^2$.

The game is solved by backward induction and $P_i$’s maximization program in the second stage of the game is again given by $\max_{(p_i, w_i)} \pi_i = (p_i + \delta f_i) x_i + w_i(q_i)$. Consider for simplicity that $R_i = R$, where $i = A, B$. Taking the partial derivatives of $\pi_i$ with respect to the gamer price and the license fee gives $P_i$’s best-reation functions on both sides of the market. These are given by

$$w_i(p_i) = \frac{\delta R - p_i (\delta + \gamma)}{t}, \quad i = A, B,$$

and

$$p_i(w_i, f_i) = \frac{\tau (R + (\gamma - \delta) f_i - 2w_i(\delta + \gamma))}{2\tau}, \quad i = A, B.$$ 

Solving the system of the first-order conditions (18) - (19) yields the optimal license fee and gamer price in the second-stage equilibrium:

$$w_i^*(f_i) = \frac{\tau (R(\delta - \gamma) + f_i (\delta^2 - \gamma^2))}{2(t\tau - (\delta + \gamma)^2)}, \quad i = A, B.$$ 

(17)
and
\[ p_i^*(f_i) = \frac{R(t\tau - 2\delta(\delta + \gamma)) + f_i t\tau(\gamma - \delta)}{2(t\tau - (\delta + \gamma)^2)}, \quad i = A, B. \] (21)

As in the symmetric equilibrium of the previous section, platforms subsidize publishers if \( \gamma > \delta \). The equilibrium profit obtained by platforms in the second stage of the game is given by
\[ \pi_i^*(f_i) = \frac{\tau(R + (\delta + \gamma)f_i)^2}{2(t\tau - (\delta + \gamma)^2)}, \quad i = A, B. \]

Turning to the first stage of the game, each platform again faces a quadratic investment cost function \( C(f_i) = \phi f_i^2 \) to publish \( f_i \) games in-house. Imposing the following parameter restriction ensures concavity of each platform’s profit function:

**A4.** \( 2\phi > \frac{(\delta + \gamma)^2 t\tau}{(t\tau - (\delta + \gamma)^2)\tau} \).

The outcome of the first-stage equilibrium is as follows:

**Proposition 3.** The number of games published in-house by each platform in the first stage of the game is given by
\[ f^* = \frac{(\delta + \gamma)\tau R}{2\phi (t\tau - (\delta + \gamma)^2) - \tau(\delta + \gamma)^2}. \] (22)

With multihoming on both sides of the market, each platform earns strictly higher profits in the symmetric equilibrium when choosing to publish \( f^* \) games in-house. In the limit, as \( \phi \to \infty \), the equilibrium profits with first-stage investments converge to those without.

**Proof.** See Appendix.

The proposition shows that, in contrast to the case with singlehoming gamers, platforms are now strictly better off in the symmetric equilibrium if they choose to release \( f^* \) first-party titles compared to a situation where they refrain from in-house publishing. Consequently, expression (22) is a decreasing function in \( \phi \). Platforms have now monopoly power (with overlapping market shares) on the gamer side and the publisher side of the market. In this case, in-house publishing leads to an increase in the gamer demand without stealing business from the rival. This, in turn, increases the willingness of publishers to port their game to a platform. Moreover, due to their monopoly power, platforms can now adjust their fees for both gamers and publishers to balance
their investments into in-house publishing.\textsuperscript{11} Thus, platforms realize strictly higher profits in the symmetric equilibrium when choosing to invest into first-party titles before entering the pricing stage. Consequently, an increase in the cost parameter $\phi$ harms both platforms.

### 4.1 Welfare implications

Finally, it remains to explore the impact of platforms’ first-stage investments on social welfare in case that both gamers and publishers can multihome. Gamers can now choose to access multiple platforms. Hence, they obtain an aggregate surplus of the form

$$GS = \int_0^{x^*_b} (R_A + \gamma q_A - p_A - tx) \, dx + \int_{x^*_b}^1 (R_A + \gamma q_A - p_A - t(1-x)) \, dx + \int_{\frac{1}{2}}^{x^*_b} \left( R_B + \gamma q_B - p_B - t \left( \frac{1}{2} - x \right) \right) \, dx + \int_{\frac{1}{2}}^{x^*_a} \left( R_B + \gamma q_B - p_B - t \left( x - \frac{1}{2} \right) \right) \, dx. \tag{23}$$

Again, assume that $R^i = R^j = R$. Proceeding in the same way as above, that is, first inserting (20) and (21) into (23) and second inserting (22) into the resulting expression, one obtains the surplus perceived by gamers in the symmetric equilibrium, which is given by

$$GS^* = \frac{2t\tau^2\phi^2 R^2}{(2\phi(t\tau - (\delta + \gamma)^2) - \tau(\delta + \gamma)^2)^2}. \tag{24}$$

Publishers are in the same situation as in the previous section. Therefore, their aggregate surplus remains defined by (14). Proceeding as before yields the surplus realized by publishers in the symmetric equilibrium:

$$PS^* = \frac{2\phi^2 \tau (\delta + \gamma)^2 R^2}{(2\phi(t\tau - (\delta + \gamma)^2) - \tau(\delta + \gamma)^2)^2}. \tag{25}$$

In contrast to the previous case with singlehoming gamers, this expression is no longer unaffected by the number of in-house games because investing into first-party titles leads to an increase in gamer demand without stealing business from the rival. This, in turn, increases the value to publishers of releasing their game for a platform.

\textsuperscript{11} A detailed discussion of this effect is provided in the following section on the welfare implications.
Finally, social welfare is again defined as the unweighted sum of the aggregate benefits of gamers, publishers and both platforms. In the symmetric equilibrium, the level of social welfare is given by

$$W^* = \frac{2\tau \phi R^2 \left( \phi \left( 3t\tau - (\delta + \gamma)^2 \right) - \tau(\delta + \gamma)^2 \right)}{(2\phi \left( t\tau - (\delta + \gamma)^2 \right) - \tau(\delta + \gamma)^2)^2}.$$  \hspace{1cm} (26)

From (24), (25) and (26), it follows that:

**Proposition 4.** The aggregate surpluses of gamers and publishers and the level of social welfare are larger if platforms invest into in-house games in the first stage. Therefore, an increase in the cost parameter $\phi$ harms gamers and publishers and decreases social welfare.

**Proof.** See Appendix.

With multihoming gamers, the impact of first-stage in-house publishing is not as clear as in the case with singlehoming gamers. The reason for this is that first-stage investments now affect platforms’ price strategy on both sides of the market. To show this formally, one needs to determine the license fee and the gamer price in the symmetric equilibrium. Inserting (22) into (20) and (21) yields

$$w^* = \frac{\tau \phi (\delta - \gamma)R}{2\phi \left( t\tau - (\delta + \gamma)^2 \right) - \tau(\delta + \gamma)^2}$$

and

$$p^* = \frac{(\phi (t\tau - 2\delta(\delta + \gamma)) - \tau(\delta + \gamma)) R}{2\phi \left( t\tau - (\delta + \gamma)^2 \right) - \tau(\delta + \gamma)^2}.$$  

Assume now that the network externality exerted by gamers on publishers exceeds the one exerted by the variety of games on gamers, that is, $\delta > \gamma$. In this case, $w^*$ and $p^*$ are strictly positive by virtue of $A3$ and $A4$. From (22), it is easily seen that the number of in-house games is a decreasing function in the cost parameter $\phi$. Consequently, if $\phi$ decreases, platforms optimally increase their number of first-party titles. This makes them more attractive to gamers, which, in turn, increases the publishers’ incentives to port their game to them. This effect is so strong that platforms optimally decrease the gamer price and increase the license fee in the second stage of the game.\(^{12}\) Hence, because publishers enjoy network benefits of being in contact with

\(^{12}\)Taking the partial derivative of the equilibrium strategic variables with respect to $\phi$, one obtains $\partial w^*/\partial \phi =$
gamers that are greater than those enjoyed by gamers from the variety of games, it is optimal for platforms to pass on profits, which are made on the publisher side of the market, to gamers in the form of a lower equilibrium price.

Thus, there is a countervailing effect of an increasing number of in-house games on the aggregate surplus of publishers. On the one hand, they benefit from the increased strength of the indirect network externality. On the other hand, they suffer from the increase in the equilibrium license fee. However, in the symmetric equilibrium, the first effect outweighs the second. As a consequence, the number of publishers porting their game to a platform increases in the number of in-house games on that platform. In contrast, gamers benefit in two ways. First, they benefit from the increased strength of the indirect network externality. Second, they benefit from the decrease in the equilibrium price. Because all types of agents benefit from an increase in the investments into in-house games in the first stage of the game, it is obvious that social welfare increases as well.

5 Conclusion

This paper analyzes the impact of software in-house publishing by console manufacturers in the video game industry. This industry exhibits strong cross-group externalities between software publishers and gamers. Console manufacturers are aware of these positive externalities and invest into first-party titles to make their console more attractive to gamers. The video game market is usually characterized by a scenario where gamers use a single platform and publishers may release games for several platforms. The paper examines such a scenario and compares it with a market configuration where gamers may choose to use multiple platforms. This has become particularly relevant since an increasing overlap in the use of platforms has taken place in the thriving market for the recent console generations.

The provided set-up is a two-sided market model where two platforms compete for game

\[
-\frac{(\delta - \gamma)(\delta + \gamma)r^2R}{(2\phi(t\tau -(\delta + \gamma)^2) - r(\delta + \gamma)^2)^2}, \quad \frac{\partial p^*/\partial \phi}{= -\frac{(\delta - \gamma)(\delta + \gamma)r^2R}{(2\phi(t\tau -(\delta + \gamma)^2) - r(\delta + \gamma)^2)^2}}. \quad \text{The first expression is strictly negative and the second one is strictly positive if } \delta > \gamma.
\]

In equilibrium, the number of games on a platform released by independent publishers is given by

\[
q^*_b + q^{**} = \frac{2\phi(t\tau -(\delta + \gamma)^2) - r(\delta + \gamma)^2)}{2\phi(t\tau -(\delta + \gamma)^2) - r(\delta + \gamma)^2}}. \quad \text{Taking the partial derivative with respect to } \phi \text{ gives } \partial (q^*_b + q^{**})/\partial \phi = \frac{2\phi(t\tau -(\delta + \gamma)^2) - r(\delta + \gamma)^2)}{2\phi(t\tau -(\delta + \gamma)^2) - r(\delta + \gamma)^2}}. \quad \text{which is strictly negative.}
\]
publishers and gamers. Platforms charge fees on both sides of the market. In doing so, they have to consider positive cross-group externalities between gamers and publishers. Before entering competition, a platform can invest into in-house games, making it more attractive to gamers which, in turn, increases the incentives of publishers to port games to it. In case that gamers singlehome and their side of the market is covered, in-house publishing results in an exacerbation of competition for gamers. Therefore, one might expect that platforms have no incentives to publish games in-house. However, the analysis reveals that this is not the case because in-house publishing results in a business stealing effect due to the strong cross-group externalities. As a consequence, platforms cannot credibly commit to abstain from in-house publishing in equilibrium, finding themselves in a prisoner’s dilemma. However, the losses faced by platforms are fully outweighed by the benefits enjoyed by gamers in terms of social welfare, that is, total welfare is an increasing function in the number of in-house games.

This prisoner’s dilemma situation is no longer present if gamers can multihome. The underlying form of multihoming is similar to the one presented by Armstrong (2006), that is, gamers make their decision to use one platform independently from their decision to use the other. This grants monopoly power to platforms on the gamer side of the market. As a consequence, in-house publishing becomes profitable for each platform because it results in an increase in the gamer demand without stealing business from the rival. In this scenario, both gamers and publishers benefit from platform investments into first-party titles due to the cross-group externalities, which are strong enough so that even an increase in the equilibrium license fee does not harm publishers.

The paper sheds light on the practice of video game console manufacturers to develop and publish games in-house that run exclusively on their system. The results indicate that console manufacturers, in order to decrease competitive pressure, should have aligned preferences to create market structures where gamers are incentivized to use multiple consoles. This may be achieved by increasing the degree of differentiation between the systems. For example, some consoles may rather target ‘hardcore gamers’, while others may focus on consumers who prefer multi-purpose devices. Indeed, there is evidence that console manufacturers started to follow this strategy and that the industry has experienced an increase in cross-platform use.
A Appendix

Proof of Proposition 1.

Consider that platforms do not undertake first-stage investments. In this scenario, the equilibrium profit of each platform boils down to

$$\tilde{\pi}^* = \frac{2t\tau - (\gamma^2 + 6\gamma\delta + \delta^2)}{8\tau}.$$

In contrast, with first-stage investments, a representative platform $P_i$’s maximization program in the first stage of the game is given by

$$\max_{f_i} \pi_i^*(f_i) = \frac{(2t\tau - (\gamma^2 + 6\gamma\delta + \delta^2))(3t\tau + 2\tau(\delta + \gamma)(f_i - f_j) - 2(\gamma^2 + 4\gamma\delta + \delta^2))^2}{8\tau(3t\tau - 2(\gamma^2 + 4\gamma\delta + \delta^2))^2} - \phi f_i^2, \quad i = A, B.$$

Taking the partial derivative of $\pi_i^*(f_i)$ with respect to $f_i$ and solving the system of the platforms’ best-reaction functions gives (11). This expression is strictly positive because the restriction imposed by $A1$ is sufficiently strong to ensure that $3t\tau > 2(\gamma^2 + 4\gamma\delta + \delta^2)$. Inserting (11) back into $\pi_i^*(f_i)$, one obtains a platform’s profit in the symmetric equilibrium:

$$\pi^*(\phi) = \frac{2t\tau - (\gamma^2 + 6\gamma\delta + \delta^2)}{8\tau} - \frac{(\delta + \gamma)^2(2t\tau - (\gamma^2 + 6\gamma\delta + \delta^2))^2}{16\phi(3t\tau - 2(\gamma^2 + 4\gamma\delta + \delta^2))^2} - \phi f_i^2, \quad i = A, B.$$

Obviously, $\pi^*(\phi)$ is strictly smaller than $\tilde{\pi}^*$ since $\pi^*(\phi) - \tilde{\pi}^* = -\phi f_i^2$, which is strictly negative. It follows that in the limit, as $\phi \rightarrow \infty$, $\pi^*(\phi)$ converges to $\tilde{\pi}^*$. ■

Proof of Proposition 3.

Without investments into in-house games, a platform’s profit in the symmetric equilibrium reduces to

$$\tilde{\pi}^* = \frac{\tau R^2}{2(t\tau - (\delta + \gamma)^2)}.$$

With in-house publishing, $P_i$’s maximization program in the first stage becomes

$$\max_{f_i} \pi_i^*(f_i) = \frac{\tau(R + (\delta + \gamma)f_i)^2}{2(t\tau - (\delta + \gamma)^2)} - \phi f_i^2, \quad i = A, B.$$
Taking the partial derivative with respect to $f_i$ and solving the resulting system of first-order conditions gives (22). The second-order condition of the maximization problem is satisfied if $2\phi > \frac{(\delta + \gamma)^2\tau}{t\tau - (\delta + \gamma)^2}$. This also ensures that the expression (22) is strictly positive. Inserting (22) back into $\pi_i^*(f_i)$ gives the equilibrium profit realized by each platform in the first stage:

$$\pi^*(\phi) = \frac{\tau\phi R^2}{2\phi (t\tau - (\gamma + \delta)^2 - \tau(\gamma + \delta)^2)}.$$ 

Subtracting the equilibrium profit without first-stage investments from the one with first-stage investments gives

$$\pi^*(\phi) - \bar{\pi}^* = \frac{(\gamma + \delta)^2\tau^2 R^2}{2 [t\tau - (\gamma + \delta)^2] [2\phi (t\tau - (\gamma + \delta)^2 - \tau(\gamma + \delta)^2)]}.$$ 

This expression is strictly positive because the first square bracketed term in the denominator is positive by virtue of $A3$ and the second square bracketed term in the denominator is positive by virtue of $A4$. It is also easily verified that $\lim_{\phi \to \infty} \pi^*(\phi) = \bar{\pi}^*$. ■

**Proof of Proposition 4.**

From (20) and (21), one can easily see that the license fee and the gamer price in the symmetric equilibrium without in-house publishing are given by $\bar{w}^* = \frac{\tau R(\delta - \gamma)}{2(t\tau - (\gamma + \delta)^2)}$ and $\bar{p}^* = \frac{R(t\tau - 2\delta(\gamma + \delta))}{2(t\tau - (\gamma + \delta)^2)}$.

Using (23) and (14), the resulting surpluses of gamers and publishers without first-stage investments can be calculated as follows:

$$\bar{GS}^* = \frac{t\tau^2 R^2}{2(t\tau - (\gamma + \delta)^2)^2}$$

and

$$\bar{PS}^* = \frac{\tau(\gamma + \delta)^2 R^2}{2(t\tau - (\gamma + \delta)^2)^2}.$$ 

Subtracting the respective symmetric equilibrium surpluses without first-stage investments from those with first-stage investments given by (24) and (25), one obtains

$$GS^* - \bar{GS}^* = \frac{R^2 t(\delta + \gamma)^2 \tau^3 (4\phi (t\tau - (\delta + \gamma)^2) - (\delta + \gamma)^2\tau)}{2(t\tau - (\gamma + \delta)^2)^2 (2\phi (t\tau - (\delta + \gamma)^2) - (\delta + \gamma)^2\tau)^2}.$$ 

24
and
\[
PS^* - PS^\ast = \frac{(\delta + \gamma)^4 \tau^2 R^2}{2(t\tau - (\gamma + \delta)^2)^2(2\phi(t\tau - (\delta + \gamma)^2 - (\delta + \gamma)^2 \tau)^2).}
\]

The denominator of both expressions is strictly positive. The numerator can be shown to be positive if \(4\phi > \frac{(\delta + \gamma)^2 \tau}{t\tau - (\delta + \gamma)^2} \), which always holds if \(A4\) is satisfied. Thus, because the aggregate surpluses of both gamers and publishers and the profits of the platforms increase in the number of in-house games in the symmetric equilibrium, the level of social welfare does so as well. Consequently, it can be easily shown that \(\partial GS^*/\partial \phi < 0, \partial PS^*/\partial \phi < 0\) and \(\partial W^*/\partial \phi < 0\) if \(A3\) and \(A4\) are binding.
B References


