To invest or to share? Investigating the coordination of platform functionality investment, first-party content investment, and revenue-sharing

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Platform functionality plays a crucial role in software-based platforms and their ecosystems as a strategic lever to facilitate content creation. Many such platforms have started to bundle first-party and third-party content. When the first-party and third-party content providers co-create content for the bundle, the platform's functionalities may influence its revenue-sharing and content investment strategy. It is thus critical for the platforms to coordinate their use of platform functionality, revenue-sharing, and first-party content investment to manage their ecosystems. This paper offers a framework to analyze how the platform uses these three strategic levers together under different circumstances. Contrary to the existing view, we found that the platform may choose to increase revenue-sharing while increasing first-party content investment. This is a new possibility because the platform can simultaneously invest in platform functionality that increases the price potential of the bundle. More interestingly, the platform's coordination of revenue-sharing and platform functionality investment depends on the cost asymmetry between first-party and third-party content providers. When the platform has a first-party advantage, the platform should invest more in platform functionality when the cost asymmetry is relatively large. However, the platform should increase revenue-sharing and decrease first-party content investment when third-party content providers have a cost advantage. Implications for both entrant and incumbent platforms are discussed.

1. Introduction

Many software-based platforms (such as Apple's App Store and Microsoft's Xbox) do not simply act as a marketplace that connects consumers and third-party developers but also as first-party developers. Because bundling a variety of information goods is more profitable (Bakos and Brynjolfsson 1999), recently, these software-based platforms partnered with third-party content providers and offered bundles to consumers with some success. Video games platforms are good motivating examples. Microsoft's Xbox Game Pass is a video game bundle that allows consumers to access hundreds of games for a fixed monthly fee. In addition to Microsoft's first-party game titles (such as Halo), consumers can also enjoy various third-party games. [1] With 18 million subscribers, Xbox Game Pass brings Microsoft $3.2 billion in revenue per year. Sony, another major player in the video game industry, also provides a similar bundle called PlayStation Now that generates millions of revenue with 3.2 million customers. In addition, the same business structure can emerge from other software-based platforms via backward integration. MacPaw started as a macOS application developer who has produced several successful products. They recently partnered with third-party developers and launched Setapp, a macOS application bundle that includes both first-party and third-party applications (e.g., email clients, archive management software, and PDF readers). Zapier is a platform that enables interoperability and programmability across multiple platforms and applications. For example, It can automatically add Zoom participants to a newsletter as subscribers. Zapier offers these functionalities developed by itself and third-party providers as a fixed price bundle. Other examples discussed in the literature also include Trello and Slack, which integrate third-party extensions into their platform and offer this suite of features for a single price (Bhargava 2021a). However, not all software-based platforms have succeeded. A notable example is Google Stadia, a cloud gaming platform similar to Microsoft Game Pass and Sony's PlayStation Now. Google Stadia decided to shut down its first-party game development division and struggled to grow[2]. However, the existing literature does not offer adequate guidance on the strategies for these platforms.

There are two key aspects of platform strategies that need a closer look. First, the platform relies on the quality of the bundle to attract consumers. For a traditional two-sided platform that does not produce content, the only way to grow the bundle is by attracting third-party content providers by

[1] For example, Microsoft formed a strategic partnership with Electronic Arts (EA) to include EA's games in Xbox Game Pass. https://www.ea.com/ea-play/news/ea-play-coming-to-xbox-game-pass

[2] https://blog.google/products/stadia/focusing-on-stadias-future-as-a-platform-and-winding-down-sge/

reducing supplier side participation fee (e.g., Bhargava 2021b, Hagiu and Spulber 2012) or investing in platform functionalities to lower the content production cost for third-party content providers (Tan, Anderson, and Parker 2020). However, when the platform cocreates the bundle with the third-party content provider, instead of relying solely on third-party content providers to provide content, the platform has an alternative way to attract customers via investing in first-party content. A question naturally arises – How should the platform source the content from both first-party and third-party content providers and coordinate the content cocreation process? Prior literature has considered the content supply distribution and revenue sharing problem *among third-party content providers* who cocreate a bundle managed by the platform (Bhargava 2021a). As the platforms introduce the first-party content provider to the supplier side, their revenue sharing strategy becomes more complicated. Thus, there is a need for a framework to capture the economic forces behind first-party content investment and revenue sharing.

Second, the effect of investing in platform functionality is more nuanced than what existing literature has considered (e.g., Tan, Anderson, and Parker 2020) when the third-party developer and the first-party content provider cocreate a bundle. To facilitate content creation (i.e., software development), these platforms provide platform functionalities that can be utilized by content providers and lower the production cost. For example, Microsoft's Xbox Live and Azure PlayHub technology allow developers to conveniently develop multiplayer functionality and social features without the need to develop their ad hoc multiplayer infrastructure. These platform functionalities benefit both first-party and third-party content providers, allowing them to produce higher quality content with the same or lower costs. On the one hand, the platform benefits from the increased content quality contribution from the third-party content provider by investing in platform functionalities. Since a contribution from either the first-party or third-party content provider can increase the price potential for the bundle, the potential market size for the bundle is elastic. In this sense, third-party content providers are collaborators. Therefore, lowering the development cost for both first-party and third-party content providers could enlarge the size of the pie, increasing the platform's profit. On the other hand, the first-party content provider and the third-party content provider compete for the revenue share of the bundle, even though they are not producing competing content. Therefore, the effect of investing in platform functionality may depend on the relative strengths of the two forces and market conditions.

Notably, cost asymmetry may also complicate the platform's strategy in coordinating revenue sharing and first-party content production, affecting platform functionality investment. Platforms vary in the efficiency of creating content, resulting in a cost asymmetry between the first-party and third-party content providers. For example, while Google may be efficient in developing software, Google Stdia is likely less efficient in developing video games than a third-party game studio like Electronic Arts. Multiple factors may contribute to the cost asymmetry: Google lacks the experience in developing games, and Google Stadia is a cloud-based platform requiring significantly different skills than traditional hardware platforms. However, some other platforms may be more efficient in making first-party content. For example, Microsoft and Sony have acquired third-party studios, gathering necessary talents over the years. Their first-party content providers may work closely with the platform and access the latest platform functionality ahead of public release. When there is a cost asymmetry between first-party and third-party content providers, investing in platform functionalities may magnify the content production cost asymmetry across different content providers (Bhargava 2021b), intensifying the competition for bundle revenue share. However, no existing work has incorporated this aspect in their framework.

On a bundling-based software platform, the combination of available price- (e.g., revenue sharing, end-user pricing) and non-price-levers (e.g., first-party content investment, platform functionality) as well as the existence of cost asymmetry between first- and third-party content provider lead to ambiguity on how the platform should strategically utilize them together to maximize profit. Such ambiguity creates a need for a unifying framework to analyze the multi-sided interplay among these strategic levers.

This paper seeks to answer the following two central research questions:

- How should the platform source content from both the first-party and third-party content provider? In other words, how does it balance the first-party content investment with revenue-sharing?
- How does the platform determine the optimal platform functionality level, and how does it influence other strategic levers?

To do so, we developed an analytical model that features three players: a monopolistic platform (such as Xbox Game Pass) that decides the end-user-facing bundle price, revenue sharing proportion, first-party content output, and the platform functionality level; a third-party content provider (such as Electronic Arts) who decides the third-party content output; and a heterogeneous body of consumers who value the total content quality of the bundle differently.

To provide practical guidance for both existing platforms and entrants, we organize our analysis into two parts. We first analyze how should an existing platform should coordinate first-party content investment and revenue sharing, given an exogenous and pre-existing platform functionality level. With that, we further analyze how platforms with different functionality levels determine key decisions variables under varying market conditions. We next consider entrants who are planning to build a platform and have to decide the platform functionality level. By endogenizing the platform functionality investment decision, we identify key determinants of the platform's functionality optimal strategy and study how it works in tandem with revenue-sharing and first-party content investment, uncovering the three-sided dance among these three strategic levers.

In our analysis, a few interesting results arise. First, contrary to the existing view that the platform either decreases participation fees (seller subsidy) or increases first-party content investment (buyer attraction) (Hagiu and Spulber 2012), we show that the platform may actually choose to increase revenue sharing and increase first-party content investment together. By investing in platform functionality, the platform can grow the size of the pie by investing more in first-party content while sharing more revenue to solicit more content contributions from the third-party content provider, creating a win-win for the platform and third-party content provider. Second, counterintuitively, a platform with a higher functionality level always shares more revenue with third-party content providers than a platform with lower functionality. However, a more nuanced strategy emerges when considering cost asymmetry between first-party and third-party content providers facing different market sizes. The relationship between the optimal revenue sharing and exogenous platform functionality level is of an inverted-U shape when the first-party content provider has a content production cost advantage: a low-functionality platform increases revenue sharing as it invests more in platform functionality whereas a high-functionality platform does the opposite. This relationship is also affected by other market conditions. For example, platforms facing a larger market size are more likely to decrease revenue sharing with further platform functionality investment. This analysis aims to provide strategic guidance for existing platforms with varying levels of platform functionality and first-party cost advantage (or disadvantage) to manage revenue sharing and first-party content production.

Interestingly, we found that the relationship between the optimal revenue-sharing and endogenous platform functionality is of a U-shaped curve if changes in optimal values are driven by cost asymmetry. As the first-party disadvantage shrinks or as the first-party advantage grows (e.g., via better internal training and hiring more talent), the platform first reduces then increases revenue-sharing while it consistently invests more in platform functionality. We highlight that platforms in different stages (e.g., entrant versus incumbent) should employ different strategies to coordinate content production, revenue-sharing, and platform functionality investment.

The rest of the paper proceeds as follows. Section 2 reviews related streams of literature. Section 3 specifies the analytical model. In the first half of Section 4, we first study the equilibrium where the platform fucntionality is exogenous. In the second half, we endogenize platform functionality and examine the relationship between optimal platform functionality investment and revenue sharing. In section 5, we discuss interesting results and provide managerial implications. Other possible extensions and future directions are also disucssed.

2. Related Works

Our work relates to three streams of literature: (1) bundling on two-sided platforms, (2) platform functionality investment, and (3) first-party and third-party coordination. We next review the related literature and highlight the contribution of this work.

2.1. Bundling on a Two-sided Platform

In this paper, we focus on the business models where the platform sells information goods as a bundle. The bundling of information goods (such as video game bundles) is increasingly popular as it improves social welfare and is more profitable (Bakos and Brynjolfsson 2000, 1999). Earlier works (Bakos and Brynjolfsson 1999, Geng et al. 2005, Amelio and Jullien 2012, Chao and Derdenger 2013) have argued that bundling can extract additional surplus from consumers as a means of price discrimination and is preferable to component pricing (*à la carte*) when the two-sided platform needs to subsidize one side. More relatedly, Chao and Derdenger (2013) found that mixed bundling is profitable on a two-sided platform with both first-party and third-party content when compared to pure component pricing. Earlier works typically focus on comparing component pricing with bundling strategies, but they neglect the production decision of first-party content developers and third-party content developers. The quality or the quantity of the goods are assumed to be exogenous (e.g., Chao and Derdenger 2013). In contrast, the qualities of content are derived endogenously in our model.

Most existing literature neglects the negotiation of profit-shares. For example, Chao and Derdenger (2013) assumed that the developers receive an exogenously fixed fee from the sale of the bundle. It is important to understand how a revenue-sharing scheme will affect how the production decision, as we focus on the production decisions made by the first-party and third-party platforms. Bhargava (2021a) provides a framework where a monopolistic platform sources content from third-party content providers and provides a bundle. This framework provides insights into how the cost distribution of multiple third-party content providers affects the platform's strategies and various outcomes. Bhargava (2021b) considers a three-sided platform that connects the consumers, advertisers, and content providers. The platform offers a bundle that sources content from multiple heterogeneous content providers. While it studies how profit-sharing proportion γ may affect the bundle size, it only provides limited discussion on how the profit-sharing proportion is determined in the equilibrium. For example, it did not discuss how factors such as market size, platform functionality, and first-party advantage may affect the optimal profit-sharing proportion.

With this regard, by allowing the platform to negotiate with third-party on revenue sharing while simultaneously allowing them to make production decisions, we capture the interactions among the revenue sharing proportions, platform functionality investment, and content production decisions.

Unlike most prior works in this stream of literature, our intention is not to compare bundling with component pricing. Rather, we try to study the platform's strategy of producing first-party content and third-party content. To focus on our main research questions, we consider only pure bundling. By focusing on pure bundling, we also address real-world scenarios where the platform requires third-party content to be exclusively available in the bundle.[3]

2.2. Platform Functionality

Platform functionality refers to components on the platform that can be utilized by the products on the platform. Besides the aforementioned example of Azure PlayHub SDK, platform functionality can also exist in different forms. For example, Sony's PlayStation 5 features an advanced storage solution that reduces concerns over game loading time and memory usage, freeing up efforts that would otherwise be used to address the issue [4]. Platform functionality reduces the content production cost by providing components necessary for content development.

There are several similar concepts in the existing literature. Integration tools studied by Tan et al. (2020) is similar in the sense that it also reduces content production cost for third-party content providers. In their work, integration tools refer to tools that platforms can develop to help third-party

[3] https://www.apple.com/newsroom/2021/04/apple-arcade-expands-its-award-winning-catalog-to-more-than-180-games/

[4] https://www.axios.com/sony-ps5-insomniac-ratchet-clank-1ad70cf8-398f-4adb-aea2-716b03860ad9.html

content providers integrate their products onto the platform. A prominent example they mention is third-party Internet-of-Things (IoT) vendors developing products for IoT platforms. Because the integration to the platform is difficult and expensive, the cost of integration is significant. As such, integration tools are of strategic importance for the platform as it acts as a way to subsidize third-party vendors or content providers. In a similar vein, Bhargava (2021a) and Bhargava (2021b) both briefly discussed the effect of reducing production cost via integration tools (SDK and training programs) on the bundle size and content quality of heterogeneous third-party content providers. However, integration tools only affect third-party content providers and are considered exogenous in their work. Anderson, Parker, and Tan (2013) study the trade-off of investing in platform performance that *increases* the cost of participation. In their formulation, while platform performance provides better performance of the platform and attracts consumers, it also burdens third-party content providers.

Platform functionality differs from integration tools in that platform functionality is a core component of the platform, not merely developed for integration. In particular, platform functionality can also be utilized by first-party content. Thus, the economic forces behind the investment of integration tools and platform functionality may differ, especially with the presence of the first-party content investment decision. It also differs from platform performance in that it does not increases the attractiveness of the platform directly. Rather, it reduces the cost of production to encourage content production and leverages the cross-side effect to increase the overall attractiveness of the platform bundle. Given these fundamental differences between platform functionality and other similar concepts in the literature, there is a need for a framework that captures the economic forces behind platform functionality investments. Our model shows that platform functionality investment strategies can differ from the integration tools or platform performance strategies.

2.3. First-party and Third-party Coordination

When a platform not only acts as a platform but also acts as a content developer or seller, the platform is said to be operating in *dual mode*. Hagiu and Spulber (2012) looks at how the platform will utilize first-party content as a strategic resource, both when first-party content is a complement and a substitute to third-party content. They suggest that the platform coordinates the production of first-party and third-party content when competing platforms form strategies that depend on the buyer and seller expectations. More recently, Hagiu et al. (2020) finds that while dual mode is the most profitable model for a platform, it may lower the third-party content developer surplus. However, their result hinges on the ability of third-party sellers to set prices, which cannot be generalized to the subscription-based bundling business model.

In our paper, the platform is always allowed to produce first-party content. We draw on the dual mode literature and contribute to this line of work by exploring how the investment in integration tools may influence first-party and third-party coordination on content production. Specifically, this setup allows us to answer two questions that are not addressed by existing works. First, the integration tools are not a simple substitute for seller-side subsidy. Integration tools not only reduce the marginal cost for the third-party content developer but also reduce the marginal cost for first-party content production. Introducing the integration tools in a two-sided platform with both first-party and third-party content complicates the tensions. We reveal how the platform balance the trade-off between developing first-party content and developing integration tools. Second, existing works in dual mode mostly focus on component pricing. They cannot address how the platform and third-party content provider negotiate on the profit-sharing scheme in a bundling context while simultaneously coordinating on content production decisions.

Until recently, Bhargava (2021a) discusses a potential scenario ("backward integration") where the platform may act as content provider (or first-party content provider). This allows him to discuss how the mere possibility of first-party entry may affect the range of profit-sharing proportion (γ) on a high level. Nevertheless, the revenue sharing proportion is still considered exogenous in the rest of the discussion. For example, it does not allow readers to answer the questions like how market conditions (such as market size and integration tool costs) affect profit-sharing γ. Bhargava (2021b) discussed the effects of the platform's intrinsic value and first-party content on outcomes such as advertisement revenue and third-party content quality. However, the first-party content quality is considered exogenous. Thus, their model did not capture the effect of integration tools on first-party content investment and the second-order effect of integration tools on revenue-sharing (via its effect on first-party content investment).

This paper contributes to the platform literature by studying a unique context in the intersection of the three streams of literature. First, we extend the understanding of the investment decisions to a context where first-party and third-party both produce content. Second, our model contributes to the first-party and third-party coordination literature by looking at the effects of platform functionality on content production and revenue-sharing. Finally, we extend the bundling on two-sided platform literature by studying the three-sided interplay among platform functionality investment, content production, and revenue-sharing decisions.

3. Model Setup

In line with the existing literature on digital platforms (e.g., Bhargava 2021b,a), our model features a monopolistic platform that connects the consumers and the content providers. We model two types of content providers - a first-party content provider, which is the platform itself, and a third-party content provider. The first- and third-party content providers offer horizontally differentiated content. (Give examples of why horizontal differentiated content is the primary form). The platform offers the first-party and third-party content as a single bundle to its consumers. Consumers perceive the bundle value as the sum of content quality of all content included in the bundle. The price of the bundle is determined by the platform, which also decides the proportion of revenue γ that is shared with the third-party developer. Therefore, the third-party content developer does not set a separate unit price for their product.

An example of the business model that our model captures is Microsoft's Xbox Game Pass. Xbox Game Pass is a video game bundle that includes both first-party and third-party games. The games in the bundle span across a wide range of categories. The first-party and third-party content developers are non-competing (Give specific examples of non-competing games). The platform develops functionality (i.e., SDKs such as DirectX) and distributed them to first-party and third-party content providers. Given the platform functionality, first-party and third-party content providers develop games on top of these functionalities for the platform. Absent these functionalities, each content provider would have to develop their own components ad hoc. Microsoft then set a bundle price and launch Xbox Game Pass. Our model also applies to other platforms like Google Stadia, Amazon's Luna, and Sony's PlayStation Now. Abstracting away from the example of video game platforms, our model also applies to a number of other businesses such as Setapp or Trello.

We capture this decision-making sequence by developing a four-stage model. In the first stage, the platform determines the number of functionalities x. In the second stage, the platform offers a revenue-sharing contract to its third-party content provider. Next, in the third stage, the third-party content provider decides its content quality as its output level. The platform simultaneously decides its first-party content quality. In the fourth stage, the platform sets the bundle price, and consumers make their purchase decisions.

The timing of the game is summarized as follows:

1. The platform develops x amount of functionalities.

2. The platform offers a revenue-sharing contract γ to the first-party and third-party content developer.

3. The third-party content developer receives the contract and observes all the above information. The first-party and third-party content providers respond with a commitment to developing content with certain qualities.

4. The platform sets the bundle price and launches the bundle. Consumers make their purchase decisions.

Next, we characterize the decision-making process in each period. To solve this model using backward induction, we first look at consumers' decision-making process.

3.1. Consumers

Because the content provided by the third-party and the first-party content providers are non-competing, consumers enjoy the content qualities additively. As such, a consumer's utility function is the sum of the platform's existing content inventory, the quality of newly developed first-party content, and newly developed third-party content, minus the prices to the bundle p. The consumers are homogeneous in their preference of first-party and third-party content but are heterogeneous in their overall valuation of the bundle. Following the setup in Tan et al. (2020), we assume a continuum of heterogeneous consumers with heterogeneous taste parameter z, uniformly distributed in $[0,1]$. A greater z means the consumer has less interest in the entire bundle, known as the consumer's mismatch cost. For example, if the platform is a video game bundle like Xbox Game Pass or Apple Arcade, consumers with a higher z have less interest in video gaming in general. Thus, the utility function of a consumer located at i is:

$$u_i(v, q_F, q_C, p) := v + q_F + q_C - p - z_i, z \sim U(0,1)$$

where v is the intrinsic value of the platform. The intrinsic value of the platform refers to the platform's value without adding newly developed content. It includes values such as social networking, video playback, as well as existing first-party content. For instance, in addition to the newly developed games, Microsoft may also include existing first-party games from earlier versions in the Xbox Game Pass bundle. [5] q_F is the quality of newly developed first-party content, and q_C is the quality of newly developed third-party content. Consumers who will purchase the bundle are those who derive a positive utility from it:

$$u_i(v, q_F, q_C, p) := v + q_F + q_C - p - z_i > 0$$

Solving for z yields: $z < z^* = v + q_F + q_C - p$. As z is uniformly distributed between 0 and 1, the number of consumers that the platform will amass (N_P) is:

$$N_P(v, q_F, q_C, p) = Nz^* = N(v + q_F + q_C - p) \tag{1}$$

where N is an exogenous parameter for the total potential market size.

[5] Microsoft says that it will include all its existing and future first-party games in the bundle
https://www.windowscentral.com/all-microsoft-studios-games-will-launch-xbox-game-pass-moving-forward

3.2. Content Providers

The production cost for content providers has three components: (1) number of components c, (2) the content quality $q_i, i \in \{C, F\}$ for third- and first-party respectively, and (3) content cost factor α, which captures the relative cost efficiencies between the first- and third-party content providers in creating their products.

Let c denote the number of components necessary for developing typical content on the platform for first-party and third-party content providers. Examples of these components in the gaming industry are graphic rendering programs, character design, 3D maps, etc, which are needed in both first- and third-party products. Platform functionality x developed by the platform can reduce the number of such components to $c - x$.

The primary decision for content developers is to decide the quality of the content, denoted by q. In the rest of the paper, we use q_F to denote the quality of the first-party content and q_C to denote third-party content. Content developers face a diminishing marginal return on content quality q (). That is, they face increasing marginal costs to make higher quality content (Similar to Tan et al. 2020). This cost function form is typical in software development, where it is usually cheap to make a minimum viable product (MVP), it becomes increasingly hard to make marginal improvements in functionality (e.g. larger codebases are harder to maintain), and consumer experience (e.g. more expensive consumer research). Slaughter et al. (1998) empirically showed that the marginal improvement diminishes as the product life cycle. Therefore, the first-party and third-party content developers both face a baseline production cost of αq^2 [6], where α is the content cost factor, measured by cost per unit content quality squared.

Let α_F, α_C denote the content cost factor for the first-party and the third-party respectively, which reflect the general efficiency of content providers. In practice third-party content provider often has

[6] Similarly, Hagiu and Spulber (2012) use a cost function $c(x^2/2)$, where x is the amount of first-party content in their model. Choudhary (2007) also use a similar functional form.

cost advantages for various reasons. For example, the platform may have a less experienced team for content creation, in which case the platform may have a production disadvantage. Alternatively, a third-party content provider have more specialized knowledge and talent to identify and create content that consumers like. Let δ be an exogenous parameter that captures the degree of third-party advantage. The cost factors can then be expressed as $\alpha_F := \alpha + \delta$ and $\alpha_C := \alpha - \delta$, where $\alpha = 1$ is the normalized cost factor of both content providers.

Therefore, the utility function and the profit maximization problem for the third-party content provider is:

$$\max_{q_C} \pi_C(q_C) = \gamma p N_P - \alpha_C(c-x)q_C^2 \tag{2}$$

3.3. Platform

The platform develops both the platfom functionality and the first-party content. Therefore, there are two cost functions in the platform's utility function:

$$\pi_P(x, \gamma, q_F, p) = (1-\gamma)pN_P - \alpha_F(c-x)q_F^2 - kx^2 \tag{3}$$

The first cost function $\alpha_F(c-x)q_F^2$ captures the cost of producing first-party content, which is consistent with the third-party content developer's cost function. The second cost function kx^2 captures the cost of developing platform functionality. Following Tan et al. (2020), we model the cost of developing platform functionality x with kx^2, where k is the cost per functionality squared. Similar to content investment, the investment in platform functionality faces a diminishing return. Table 1 summarizes all variables and parameters.

4. Equilibrium Analysis

We use backward induction to deduce the equilibrium outcomes. Denote the optimal level of decision variables with an asterisk (such as γ^*). In the fourth stage, the platform sets the bundle price that maximizes its profit:

$$\max_{p} \pi_P = (1-\gamma^*)pN_P(p) - \alpha_F^*(c-x^*)q_F^{*2} - kx^{*2}$$

Symbol	Description	Domain
	Endogenous (Decision) Variables	
x	Number of platform functionality (e.g. API, SDK)	$[0, \infty)$
p	Total price of platform and content bundle	$[0, \infty)$
q_F	Quality of first-party content	$[0, \infty)$
q_C	Quality of third-party content	$[0, \infty)$
γ	Proportion of revenue shared to the third-party content developer	$[0, 1]$
	Parameters	
k	Cost per functionality squared	$[0, \infty)$
α	Baseline cost per unit content quality squared	1
δ	Degree of third-party advantage	$(0, 1)$
N	Potential number of consumers in the market (market size)	$[0, \infty)$
v	Platform's intrinsic value and first-party content inventory	$[0, \infty)$
c	Number of content components	$(0, \infty)$
z	Consumer's location in the distaste space from 0 to 1	$[0, 1]$

Table 1 Table of Terms

which gives the best response function of the platform:

$$p^*(q_C^*, q_F^*) = \frac{1}{2}(q_C^* + q_F^* + v) \tag{4}$$

It is also easy to verify that:

$$N_P := N(v + q_F^* + q_C^* - p^*) = N(2p^* - p^*) = N \times p^* \tag{5}$$

In the third stage, the first-party and the third-party content provider simultaneously determine their content quality. We substitute the best response function (equation 4) into the maximization problems:

$$\max_{q_C} \pi_C = \gamma^* p^*(q_C, q_F) N_P(q_C, q_F) - \alpha_C (c-x) q_C^2$$

$$\max_{q_F} \pi_P = (1-\gamma^*) p^*(q_C, q_F) N_P(q_C, q_F) - \alpha_F (c-x) q_F^2 - kx^2$$

which gives the best response functions for content production:

$$\begin{aligned} q_C^*(\gamma^*, x^*) &= v \frac{N\alpha_F \gamma^*}{4\alpha_C\alpha_F(c-x^*) - N\left(\alpha_C(1-\gamma^*) + \alpha_F\gamma^*\right)} \\ q_F^*(\gamma^*, x^*) &= v \frac{N\alpha_C(1-\gamma^*)}{4\alpha_C\alpha_F(c-x^*) - N\left(\alpha_C(1-\gamma^*) + \alpha_F\gamma^*\right)} \end{aligned} \tag{6}$$

In the second stage, the platform determines the revenue sharing proportion γ by solving:

$$\max_{\gamma} \pi_P = (1-\gamma) p^*(\gamma, x) N_P(\gamma, x) - \alpha_F (c-x) q_F^*(\gamma, x)^2 - kx^2$$

The optimal choice of revenue sharing parameter γ^* can be obtained by solving the first-order condition with respect to γ and check for the second-order condition:

$$\gamma^*(x) = \frac{\left(N - 2\alpha_C(c-x)\right)\left(N - 4\alpha_F(c-x)\right)}{N(N - 2(\alpha_C + \alpha_F)(c-x))} \tag{7}$$

We can express the equilibrium in the second stage with respect to x:

$$\begin{aligned} p^*(x) &= v \frac{2\alpha_C(c-x)(2(\alpha_C+\alpha_F)(c-x) - N)}{(4\alpha_C(c-x) - N)(4\alpha_F(c-x)N)} \\ q_C^*(x) &= v \frac{2\alpha_C(c-x) - N}{4\alpha_C(c-x) - N} \\ q_F^*(x) &= v \frac{2\alpha_C(c-x)}{4\alpha_F(c-x) - N} \\ \gamma^*(x) &= \frac{\left(2\alpha_C(c-x) - N\right)\left(4\alpha_F(c-x) - N\right)}{N(N - 2(\alpha_C+\alpha_F)(c-x))} \end{aligned} \tag{8}$$

In the first stage, the platform determines the optimal platform functionality x^*:

$$\max_{x} \pi_P = (1-\gamma^*) p^*(\gamma^*, x) N_P(\gamma^*, x) - \alpha_F (c-x) q_F^*(\gamma^*, x)^2 - kx^2$$

By substituting equation 7 into the first-order condition with regard to x, we have:

$$x^* = Sol.[2kx = \frac{4\alpha_C^2\alpha_F v^2 (c-x)^2 \left(8N(\alpha_C+\alpha_F)(c-x) - 16\alpha_C\alpha_F(c-x)^2 - 3N^2\right)}{(N - 4\alpha_C(c-x))^2 (N - 4\alpha_F(c-x))^2}] \tag{9}$$

To avoid a degenerate case where the platform functionality x is close to c when the content providers can produce content nearly for free, we assume that x is relatively small with respect to c. This is to reflect the reality the platform functionality's effect on content production is bounded at some level $\bar{x}$. In practice, a large proportion of content production cannot be replaced by platform functionality. For example, while an SDK may help with integrating the game with the platform-specific features (e.g., to utilize platform-specific hardware) and some generic functionalities (e.g., game account management such as Apple's Game Center), no SDK can help with the art creation process, gameplay design, custom game logic, etc. As such, assumption 1 ensures that the optimal x does not become unrealistically large when the platform functionality is too easy to develop.

Assumption 1. *Platform functionality development cost parameter k is sufficiently large.*

We also focus on the equilibrium where the market is not fully covered, as currently, no business has captured the entire potential market.

Assumption 2. *In the equilibrium, the market is not fully covered. That is, equation 1 satisfies $0 < N_p(q_F^*, q_C^*, p^*) < 1$.*

Finally, we assume that both the first-party and third-party content providers have an incentive to develop content.

Assumption 3. *In the equilibrium, both parties will participate in content production: $q_F^* > 0 \wedge q_C^* > 0 \rightarrow 2\alpha_C(c - x^*) < N < 4\alpha_F(c - x^*)$.*

In the following subsections, we start our analysis by answering the first two research questions on (1) how platform functionality affects the platform's revenue-sharing strategy for existing platforms and (2) how a new platform determines its platform functionality and coordinates it with its revenue-sharing strategy. The first research question is relevant to existing platforms where platform functionality is already developed. In the first half of this section, we discuss the marginal effect of platform functionality on other decision variables given an exogenous level of platform functionality x under different cost asymmetry cases. This allows us to study how platforms with varying platform functionality may share revenue and invest in first-party content differently. To answer this question, we focus on the equilibrium in the second stage, which allows us to discuss how platform functionality level x affects other decision variables (e.g., revenue sharing γ) and the welfare of stakeholders in the ecosystems. In the second half of this section, we focus on the second question relevant to new entrants whose platform functionality is not yet determined. We analyze the equilibrium in the first stage, where platform functionality is endogenously determined to answer this question.

4.1. Effects of Platform Functionality on Existing Platforms

This section considers x as exogenous to study how existing platforms with varying functionality levels may behave differently. Sourcing content to increase the overall quality of the bundle is a critical problem for the platform. The platform has three strategic levers to increase the quality of the bundle. First, the platform can increase the revenue-sharing proportion, incentivizing the third-party content provider to produce higher quality content. Increasing revenue-sharing proportion is similar to reducing participation fees on an à-la-carte two-sided platform. Second, the platform can directly invest in first-party content and increase its quality. Notably, because the first-party and third-party co-create a bundle, investing in first-party content will have a second-order positive effect on third-party content quality. Since the third-party content provider's profit is a fraction of the bundle sales, $\frac{\partial \pi_C}{\partial q_C}$ includes positive q_F terms (see equation 2). Finally, the platform can invest in platform functionalities to reduce the cost of producing content, thereby improving the quality of both first-party and third-party content.

Naturally, an important decision problem for the platform is when and how to use these three strategic levers to maximize its profit. To study how the platform coordinates first-party and third-party content providers with its strategic levers, in this section, we look at how the platform leverage first-party content q_F and revenue sharing γ to maximize its profit.

4.1.1. Effect of Platform Functionality on Content Qualities We start by analyzing the effect of platform functionality on the platform's first-party content investment strategy.

LEMMA 1. *The partial derivatives of optimal content qualities from the first-party and the third-party with respect to platform functionality x are:*

$$\frac{\partial q_F^*(x)}{\partial x} = \frac{2\alpha_C N v}{(4\alpha_F(x-c)+N)^2} > 0$$

$$\frac{\partial q_C^*(x)}{\partial x} = \frac{2\alpha_C N v}{(4\alpha_C(x-c)+N)^2} > 0$$

Lemma 1 implies that platforms with higher functionality levels always produces higher first-party content (q_F) and attracts third-party content of higher quality (q_C). Intuitively, a decrease in content production costs increases the marginal return on content investment, increasing the optimal content qualities. Thus, investing in platform functionality can effectively grow the bundle size for any existing platform.

Investing in first-party content may seem a competing strategic lever with revenue sharing. One may argue that platforms with more functionality may share less revenue with the third-party content provider because they already source enough content from the first-party content provider. However, we observe that platforms with high functionality levels attract third-party content of higher quality. Is this a result of platform functionality or revenue sharing? Does platform functionality go hand-in-hand with sharing more revenue with the third-party content provider? Or are these two strategic levers substitutes? We next investigate the revenue-sharing strategy.

4.1.2. Effect of Platform Functionality on Revenue Sharing We find that platform's revenue-sharing strategy depends on the cost asymmetry and the relative value of platform functionality. Lemma 2 characterizes the boundary conditions of cost asymmetry δ for which the platform employs two opposing revenue-sharing strategies. To illustrate the results, we show a numerical example in Figure 1.

LEMMA 2. *The condition for the platform to reduce revenue sharing with platform functionality can be characterized by:*

$$\frac{\partial \gamma^*}{\partial x} = \frac{2(\delta+1)\left(8(\delta-1)N(c-x) - 16(\delta-1)(c-x)^2 + N^2\right)}{N(N-4(c-x))^2} < 0 \iff \delta < \frac{(N-4(c-x))^2}{8(c-x)(2(c-x)-N)}$$

Similarly, the conditions for the platform to reduce revenue sharing with the market size N and number of components c can be characterized by

$$\frac{\partial \gamma^*}{\partial N} < 0 \iff \delta < \frac{(N-4(c-x))^2}{8(c-x)(2(c-x)-N)}, \frac{\partial \gamma^*}{\partial c} < 0 \iff \delta > \frac{(N-4(c-x))^2}{8(c-x)(2(c-x)-N)}$$

Assumption 3 implies that $\frac{(N-4(c-x))^2}{8(c-x)(2(c-x)-N)} < 0$. *Therefore, when* $\delta > 0$, $\frac{\partial \gamma^*}{\partial x} < 0, \frac{\partial \gamma^*}{\partial N} < 0, \frac{\partial \gamma^*}{\partial c} > 0$.

The condition for the platform to decrease revenue-sharing with cost asymmetry δ is:

$$\frac{\partial \gamma^*}{\partial \delta} < 0 \iff \delta < -\frac{N}{8(c-x)}$$

which violates Assumption 3. Thus, $\frac{\partial \gamma^*}{\partial \delta} > 0$.

When the first-party advantage is relatively small (or a disadvantage), *ceteris paribus*, the optimal revenue-sharing proportion γ^* increases with the marginal return of content investment. Specifically, γ^* is increasing with market size N and platform functionality x but decreasing with the number of components c. Intuitively, a higher platform functionality level x and a lower number of components c correspond to a higher return to content investment as the cost $(c-x)$ decreases. Market size N increases the return from the demand side by increasing the number of additional consumers per unit of bundle value increase. Intuitively, when the third-party content provider gains cost advantage over first-party content provider (i.e., increasing δ), the platform shares more revenue to incentivize quality contribution from the third-party content provider.

When the marginal return of content investment increases, the third-party content provider becomes more responsive to an increase in revenue share. Because first-party and third-party content providers co-create a bundle, the increase in third-party content quality, in turn, increases the marginal return

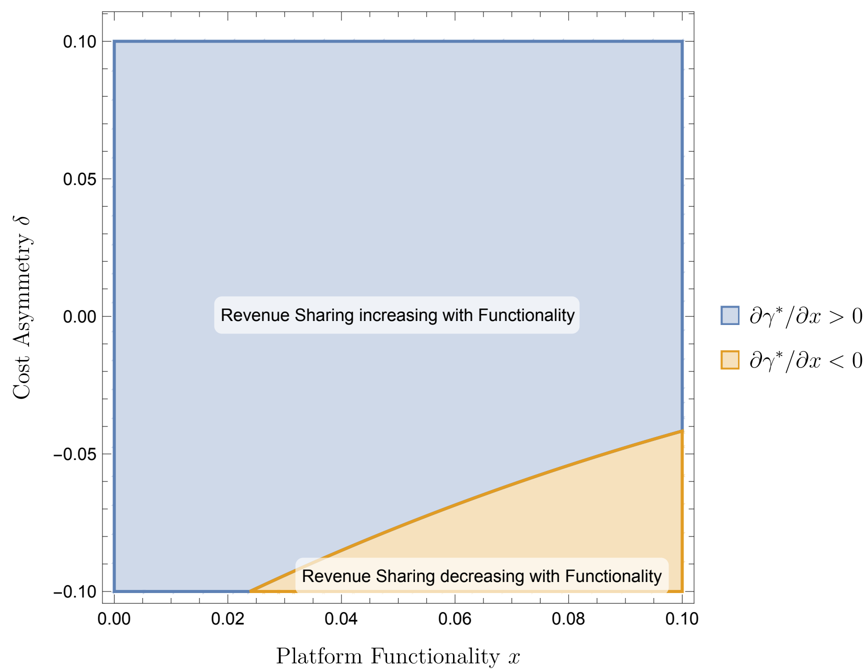


Figure 1 **Platform's revenue sharing strategies may be increasing ($\partial\gamma^*/\partial x > 0$) or decreasing ($\partial\gamma^*/\partial x < 0$) with platform functionality depending on cost asymmetry δ and platform functionality x. This plot is generated with parameters $c = 1, v = 0.1, k = 1, N = 3$.**

of investing in first-party content, incentivizing the platform to invest more in first-party content. As the platform invests more in first-party content, the third-party content provider is more willing to produce higher-quality content. This interaction forms a positive feedback loop that increases the total bundle value. Thus, when the first-party advantage is smaller than the threshold, the platform is better off forfeiting a small proportion of revenue share to incentivize third-party while investing more in first-party content to increase the size of the pie.

When the first-party and the third-party content providers share similar production costs, it is more profitable to offer a higher γ to let the third-party content provider face the diminishing return and contribute more value to the bundle. Intuitively, this stays true when the third-party content provider has a significant advantage. However, when the platform enjoys a significant amount of first-party advantage, it is increasingly hard for the third-party content provider to be responsive to a unit increase in revenue-sharing. In this case, the platform relies more on first-party content.

Of our particular interest is how the platform changes its revenue-sharing strategy with the platform functionality. While platform functionality does not directly affect cost asymmetry, it makes the weight of "cost-minimizing" relatively inconsequential in the platform's decision process. When the platform does not solely rely on third-party content providers for content creation, the only reason why the platform may allow third-party's participation is that they can bring in more value than the small proportion of profit shared with them. Even when first-party and third-party content providers are equally efficient in producing content, it is still profitable to leverage third-party content because of the diminishing return of content investment. However, when platform functionality increases, the overall cost $c-x$ decreases, making the content production cost inconsequential. The platform gradually loses the incentive to share with the third-party content provider as the platform functionality increases. Nevertheless, when the platform functionality level is still relatively low, this force is weaker than the aforementioned positive feedback loop effect. As such, the platform's revenue-sharing strategy hinges on the value of platform functionality. This insight is summarized in Proposition 1.

PROPOSITION 1. *Platforms with relatively high functionality level and enough first-party advantage decreases revenue sharing when it further invests in platform functionality. Platforms with relatively low functionality level or with lower first-party advantage always increases revenue sharing.*

Proposition 1 reveals important dynamics between the platform functionality and revenue sharing. First, our results divert from the existing view that the platform may either choose to subsidize third-party content providers or invest in first-party content (Hagiu and Spulber 2012). We found that many platforms actually increase revenue-sharing (akin to subsidizing third-party content providers) while increasing first-party content investment (according to Lemma 1). Second, we show that platforms facing first-party advantage may employ different revenue-sharing strategies. With enough first-party advantage, these platforms first increase then decrease revenue-sharing as their platform functionality increases, showing an inverted-U-shaped curve.

Results in this section provide several managerial implications for existing platforms. We show that platforms need to choose different revenue-sharing strategies depending on the cost asymmetry and existing platform functionality. Platforms with a first-party disadvantage or a small first-party advantage should always increase revenue sharing to encourage third-party content creation. However, for platforms with large enough first-party advantage, their revenue sharing strategy depends on their current level of platform functionality. If the existing platform functionality is already abundant (e.g., when x is relatively high), they may decrease revenue-sharing as they invest more in platform functionality.

4.2. Strategies for Entrant Platforms

In this section, we consider entrant platforms that need to determine platform functionality, first-party investment, and revenue-sharing. In recent years we have seen numerous new platforms that follow this business model. For example, Google Stadia and Amazon Luna are cloud-based video game bundles that have (or plan to) invested in first-party games. Netflix is also rolling out first-party and third-party games to its subscribers on iOS and Android [7]. These new platforms need to coordinate their plans of investing in platform functionality with other decisions. We start by characterizing how the platform determines its functionality level. Then, we discuss the platform strategies under different market conditions.

4.2.1. Platform Functionality Investment Strategy Before developers can develop content for the platform, the SDK needs to be distributed to the developers. Thus, the platform functionality level x is determined in the first stage of the game. As the closed-form solution becomes intractable, we rely on numerical solutions to characterize the platform functionality strategy. We ran a numerical simulation on a wide range of parameters, and the results were qualitatively consistent. Figure 2 shows examples of how optimal functionality is influenced by key market conditions.

PROPOSITION 2 **(Optimal Functionality Level)**. *The optimal platform functionality x^* is increasing with marginal return to content investment. Specifically, x^* is:*

- *increasing with potential market size N*
- *increasing with platform intrinsic value v*

[7] https://techcrunch.com/2022/01/19/netflixs-gaming-service-adds-two-more-titles-on-ios-and-android/

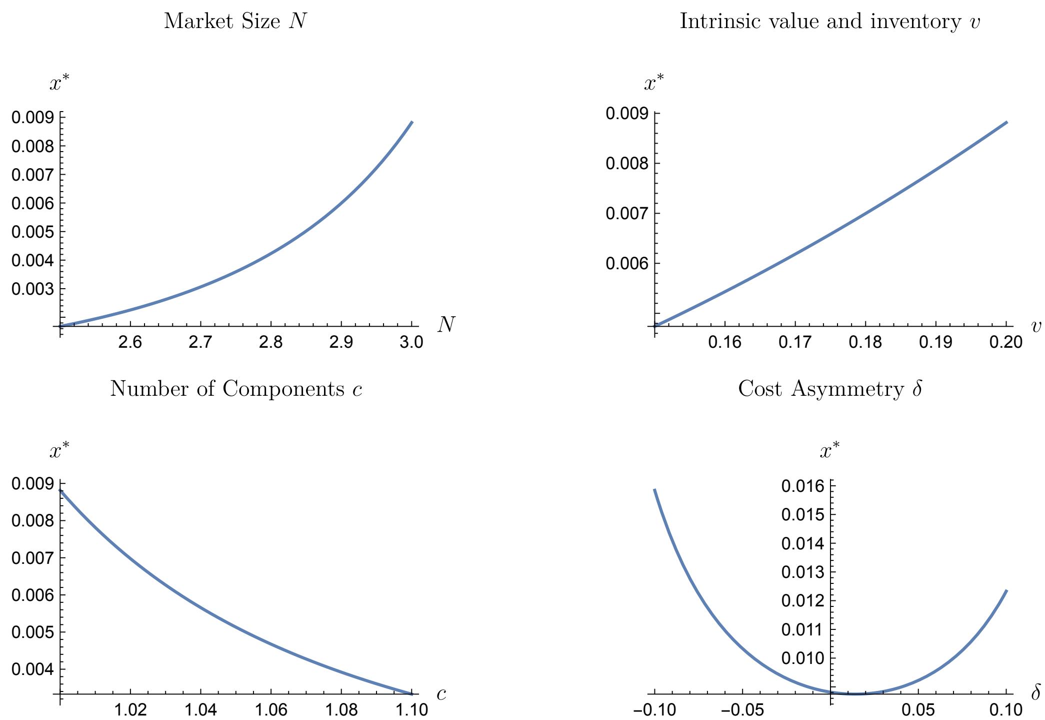
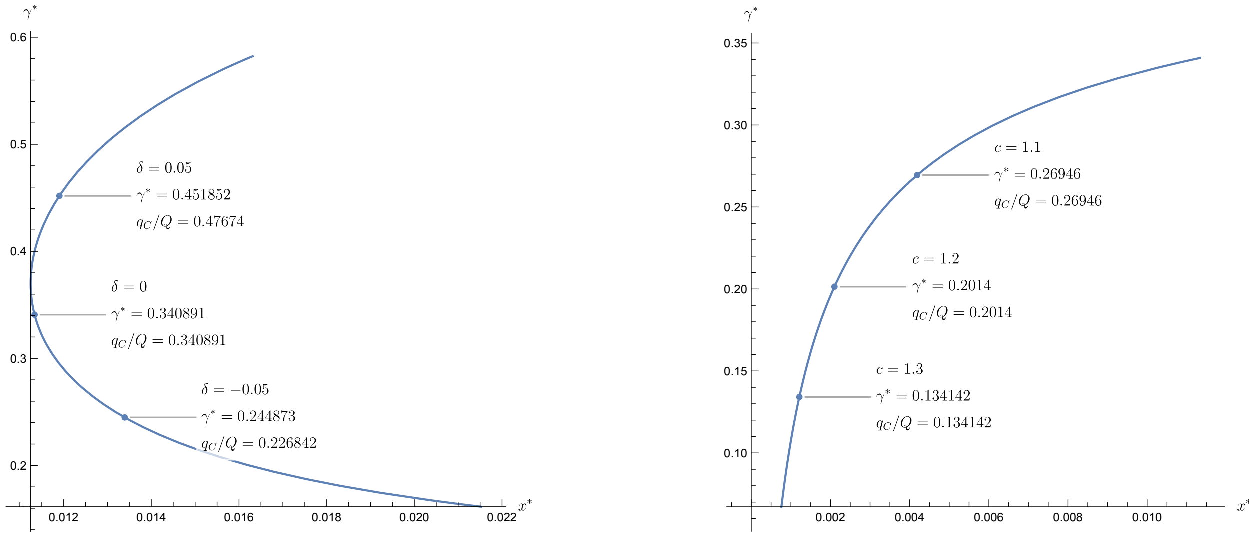


Figure 2 Platform's optimal functionality levels under different market conditions. The default parameters are $c = 1, k = 50, N = 3, v = 0.2, \delta = 0$**.**

- *decreasing with number of components c*
- *first decreasing then increasing with cost asymmetry δ*

Proposition 2 summarizes the platform's functionality strategy. In general, the platform is more willing to invest in platform functionalities when the price potential of the bundle increases or when a unit increase of bundle value can acquire a greater number of customers. A larger market size N and a higher platform intrinsic value v both increase the number of acquired customers, increasing the marginal return for investing in platform functionalities. In contrast, counterintuitively, the platform invests less in platform functionality when making content requires more components. When the number of components c increases, content becomes costly to develop for both first-party and third-party content providers, decreasing the bundle size. As a result, the price potential of the bundle and the marginal return of platform functionality decrease.



(a) Varying cost asymmetry (δ)

(b) Varying number of components (c)

Figure 3 **Relationship between Optimal Revenue-sharing Proportion γ^* (y-axis) and Optimal Platform Functionality x^* (x-axis). Parameters are $k = 10, N = 3, v = 0.1, c = 1$.**

Interestingly, we found that the relationship between the optimal platform functionality and the cost asymmetry is non-monotonic. The platform invests least in platform functionality when the third-party content provider has a *slight* advantage (i.e., a positive but small δ). When the third-party content provider has a greater advantage (i.e., a greater and positive δ), the platform increases its functionality investment. Likewise, when the first-party content provider has a greater advantage (i.e., a negative, greater δ), the platform increases its functionality investment as well, but at a faster rate.

4.2.2. Coordination of Revenue-Sharing Strategy and Platform Functionality In section 4.1, we characterized how platforms with different pre-existing functionality levels leverage revenue-sharing strategy to maximize their profit. This section focuses on how a new platform coordinates the use of these two strategic levers when the platform can decide on its investment in platform functionality. To study how the two strategic levers work together, we examine the relationship between the optimal revenue-sharing proportion and platform functionality level.

There are several interesting observations. The platform coordinate the use of revenue-sharing and platform functionality differently when facing a change in different market condition. Figure 3a illustrates how platforms facing different cost asymmetry adjust γ^* and x^* simultaneously. As the platform gains first-party advantage (e.g., δ decrease from 0 to -0.05), it decreases γ^* while increasing x^*. In contrast, when the third-party content provider gains an advantage (e.g., δ increases from 0 to 0.05), the platform first decreases then increases x^* while increasing γ^*. Notably, the inflection point is located at some negative δ that is close to 0. That means that the platform invests the least in platform functionality when the third-party content provider has a slight advantage.

REMARK 1. When third-party content provider has a disadvantage (i.e., negative δ), revenue-sharing and platform functionality are *substitudes* when δ changes. When the third-party content provider gains enough advantage (i.e., δ greater than some threshold that is slightly above zero), revenue-sharing and platform functionality are *complements* when δ changes.

However, figure 3b tells a different story when the platform responds to a change in the number of components c. The platform always decreases γ^* and x^* when the number of components c increases. This relationship holds regardless the cost asymmetry. When c increases, the overall return to content investment decreases as the cost of content production increases. This makes the third-party content provider less responsive to a unit increase in γ. As such, the platform shares less revenue with the third-party and has to take more responsibility of making content via investing in first-party content.

REMARK 2. When the number of component c changes, platform functionality and revenue-sharing are complementary strategies.

It is also interesting to compare revenue sharing porportion with the distribution of first-party and third-party content quality in the bundle. Let $Q = q_C^* + q_F^*$. Note that when there is no asymmtery $(\delta = 0)$, it is easy to verify that $\gamma^* = q_c^*/(q_C^* + q_F^*)$ independent of the value of x using equation 8. Absent cost asymmetry, the platform shares the revenue exactly as the proportion of third-party content contribution. However, when $\delta > 0$, $\gamma^* < q_c/Q$. This means that when the third-party content provider has an advantage, the platform "under-shares" the revenue. When the first-party content provider has an advantage $(\delta < 0)$, the platform "over-shares" the revenue with third-party content provider. The intuition is that even though producing content with higher quality does not directly increase the its share of the revenue, because the size of the pie (i.e., Q) increases, both parties indirectly benefit from it. Thus, whoever has an production advantage has the incentive to produce content of higher quality than a "fair contribution" according to γ.

5. Discussion

Bundling information goods is an increasingly popular business model. More importantly, more platforms have become first-party content providers in these bundles. Therefore, there is a need for a comprehensive framework that captures both platform functionality investment and the nuanced relationship between the first-party and third-party content providers. The analysis of our framework provides several managerial implications for both entrants and incumbent platforms.

For example, an incumbent platform with a content production cost disadvantage should increase revenue-sharing as it invests in platform functionality. However, when an incumbent platform gains a content production cost advantage, our analysis suggests that it should stop further increasing revenue-sharing. Instead, it should decrease revenue-sharing and increase its investment in first-party content. Such a change in both revenue-sharing and first-party content investment strategies represents a paradigm shift – the platform's bundle is now more saturated with high-quality first-party content, whereas the prominence of third-party content has started to decrease. Similar patterns can be observed in the video gaming industry – platforms that enjoy a first-party advantage, such as Microsoft's Xbox and Sony's PlayStation that had acquired game studios over the years, include significant amounts of high-quality first-party content in their bundles. In contrast, Apple Arcade includes no first-party content as Apple is inexperienced in making video games and faces a third-party advantage in the mobile gaming space. Our work highlights the importance of coordinating platform functionality, revenue-sharing, and first-party content investment.

Our framework also speaks to entrant platforms such as Google Stadia and Amazon Luna. We found that when the platform is facing a third-party advantage, the optimal strategy is to share more revenue while investing relatively more in platform functionality. The platform should refrain from investing too heavily in first-party content unless it has acquired the first-party advantage. To launch the Google Stadia service, Google was determined to invest in first-party content. However, like Apple, Google is inexperienced in developing video games. In addition, since Google Stadia is a new cloud-based game streaming service, it requires more software development resources to deliver the same gaming experience than a traditional gaming platform. Third-party developers have cited difficulties in developing content for Google Stadia. In 2021, Google shut down the internal studio and halted first-party content development [8]. As it failed to develop first-party content and attract both third-party developers and consumers, Google Stadia has pivoted to a technical business-facing solution from a consumer-facing platform [9]. When an entrant faces a third-party advantage, our model suggests that it should invest more in platform functionality instead of first-party content.

It is important to note that our model focuses on a single period, reflecting a platform development cycle. However, in the long-term, the new first-party content developed in the current cycle will be considered as the platform's intrinsic value and content inventory v in the next cycle. Therefore, a two-period model that captures the strategic value of the first-party content investment may be an interesting extension. In addition, we assume a monopolistic platform. In reality, many platforms are competing with other platforms. Under competition, first-party content and exclusive content may become more important. It is then interesting to also account for how competition may influence platform's coordination of the three strategic levers. Finally, we focus on how platform manage bundle value distribution and revenue-sharing between the first-party and third-party content provider.

To conclude, this paper provides a comprehensive framework to study how platform should manage its bundle ecosystem using three strategic levers in a coordinated manner – first-party content investment, revenue-sharing, and platform functionality. Our analysis offers guidance on how existing platforms should change its strategy when faced with changes in market conditions and how new entrant platforms should form its strategy under different circumstances.

[8] https://blog.google/products/stadia/focusing-on-stadias-future-as-a-platform-and-winding-down-sge/

[9] https://arstechnica.com/gadgets/2022/03/stadias-pivot-to-a-google-cloud-product-is-official/

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