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Analyzing game-streaming services in two-sided markets: Direct selling and cloud alliance models

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Abstract

This study analyzes the profit of a cloud console provider facing competition from a hardware console provider in a two-sided market composed of game developers and consumers. The cloud console provider can either sell its subscription package to consumers independently or organize a cloud alliance with an ISP to market. As compared with the direct selling model, the cloud alliance model with full coordination can yield greater total revenue if the benefit the game developers receive from the consumer side is higher than the value the consumers receive from the developer side. However, the overall profit of the cloud alliance declines when this condition is reversed. This undesired result can be resolved by leveraging the game-streaming subscriber base to yield a moderate amount of additional revenue for the cloud console provider.

Keywords: Cloud service, two-sided market, profit sharing, virtual machine, network effect.

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1. Introduction

Google recently launched its console-free streaming service to venture into the market of the video game industry with the slogan "The future of gaming is not a box; it's a place" (as cited in https://blog.wiredscore.com/uk/google-stadia). Instead of having a dedicated game console such as Microsoft's Xbox or Sony's PS4, consumers can play games instantly anywhere by accessing Google's Chrome browser. Moreover, the network effect from a large-scale user base can facilitate profitable marketing activities through selling subscribers' attention. [1,2] For instance, as compared with traditional ads, a customized marketing campaign can resolve information overload on the Internet by using the available subscriber history and demographics to create a marketing channel between advertisers and the subscribers who are likely to be of interest. Similarly, with the popularity of live streaming and the Internet celebrity economy, Google, holding the advantage of the YouTube platform, can bring in revenue by streaming gaming clips to its audience, just like the business of live streaming platforms such as Twitch.

One of the keys to the success of console-free streaming service is the reduction of IT cost, which is linked to the number of machines for provision and the service level (measured by delay time) that the machine instances should achieve. Virtual machine (VM) technology can power the console-free streaming service because services and applications can be consolidated in fewer resources, which increases the efficiency and utilization of existing hardware resources. Moreover, dynamic VM consolidation can reduce power consumption in the console-free streaming service and minimize the total number of active machine instances. However, several studies indicate that insufficient network bandwidth may downgrade VM performance due to oversubscription. [1,2] Better dynamic VM consolidation has been proposed by researchers to enhance the efficiency of VMs and reduce the consumption of energy. As the console-free streaming service attracts more consumers to join, it becomes essential to improve the performance of VMs for accommodating an increasing demand without leading to service degradation for players.

Moreover, there are several hurdles for the console-free streaming service to overcome due to the current business ecosystem of gaming consoles. First, the content source will be a major problem at the beginning of a product launch because the cloud platform needs many titles created by game developers to fill content vacancies rather than take years to produce all games in-house. , Second, some game developers more familiar with traditional consoles may hesitate to release their games on the emerging platform due to concerns regarding the potential consumer base and the cost of making their titles compatible with the cloud console. Third, Internet connectivity is an unavoidable bottleneck for all streaming services. Consumers need a reliable network connection of up to 25 Mbps when accessing the cloud platform. Unlike video streaming services, a gaming service needs to trace all instructions transmitted by game controllers and respond to all digital signals in real time.

Thus, the cloud console provider needs to pay a considerable Internet service fee to Internet service providers (ISPs) for reducing network latency. In addition, the data limits on the Internet connection also affect consumers' subscription intention when broadband caps are attached to their deals with ISPs. As a result, the fifth-generation technology standard for the broadband cellular network (5G) becomes a promising solution, even though its expenses could be astonishingly high before it is blended in with everyone's life. In fact, the development of 5G is a collaboration game because the partnership between service providers and telecoms can help drive the prevalence of 5G. Particularly, a survey shows consumers who desire "better quality video" and "decreased waiting time while streaming video" are willing to pay a premium for 5G. Considering the inevitable infrastructure cost of a high-speed network, an ISP should make an appropriate pricing decision to recover its heavy initial cost from either service providers or consumers, which is a chicken and egg problem.

1.1. Research Motivation and Questions

Therefore, the assistance of ISPs is indispensable for entry into the current console market because the cost of streaming tons of data traffic per month could be the last straw for both consumers and cloud console providers. This cost bottleneck will reduce consumer intention of moving toward cloud gaming services, while the latency issue also requires ISPs to deploy more equipment to stabilize the network speed everywhere at all times. Clearly, both ISPs and cloud console providers must establish a collaborative relationship to improve consumers' gaming experience. This mutually beneficial partnership seems to be the key element for competing with traditional console providers.

To further evaluate the collaborative performance between a cloud console provider and an ISP, this study aims to examine the business model of a cloud console provider in a two-sided market composed of consumers, game developers, and an ISP by answering the following research questions: (1) Could an investment in VM technology for reducing hardware costs benefit the cloud console provider? (2) The cloud console provider and ISP can coordinate their pricing decisions in a cloud alliance. As compared with making decisions independently of each other, could such a partnership achieve a higher overall profit?

1.2. Contributions and Findings

Though there are already many studies examining the two-sided market composed of consumers and content producers [6,7,8,9,10], few studies have examined the partnership between a game-streaming service provider and an ISP in a two-sided market that competes with a traditional console provider (selling consoles to consumers) under the concern of network quality managed by the ISP. The injection of game-streaming services may thoroughly change the ecosystem of current video console markets, but a series of business reports also reminds entrants of the network requirement for rendering satisfied customer experiences when providing game-streaming services. ,

In this study, the inefficiency arising from the Internet service fee can be resolved by establishing a collaborative channel between the cloud console provider and ISP, which is known as a cloud alliance in this study. Nevertheless, this collaborative contract cannot always benefit the alliance because the overall profit from the collaborative schema will decline if the benefit the game developers receive from the consumer side is lower than the value the consumers receive from the developer side, even though both the number of contracted game developers and the number of subscribers on the console-free service increase. For the cloud alliance, the traditional console provider's low pricing strategy will offset the benefit of increasing the number of subscribers. In addition to the increased license expense for the game titles, the soaring demand can imply a surging cost of Internet traffic, which is a major disadvantage of operating a console-free streaming service. Therefore, the cloud console provider can leverage its growing subscriber base to gain additional revenue by linking the subscribers of its game-streaming platform to the business of other applications with similar appeals.

To date, several famous cloud applications, such as social platforms and search engines, have shown such a business model to be viable, bringing in revenues from their high-volume subscriber bases, even though their services are almost free. Needless to say, the logs of subscriber activities in a console-free streaming service are useful for understanding a subscriber's individual preferences and valuation of certain commodities. Considering the gaming industry is dominated by traditional video console providers, our analytical result confirms the importance of transforming the subscriber base into purchasing power for achieving a mutually beneficial partnership between a cloud console provider and an ISP.

2. Literature Review

The idea of game-streaming services, in fact, dates back to the application of Game as a Service (GaaS), in which network providers launch their own multi-player gaming platforms to replace expensive consoles. [11]. To achieve a successful game-streaming service, the current pricing practice can be improved by integrating different points of view including game developers, consumers, platform providers, and ISPs. [12] Though how to lower service costs under high quality of service (QoS) requirements could be a challenge to ISPs, several algorithms and infrastructures have been proposed to achieve this cost-effective goal. [13,14] In addition, the capacity decision for better service quality has to be routinely checked by platform operators because allocating players into different machines before the game server is overcrowded can increase revenue. [15]

2.1 Competitive Pricing and the Network Effect

The profit margins of the gaming industry will decline due to the increasing competition from game-streaming services holding the advantage in which consumers bear lower hardware costs.[16] To survive in this competitive market, platform providers can invest in their own value-added service to grow their market share.[17] Both big data and the application of search engines can increase the demand of consumers and content providers by meeting their needs. [18] In addition, for most two-sided platforms on the Internet (e.g., eBay and Uber), the network effect is the critical driving force for achieving substantial revenue by increasing the interaction value between two sides through an intermediary.

The strategy of product line expansion can leverage the network effect, which is a compelling advantage of cloud services linked to their economic scales. Though no one knows if increasing product variety will be profitable, this strategy for strengthening the network effect actually hold a place for both incumbents and entrants in content markets. [2,19,20] Empirical research also indicates that introductory pricing for an increasing customer base can be first adopted before expanding product variety.[21] In fact, when consumers demand more different products, the platform operator should understand its major revenue is from producers because they face less competition attributed to large product variety. [22]

2.2 Two-Sided Market

Game-streaming services can be viewed as an application of two-sided markets because the cloud console providers have to serve as an intermediary between consumers and game developers. In this two-sided market, before coming up with a profitable strategy to interact with the agents on both sides, a platform operator should analyze the ecosystem of the gaming service by examining related issues such as switching cost, the size of content providers, consumer preference, its competitor's pricing strategy, and so on. On the seller side (e.g., game developers or content producers), the use of exclusive contact for maintaining a competitive advantage has been widely studied in the literature. [23] Mantena et al. [24] show the adoption of an exclusive contract in a video game market can benefit platform operators by softening the competition in the platform market and then growing their user bases. On the buyer side (e.g., subscribers), several selling approaches, such as coupons [25], mixed bundling strategy [26], and tying [27], have been studied in different contexts, which are similar to the video game industry according to the operational framework of content streaming services.

In fact, in some platforms (e.g., Uber and eBay) allowing consumers to choose either side to join, a bundling strategy for both sides can benefit a monopolist platform. [28] Moreover, compared with the scenario in which sellers bypass the platform to interact with buyers directly, Bataineh et al. [29] show the benefit of using an intermediary for exchanging personal data between both sides. Prior empirical studies suggested a two-sided pricing strategy should be dynamic because increased game provision does not result in hardware price escalation. [30] In addition, because of switching costs, when an intra-platform technology allows consumers to play their first-generation game by using the second-generation console, the console provider facing the threat of new entrants in a two-sided market should purchase more content from game developers with a discounted license fee rather than encourage adoption of first-generation platforms by charging consumers a discounted price. [31]

Overall, the major contribution of this study different from the prior literature associated with two-sided markets is to examine how a cloud console provider fully leverages the advantage of integration with an ISP to compete with a well-established traditional console provider. By applying a two-sided market structure with QoS requirements to examine such a partnership in the gaming industry, we clearly indicate the importance of monetizing the subscriber base to avoid the potential pitfalls of collaboration. Most prior literature considering two-sided markets highlights how the two sides affect each other with the network effect from the other side, but our model emphasizes how the network effect from the consumer side benefits the partnership.

3. The Model

To model platform competition between a traditional console provider and a cloud console provider, we adopt a stylized model [32] for observing the interaction among consumers, game developers, platform providers, and an ISP in a two-sided market, as shown in Figure 1. All notations are summarized in two symbol tables appearing in Appendix A.

Consider two platforms indexed by $i \in \{A,B\}$, respectively, each of which is an intermediary between game developers and consumers. Both platforms offer consumers all-you-can-play subscription packages in which consumers can experience all games on the platform. Specifically, platform providers supply consumers with their proprietary consoles and establish software specifications compatible with their platforms as technology standards for game developers. Thus, with such a two-sided platform, consumers can access the content created by game developers, while the game developers can reach their potential consumers.

For convenience, game developers and consumers, indexed by $j \in \{1,2\}$, respectively, are the two sides that choose one of the platforms to interact with the other side. The size of each side is normalized to one, and the group size of side j choosing platform i is denoted as $n_{(j,i)}$. In this study, platform A is a traditional console provider that distributes "free" consoles to the consumers subscribing to its gaming service. Therefore, all computing tasks can be independently processed at each console at home. The major purpose of hosting a platform over the Internet for platform A is to offer subscribers its gaming download service.

On the other hand, platform B, offering a cloud console service, processes all operations at its cloud server. As a result, allocating sufficient bandwidth for instant streaming will be a paramount concern for the cloud console provider. In addition, subscribers must maintain a constant connection with the cloud server while playing.

3.1 Game Developers

In light of the Hotelling specification [33], game developers and consumers are assumed to be uniformly distributed along two different unit lines. The two platforms A and B are located at the two endpoints of each unit line, contracting with game developers by paying a lump-sum payment F_i. With this temporal contract, platform providers can exclusively offer these games produced by the contracted game developers to their subscribers during a certain period. Once these games have expired, subscribers cannot play them anymore but still keep all records and their current status. Therefore, these subscribers may have a motivation to purchase the expired merchandise from game developers directly. That is, game developers can have additional revenue streams from subscribers after the expiration date termed in their contracts with platforms. For this reason, we denote γ as the average expected revenue game developers can receive from subscribers.

In addition, the development cost of creating a video game can be divided into platform-independent cost κ in pre-launch processes (e.g., the concept stage [34]) and platform-dependent cost. [35-37] The latter arises from the incompatibility of console standards. Thus, $\theta_1 \in [0,1]$ is used to measure each game developer's standard preference. Other possible reasons for the difference in standard preference can include technology lock-in. Then, a game developer will bear $t_d \theta_1$ and $t_d (1-\theta_1)$ platform-dependent cost when developing a game running on platform A and B, respectively. As a result, the profit of each game developer when contracting with platforms A and B can be expressed as

$\pi_{(1,A)}(\theta_1) = F_A + \gamma \cdot n_{(2,A)} - \kappa - t_d \theta_1$ and $\pi_{(1,B)}(\theta_1) = F_B + \gamma \cdot n_{(2,B)} - \kappa - t_d (1-\theta_1)$ (1)

In short, game developers must evaluate the license fees offered by platform providers, the estimated revenue from subscribers, and the development costs to decide on which console to release their games. In addition, standard preference $\hat{\theta}_1$ is used to address a game developer that is indifferent between both platforms, which is derived from $\pi_{1,A}(\hat{\theta}_1) = \pi_{1,B}(\hat{\theta}_1)$

3.2 Consumers

On the consumer side, platform provider i can charge consumers a subscription fee p_i as its major revenue source. In addition to the content from game developers, the platform providers can also design their own original games on the platform to increase their competitiveness. Therefore, υ_i is used to measure the value of the original games developed by platform i. If subscribing to platform i, consumers under an all-you-can-play policy can receive the game value $\upsilon_i + \alpha n_{(1,i)}$ where α is the expected average content value rendered by a game developer.

However, for ensuring smooth traffic, the cloud gaming server requires sufficient bandwidth to meet the lowest QoS level. Though the consumers subscribing to platform A also need the Internet for downloading games, the network speed is not a bottleneck for delivering a smooth playing experience. To identify the difference in Internet cost for the consumers between the two platforms, we let m be the extra payment charged by the ISP for high-speed network access with larger traffic capacity and better network efficiency, which is the minimum requirement for accessing platform B. The rise of the Internet fee is evaluated by consumers when choosing platforms. Thus, the basic Internet fee is normalized to zero for convenience, but all of our analytical findings remain the same.

Moreover, the degree of service differentiation can be identified by parameter t_c, reflecting how competitive both console providers are in this market. Therefore, when a consumer located at θ_2 where $\theta_2 \in [0,1]$ subscribes to platform i where $i \in \{A,B\}$, her utility can be expressed as

$$u_{2,A}(\theta_2) = \upsilon_A + \alpha n_{1,A} - p_A - t_c \theta_2 \text{ and}$$
$$u_{2,B}(\theta_2) = \upsilon_B + \alpha n_{1,B} - p_B - t_c (1-\theta_2) - m \qquad (2)$$

Similarly, consumer preference $\hat{\theta}_2$ is used to address a consumer who is indifferent between both platforms, which is derived from $u_{2,A}(\hat{\theta}_2) = u_{2,B}(\hat{\theta}_2)$.

In the subscription package sold by platform A, the console is offered free of charge, implying the hardware cost h for producing a console must be covered by platform A when making its pricing decision. Therefore, platform A's objective function can be expressed as

$$\underset{p_A, F_A}{Max}\ \pi_A = (p_A - h) n_{2,A} - F_A n_{1,A} \qquad (3)$$

On the contrary, platform B offering a cloud gaming server can reduce the hardware cost due to the advantage of a centralized management infrastructure such as VM technology . [38] Therefore, the hardware cost of consoles can be reduced to $\rho h \cdot n_{(2,B)}$, where $\rho < 1$ is used to measure the degree of cost saving due to centralized computing. However, as compared with the other platform, the cloud console provider has to pay the ISP an extra fee for high-speed Internet access. Therefore, from the perspective of platform B, this study employs four business models in terms of sales operations and monetizing subscriber attention to analyze how a cloud console provider utilizes its advantage to get through the bottleneck controlled by an ISP, as shown in Table 1.

In Models I and III, platform B will decide on the subscription fee and process all tasks related to consumers by itself. In that case, platform B accepts the Internet service fee charged by the ISP passively. From the perspective of double marginalization, prior studies (e.g.,see[39]) indicated the paramount importance of coordinating the participants in a supply chain. Therefore, in Models II and IV, platform B transfers the sales of its gaming service to the ISP through a collaborative contract. In practice, this integrated approach has been frequently adopted by different industries nowadays. For instance, telecoms can gain revenue from the sales of smartphones by tying their customers to a long-term subscription contract in exchange for new smartphones. Moreover, Models III and IV can be viewed as the extension of Models I and II because the only difference is whether platform B can receive additional revenue streams from subscribers. The abundant information collected from active subscribers can bring in a promising revenue stream driven by the network effect for the cloud console provider. Therefore, both Models I and II are introduced in Sections 3.3 and 3.4, while the features of Models III and IV are reported in Section 4.

3.3 Direct Selling Model

In Model I, the ISP will first charge the cloud console provider an Internet service fee for processing the data traffic between subscribers and platform B. Next, both platforms A and B decide on their subscription fees p_i (charged from consumers) and license fees F_i (paid to game developers) simultaneously, where $i \in \{A,B\}$. This model is also known as direct selling because the cloud console provider makes its own pricing decision. We consider that the Internet service fee charged by the ISP increases with the demand of platform B; thus, the payment is denoted as $\omega n_{(2,B)}$, where ω is the average Internet service fee per subscriber. As a result, platform B's objective function can be expressed as

$$\underset{p_B,F_B}{Max}\ \pi_B = (p_B - \rho h - \omega) n_{2,B} - F_B n_{1,B} \tag{4}$$

To seek simultaneous equilibrium and simplify the analytical results, we make two assumptions. First, the value rendered by both platforms is large enough so that all consumers will subscribe to one of the platforms. Second, $4t_c\, t_d-(\gamma+\alpha)^2>0$ and $\gamma\alpha<t_c t_d$ are the required conditions for maintaining the concavity of the platforms' profit functions, which resemble the condition for a market-sharing equilibrium in the work of Armstrong. [32]

Subsequently, we employ queueing theory to model a subscriber's arrival on the cloud gaming server as an M/M/1 queue with a mean arrival rate λ and processing rate μ. To define the capacity cost required for achieving a certain QoS level, the processing rate can be used to measure IT capacity; thus, the total capacity cost can be estimated as $c \cdot \mu$, where c is the marginal cost of the processing rate. However, only a proportion of all subscribers use the cloud gaming service at any one time. The arrival rate λ can be estimated as $\lambda=\beta n_{(2,B)}$, where β is the average usage rate of all subscribers.

To achieve real-time traffic between subscribers and the cloud gaming server, both the cloud console provider and the ISP are aware of the minimum QoS policy that regulates a threshold d as the average delay for processing a request issued by a subscriber [40]. In an M/M/1 queue, the average delay for a subscriber can be represented as $EW=1/((\mu-\lambda))$. Therefore, $EW \le d$ is the ISP's QoS requirement, which is linked to the Internet service fee because its capacity cost $c \cdot \mu$ increases with cloud gaming demand. In this way, the ISP's profit function π_C can be written as

$$\underset{\omega}{Max}\ \pi_C = (m+\omega) n_{2,B} - c\mu \quad s.t. \quad 1/(\mu-\lambda) \le d \tag{5}$$

In Equation (5), the ISP needs to fit the requirement $EW \le d$ by expanding its IT capacity (i.e., service rate μ). Thus, following prior studies [41, 42], we solve $EW=d$ to yield the ISP's minimal capacity cost $c\mu$, where $\mu=\beta n_{(2,B)}+1/d$. By using this approach, the ISP's objective function can be rewritten as

$$\underset{\omega}{Max}\ \pi_C = (m+\omega) n_{2,B} - c\left(\beta n_{2,B} + 1/d\right) \tag{6}$$

Next, the benefit of VM technology is prescribed in the following proposition.

Proposition 1.

The advanced VM technology can benefit the cloud console provider only if the cost-saving efficiency of this technology is higher than a certain level; otherwise, its profit will decrease. Formally, $(\partial\pi_B)/\partial\rho>0$ when $\rho>\rho^*$, but the opposite holds when $\rho\le\rho^*$, where$\rho^* \equiv ((3t_d\,(\upsilon_B-\upsilon_A-c\beta+3t_c-\gamma+\alpha+h)-(\gamma+2\alpha)^2\,)/(3t_d\,h)$.

For convenience, the equilibrium results composed of subscription prices (p_i), license fees (F_i), Internet service fee (ω), and demand ($n_{(j,i)}$) appear in Appendix B. Moreover, the comparative statistics of these analytical results are summarized in Table 2. VM technology can benefit the cloud console provider by reducing the hardware cost of producing consoles; however, the effort of enhancing VM technology will trigger intensive price competition from traditional console providers. Table 2 shows a traditional console provider will cut its subscription fee to respond to the cost-saving advantage of its opponents (i.e., $(\partial p^*_A)/\partial\rho>0$). In addition, the ISP will raise its Internet service fee to extract a higher revenue from the cloud console provider (i.e., $(\partial\omega^*)/\partial\rho<0$). As a result, if the strength of cost saving is not significant, the profit of the cloud console provider will drop, even if having a higher market share than before, as shown in Figure 2. Therefore, the manager of the research and development

(R&D) department must realize whether the investment made to improve the efficiency of VM technology can reach a certain level; otherwise, this investment could be a waste.

Lemma 1.

In the direct selling model, the ISP should charge the cloud console provider a lower Internet service fee when the high-speed Internet fee received from consumers increases. In addition, the ISP should even subsidize the cloud console provider when the high-speed Internet fee is higher than a certain threshold. Formally, $(\partial\omega^*)/\partial m<0$holds, and $\omega^*<0$ when $m>\hat{m}$, where

$$\hat{m} \equiv \frac{1}{2}\left(3t_c - \upsilon_A + \upsilon_B + c\beta + h(1-\rho) - \frac{2(\alpha+\gamma)^2}{3t_d} - \frac{\gamma\alpha}{3t_d}\right)$$

Net neutrality is still an ongoing debate about whether ISPs should treat all customers (including corporations and individuals) equally and cannot adopt price discrimination to increase their profits [40, 43]. Though outright blocking a competitor could violate the antitrust law, charging a higher Internet service fee for providing rapid network access seems to be acceptable to society. Therefore, our study contributes useful implications for policy makers because ISPs may reduce their Internet fees for platform providers (and even subsidize them) if they can receive a large amount from consumers. In addition, an ISP should understand the benefit of fostering a cloud console provider in the beginning state; therefore, when an incumbent, a traditional console provider, already has a multitude of original games (i.e., a high υA), subsidizing a cloud entrant can even bring in more than levying a toll.

3.4 Cloud Alliance Model

In fact, the cloud console provider and ISP can form a close-knit alliance (also known as the cloud alliance throughout this study) by delegating the ISP the role of a retailer to charge consumers for the cloud gaming service. In the cloud alliance model, the subscription fee is decided by the ISP, while the license fee paid to game developers is still determined by the cloud console provider. To gain revenue from consumers, the cloud console provider must decide how much profit it takes in for every dollar of the ISP's sales. In addition, the cloud console provider can demand the ISP bear parts of the licensing costs for reducing its cost loading from game developers. Therefore, we denote $e\cdot n_{(1,B)}$ and $g\cdot n_{(2,B)}$ as the license fee and sales revenue shared by the ISP. Next, the profits of the cloud console provider and ISP can be rewritten as

$$\underset{F_B}{Max}\ \pi_B = (g-\rho h)n_{2,B} - F_B n_{1,B} + e\cdot n_{1,B} \qquad \text{and} \qquad (7)$$

$$\underset{p_B}{Max}\ \pi_C = (p_B + m - g)n_{2,B} - c\mu - e\cdot n_{1,B} \quad s.t.\ \frac{1}{\mu-\lambda} \le d \qquad (8)$$

As shown in Figure 3, the cloud console provider in the cloud alliance model can negotiate a sharing ratio ϕ with the ISP to coordinate the ISP's pricing decision. This approach can be achieved by charging a fee per subscriber (g^*) and fee per game developer (e^*) as follows:

$g^*=\phi(p_B+m-c\beta)+(1-\phi)\rho h$ and $e^*=(1-\phi)\ F_B$

As a result, the profits of the cloud console provider and ISP can be updated as

$$\underset{F_B}{Max}\ \pi_B = \phi\left((p_B - \rho h + m)n_{2,B} - F_B n_{1,B} - c\beta n_{2,B}\right) \qquad (9)$$

$$\underset{p_B}{Max}\ \pi_C = (1-\phi)\left((p_B - \rho h + m)n_{2,B} - F_B n_{1,B} - c\beta n_{2,B}\right) - c/d \qquad (10)$$

In the cloud alliance model, the cloud console provider first announces the sharing schema composed of g*and e*. Next, both the cloud console provider and the ISP negotiate over the sharing ratio ϕ, which is an exogenous variable depending on their bargaining power. Finally, the pricing decisions regarding subscription fee p_i and license fee F_i are simultaneously made by the ISP and platform providers. Note, all scenarios in Table 1 use the same symbols; thus, we use subscripts I, II, III, and IV to differentiate the decision variables, demands, and profits in these models. Subsequently, we denote $\pi_{(B+C)}\equiv\pi_B+\pi_C$ as the sum of the ISP's and platform B's profits, which can be viewed as the overall benefit earned by the cloud alliance composed of the ISP and cloud console provider. As compared with the direct selling model, the features of the cloud alliance model are as follows.

Proposition 2.

(1) Both consumers and game developers on the cloud console platform will benefit under the cloud alliance model. Formally, $\pi_{(1,B,II)}(\theta_1)\geq\pi_{(1,B,I)}(\theta_1)$ and $u_{(2,B,II)}(\theta_2)\geq u_{(2,B,I)}(\theta_2)$.

(2) The cloud alliance can connect with more game developers and have higher consumer demand. Formally, $n_{(1,B,II)}>n_{(1,B,I)}$ and $n_{(2,B,II)}>n_{(2,B,I)}$.

(3) The overall profit of the cloud alliance increases if and only if the average expected revenue game developers receive from subscribers is higher than the average value from the titles produced by game developers. Formally, $\pi_{(B+C,II)}>\pi_{(B+C,I)}$ if and only if $\gamma>\alpha$.

Coordinating the members of a supply chain in a monopolistic market to make their individual pricing decisions collaboratively can raise their overall profit; however, this result cannot directly apply to this study in which there are other available substitutes because the Internet service fee (ω^*) charged by the ISP in the direct selling model can soften the price competition between both platforms. Without this buffer zone, the traditional console provider must respond with a lower subscription fee (i.e., $p_{(A,II)}<p_{(A,I)}$).

In the cloud alliance model, the cloud console provider can coordinate the moves between itself and the ISP. As a result, the rise in consumer demand and the number of contracted game developers benefit both sides on the cloud console platform. In addition, this advantage will benefit the cloud console provider if these game developers can sell more titles to consumers directly (i.e., $\gamma>\alpha$). In this case, the cloud console provider can save its cost of acquiring titles from game developers by lowering its license fee (i.e., $F_{(B,II)}<F_{(B,I)}$). Therefore, the advantage of a larger consumer network makes the cloud alliance better off.

On the other hand, if the game titles created by these game developers are more valuable, the cloud alliance will raise its license fee to enlarge its content library. However, because of the traditional console provider's low pricing strategy, the cloud alliance cannot fully recover its license cost from the consumer side. Although the cloud alliance cannot counter back the traditional console provider's low pricing strategy in such a circumstance, the cloud alliance model may unilaterally benefit the cloud console provider to a certain extent. For instance, our numerical result demonstrates the possibility that the cloud console provider can gain more in the cloud alliance model than in the direct selling model when its own original games become highly attractive to consumers (i.e., a higher υ_B), as shown in Figure 4.

4. Monetizing the Consumer-side Network Effect

The overwhelming amount of information makes attracting user attention on the Internet a challenging task for marketing companies, but IT companies can turn user attention into revenue by discovering the relation between merchandise and consumer preference collected from the Internet. Therefore, the cloud console provider can collect personalized information from subscribers' daily playing patterns and then create additional revenue by using these data to strengthen the efficiency of marketing activities, just like the revenue from social media and search engine services. With this useful information, a cloud console provider can know how and when to call on its subscribers to engage a certain marketing event. Since the cloud alliance model shows its advantage in expanding consumer demand for playing games on the cloud, we extend both Models I and II to Models III and IV by considering η the benefit of the consumer-side network effect for the cloud console provider to examine which business model is better off.

Therefore, Model III modifies the profit of the cloud console provider in Model I as follows:

$$\underset{p_B,F_B}{Max}\ \pi_B=(p_B-\rho h-\omega+\eta)n_{2,B}-F_B n_{1,B} \tag{11}$$

Likewise, in Model IV, the profit of the cloud console provider in Model II is adjusted as

$$\underset{F_B}{Max}\ \pi_B=(g-\rho h+\eta)n_{2,B}-F_B n_{1,B}+e\cdot n_{1,B} \tag{12}$$

In Model IV, the benefit of consumer-side network effect is excluded from the sharing schema. Therefore, both the fee per subscriber (g^*) and the fee per game developer (e^*) in the sharing schema remain unchanged. It is reasonable that the cloud console provider does not share its revenue from marketing activities with the ISP, just like Google does not share its advertising revenue from search results with any ISP. Comparing the overall profit of the cloud alliance in Model III with that in Model IV leads to the following proposition.

Proposition 3. When the benefit of the consumer-side network effect toward the cloud console provider is moderate, the overall profit of the cloud console provider and ISP in the cloud alliance model can be higher than that in the direct selling model. Formally, $\pi_{(B+C,IV)}\geq\pi_{(B+C,III)}$ when $\eta\in\left[\underline{\eta},\bar{\eta}\right]$, where $\underline{\eta}$ and $\bar{\eta}$ are the roots for $\pi_{(B+C,IV)}(\eta)-\pi_{(B+C,III)}(\eta)=0$.

To analyze the benefit of Model IV towards the cloud alliance composed of the cloud console provider and ISP, we examine the comparative statistics of these analytical results summarized in Table 3. Note, the growing subscriber base can in turn benefit the cloud console provider by monetizing subscriber attention. Therefore, as compared with the traditional console provider, the cloud console provider in Model III can attract more game developers to join and then stimulate the growth of its subscriber base at the same time. However, whether the cloud console provider will increase or decrease its subscription fee is uncertain. Moreover, the traditional console provider in Model III will cut its subscription fee in response to the market expansion behavior of its opponent.

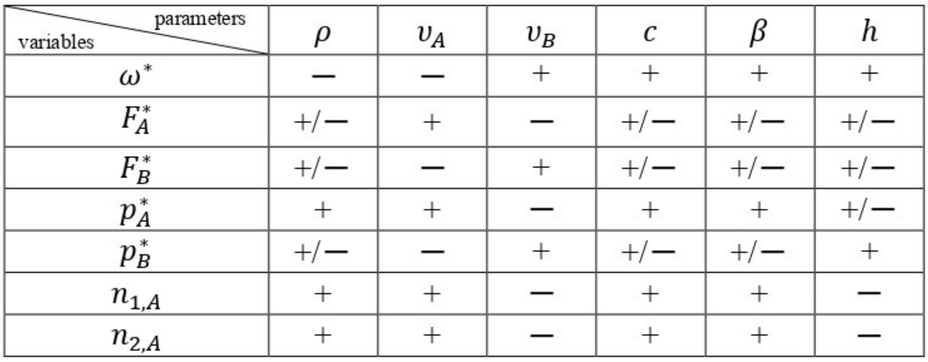
As compared with Model III, the profit of the cloud alliance in Model IV increases more sharply with the benefit of the consumer-side network effect. Not only will the license fee for game developers soar (F_B^*), but so will the subscription fee from consumers (p_B^*). As a result, the comparative statistics in Table 3 indicate the subscription fee decided by the traditional console provider in Model IV may increase with the consumer-side network effect. However, in Model III the traditional console provider always cuts this fee to respond. In other words, the traditional console provider in Model IV will not be keener on a low-pricing strategy than in Model III when the cloud console provider can bring in additional revenue from its subscribers.

As shown in Figure 5, the profit of the cloud alliance in Model IV can increase more dramatically than that in Model III; therefore, the overall profit in Model IV can be higher in a certain range of η. However, the cloud alliance model works poorly outside this range. When the benefit of the consumer-side network effect is too small, the influence of the low-priced competition launched by the traditional console provider is still significant. On the other hand, when the consumer-side network effect is too strong, the cloud alliance cannot completely leverage this advantage because this impact of the additional revenue stream is not involved in the pricing decision made by the cloud alliance.

Table 1. Business Models for Cloud Console Provider

Sales Operations Monetizing Subscriber Attention	Direct Selling	Cloud Alliance
Without	I	II
With	III	IV

Table 2. Comparative Statistics of the Direct Selling Model



parameters variables	ρ	v_A	v_B	c	β	h
ω^*	—	—	+	+	+	+
F_A^*	+/—	+	—	+/—	+/—	+/—
F_B^*	+/—	—	+	+/—	+/—	+/—
p_A^*	+	+	—	+	+	+/—
p_B^*	+/—	—	+	+/—	+/—	+
$n_{1,A}$	+	+	—	+	+	—
$n_{2,A}$	+	+	—	+	+	—

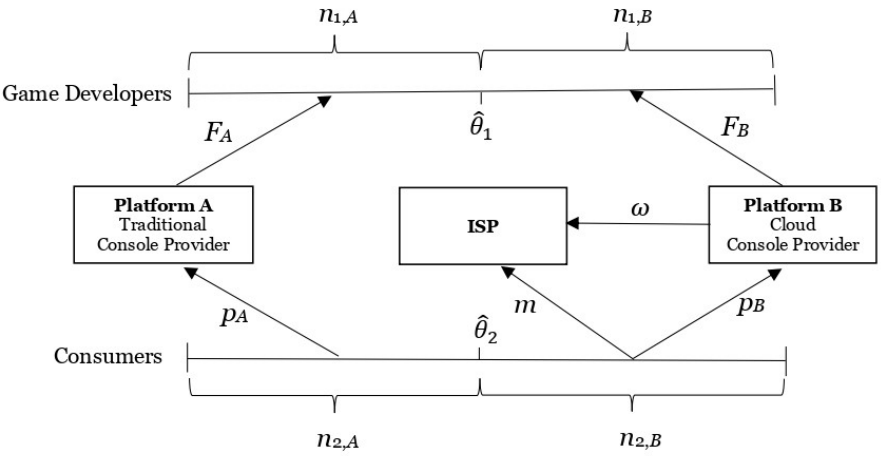


Figure 1. The Direct Selling Model (Model I)

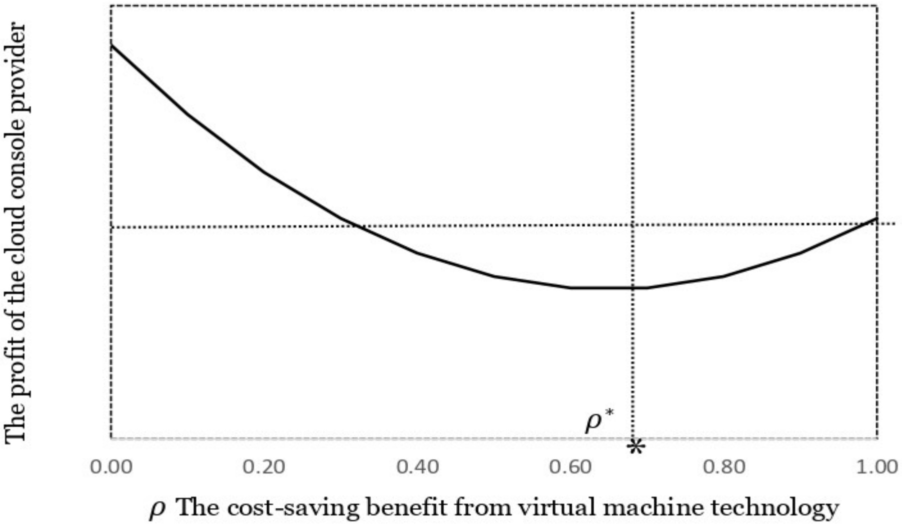


Figure 2. The Profit of the Cloud Console Provider in Model I

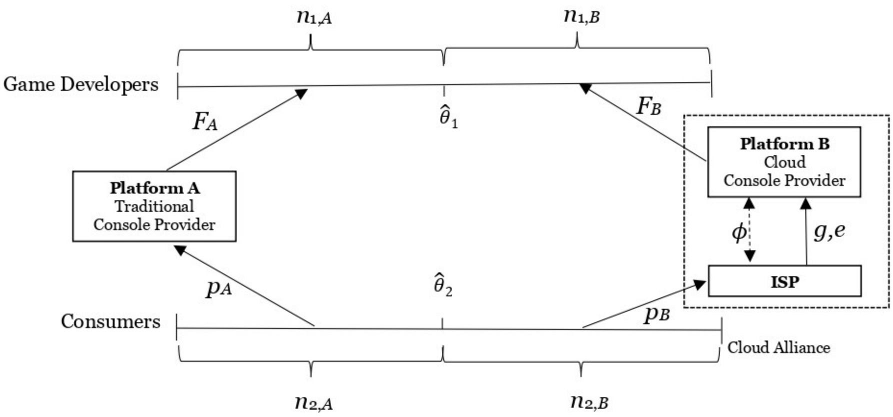


Figure 3. The Cloud Alliance Model (Model II)

Table 3. The Impact of the Consumer-side Network Effect (η) on Decision Variables and Demands [24]

Variable / Model	ω^*	F_A^*	F_B^*	p_A^*	p_B^*	$n_{1,A}$	$n_{2,A}$
III	+	+/−	+/−	−	+/−	−	−
IV	NA	+/−	+	+/−	+	−	+/−

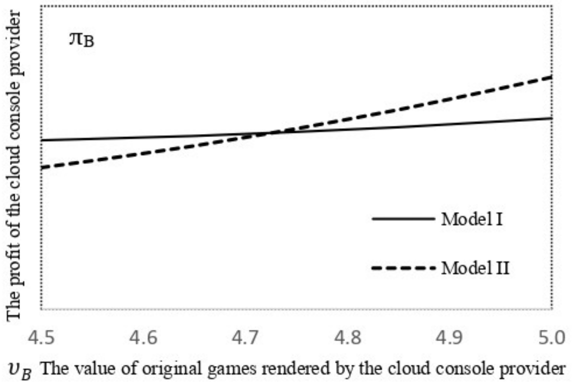


Figure 4. Profit of the Cloud Console Provider in Models I and II

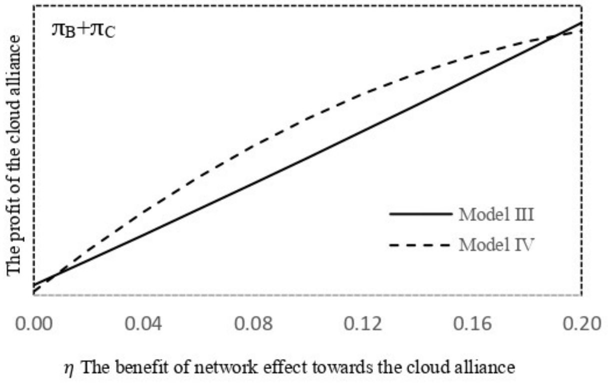


Figure 5. Profit of the Cloud Alliance in Models III and IV

5. Conclusion

The emergence of game-streaming services has appeared to emancipate consumers from the console upgrade cycle. On one end, the injection of game-streaming services may thoroughly change the ecosystem of current video console markets. Traditional console providers are starting to propose counter plans for free upgrades to next-generation consoles under a long-term subscription contract and even release their own cloud projects. On the other end, network latency for negative customer experiences when using game-streaming services has been identified by a series of business reports. However, if the network latency can be resolved in an inexpensive way, the game-streaming service will eventually hold an important portion of the video game industry.

This study considers a cloud console provider's venture into the video game market dominated by an established traditional console provider in a two-sided market. Though possessing the advantage of VM technology for reducing hardware expense, the cloud console provider must figure out the latency issue with the assistance of the ISP. Therefore, the cloud console provider can price its gaming-streaming service according to the Internet service fee charged by the ISP or collaborate with the ISP by delegating it as a retail partner to expand the market share. In addition, the cloud console provider can consider leveraging its market share to gain additional revenue from subscribers by delivering useful customized information to them. For example, game clips recommended by a cloud console provider to its subscribers may have pre-rolls to bring in revenue.

5.1 Managerial Implications

The cloud console provider must realize that the benefit of its VM technology is not absolute but relative to its content library, subscribers' average usage, the cost of producing consoles, and even the network externalities contributed by subscribers and game developers. Therefore, in addition to the costs of implementation and performance, current market conditions have to be considered when making an IT investment decision (Proposition 1). Moreover, the solution for reducing latency to improve the gaming experience depends on the ISP's paid fast lane. Our study indicates the ISP should charge the cloud console provider according to its Internet revenue from subscribers because the revenue of data traffic from the platform side will drop if few consumers subscribe to the cloud platform (Lemma 1).

The inefficiency arising from the Internet service fee can be resolved by delegating the ISP as a retailer in a cloud alliance. The cloud console provider can require the ISP pay a proportion of its revenue and bear part of the licensing cost as the conditions for the partnership. For coordinating the pricing decision made by the ISP, the cloud console provider must understand how to adjust the ISP's payment according to the revenue/cost sharing ratio in their collaborative contract. Moreover, this collaborative contract can increase the overall profit of the cloud alliance as long as the benefit received by the game developers from the consumer side is more than the value received by the consumers from the developer side. However, we also indicate that the overall profit of the cloud alliance will decline when this condition is reversed, even though both the number of contracted game developers and the number of subscribers on the cloud platform increase (Proposition 2). Therefore, the cloud console provider can leverage its growing subscriber base to gain additional revenue by linking the subscribers of its game-streaming platform to the business of other platforms with similar appeals (Proposition 3).

5.2 Limitations and Future Research

Price discrimination is a common pricing technique used by sellers; however, we consider the Internet fee paid by subscribers to be an exogenous variable. In practice, ISPs charge consumers only for the bandwidth they consume rather than the services they subscribe to. Therefore, when pricing the Internet fee charged from consumers, ISPs need to take all potential consumers into account. In addition to subscribing to the cloud gaming service, consumers may have other reasons to purchase high-bandwidth Internet access. Therefore, we view the Internet fee paid by consumers as a known parameter because making this term endogenous requires additional effort to consider the sales of the ISP's Internet access service from other different applications such as virtual reality applications and healthcare.

Currently, there are two major traditional console providers in the US market, but there is only one representative in our model. Most prior studies analyzing models in a two-sided market consider only two competing firms for highlighting the difference in the operational aspects between them. In addition, we implicitly assume all game developers focus on one platform to interact with consumers. However, the game developers, in practice, may have multiple platforms to release their titles. We examined this possible scenario but do not report the results here because of the lack of interesting findings from them. Moreover, the cloud alliance is not the only vehicle for the cloud console provider to delegate the ISP as a retailer. Numerical experiments can be conducted to examine the effect of the collaborative schema by visualizing the numerical results without pricing coordination.

A couple of research extensions are worth further consideration. First, integrating the game-streaming platform and live streaming platform for the synergistic effect appears to be inevitable because both are critical foundations in the gaming industry. Second, current traditional console providers still enjoy an asymmetric advantage due to the switching costs for consumers and the migration cost for game developers. To further evaluate the best practice for a cloud console provider, we can use different models capturing these points to examine the same issues discussed in this study.

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Appendix A. Table of Parameter and Decision Variables

Table A1. Model Parameters

Model Parameters	
$n_{(1,i)}$	The ratio of game developers contracting with platform i
$n_{(2,i)}$	The ratio of consumers subscribing to platform i
η	The average expected benefit from consumers subscribing to platform B
υ_i	The value from the original titles produced by platform i
α	The average value from the titles produced by game developers
m	The high-speed Internet fee for the consumers subscribing to platform B
t_c	The coefficient for measuring the platform preference of each consumer
κ	The platform-independent development cost for game developers
t_d	The coefficient for measuring the standard preference of each game developer
h	The hardware cost of producing a gaming console
ρ	The cost-saving benefit from virtual machine technology
μ	The service rate of the cloud gaming server
λ (β)	The arrival rates (usage rates) of the consumers subscribing to platform B
d	The threshold of average delay in the cloud gaming service
γ	The average expected revenue game developers receive from platform subscribers
c	The marginal capacity cost of the ISP

Table A2. Decision Variables

Decision Variables	
p_A (p_B)	The subscription fee charged by platform A (platform B)
F_A (F_B)	The license fee paid by platform A (platform B) to game developers
ω	The Internet service fee paid by platform B to ISP
g	The subscription revenue shared by platform B
e	The license fee of game developers shared by ISP
ϕ	The ratio negotiated between platform B and ISP for sharing revenue and cost

Appendix B. The Table of Equilibrium Results

Table B1. The Subscription Fee, License Fee, Internet Service Fee, and Demands

Model	Equilibrium Results
I	$F_A^*(\omega) = \alpha - t_d + \frac{t_d(\alpha-\gamma)(\upsilon_A - \upsilon_B - h + \rho h + \omega + m)}{9t_c t_d - 2(\gamma+\alpha)^2 - \gamma\alpha}$ $F_B^*(\omega) = \alpha - t_d - \frac{t_d(\alpha-\gamma)(\upsilon_A - \upsilon_B - h + \rho h + \omega + m)}{9t_c t_d - 2(\gamma+\alpha)^2 - \gamma\alpha}$ $p_A^*(\omega) = t_c - \gamma - \frac{\left(\begin{array}{l}(\gamma^2 + 2\gamma\alpha - 3t_c t_d)(\upsilon_A - \upsilon_B + h + \rho h + \omega + m + 2\gamma\alpha)\\ +\alpha(2\alpha+\gamma)(h - 2\gamma^2) - 3t_c t_d(h - 2\gamma\alpha)\end{array}\right)}{9t_c t_d - 2(\gamma+\alpha)^2 - \gamma\alpha}$ $p_B^*(\omega) = 2(t_c - \gamma) + (1+\rho)h + \omega - p_A^*(\omega)$ $\omega^* = \frac{3t_d\big(3t_c - 2m - \upsilon_A + \upsilon_B + c\beta + h(1-\rho)\big) - 2(\alpha+\gamma)^2 - \gamma\alpha}{6t_d}$ $n_{1,A}^* = \frac{1}{2} + \frac{(2\alpha+\gamma)\big((9t_c t_d - 2(\gamma+\alpha)^2 - \gamma\alpha) + 3t_d(\upsilon_A - \upsilon_B + c\beta - h + \rho h)\big)}{12t_d(9t_c t_d - 2(\gamma+\alpha)^2 - \gamma\alpha)}$ $n_{2,A}^* = \frac{3\big((9t_c t_d - 2(\gamma+\alpha)^2 - \gamma\alpha) + t_d(\upsilon_A - \upsilon_B + c\beta - h + \rho h)\big)}{4(9t_c t_d - 2(\gamma+\alpha)^2 - \gamma\alpha)}$
II	$F_A^* = \alpha - t_d + \frac{t_d(\alpha-\gamma)(\upsilon_A - \upsilon_B - h + \rho h + c\beta)}{9t_c t_d - 2(\gamma+\alpha)^2 - \gamma\alpha}$ $F_B^* = \alpha - t_d - \frac{t_d(\alpha-\gamma)(\upsilon_A - \upsilon_B - h + \rho h + c\beta)}{9t_c t_d - 2(\gamma+\alpha)^2 - \gamma\alpha}$ $p_A^* = t_c - \gamma - \frac{\left(\begin{array}{l}(\gamma^2 + 2\gamma\alpha - 3t_c t_d)(\upsilon_A - \upsilon_B + h + \rho h + c\beta + 2\gamma\alpha)\\ +\alpha(2\alpha+\gamma)(h - 2\gamma^2) - 3t_c t_d(h - 2\gamma\alpha)\end{array}\right)}{9t_c t_d - 2(\gamma+\alpha)^2 - \gamma\alpha}$ $p_B^* = 2(t_c - \gamma) - m + c\beta + (1+\rho)h - p_A^*$ $n_{1,A}^* = \frac{1}{2} + \frac{(2\alpha+\gamma)t_d(\upsilon_A - \upsilon_B - h + \rho h + c\beta)}{2t_d(9t_c t_d - 2(\gamma+\alpha)^2 - \gamma\alpha)}$ $n_{2,A}^* = \frac{(9t_c t_d - 2(\gamma+\alpha)^2 - \gamma\alpha) + 3t_d(\upsilon_A - \upsilon_B - h + \rho h + c\beta)}{2(9t_c t_d - 2(\gamma+\alpha)^2 - \gamma\alpha)}$
III	$F_A^*(\omega) = \alpha - t_d - \frac{t_d(\gamma-\alpha)(\upsilon_A - \upsilon_B - h + \rho h + \omega + m - \eta)}{9t_c t_d - 2(\gamma+\alpha)^2 - \gamma\alpha}$ $F_B^*(\omega) = \alpha - t_d + \frac{t_d(\gamma-\alpha)(\upsilon_A - \upsilon_B - h + \rho h + \omega + m - \eta)}{9t_c t_d - 2(\gamma+\alpha)^2 - \gamma\alpha}$

	$p_A^*(\omega) = t_c - \gamma - \frac{\left(\begin{array}{l}(\gamma^2 + 2\gamma\alpha - 3t_c t_d)(\upsilon_A - \upsilon_B + h + \rho h + \omega + m + 2\gamma\alpha - \eta) \\ +\alpha(2\alpha + \gamma)(h - 2\gamma^2) - 3t_c t_d(h - 2\gamma\alpha)\end{array}\right)}{9t_c t_d - 2(\gamma + \alpha)^2 - \gamma\alpha}$ $p_B^*(\omega) = 2(t_c - \gamma) + (1 + \rho)h + \omega - \eta - p_A^*(\omega)$ $\omega^* = \frac{3t_d(3t_c - 2m - \upsilon_A + \upsilon_B + c\beta + h(1 - \rho) + \eta) - (2\alpha + \gamma)(2\gamma + \alpha)}{6t_d}$ $n_{1,A}^* = \frac{1}{2} + \frac{(2\alpha + \gamma)\left((9t_c t_d - 2(\gamma + \alpha)^2 - \gamma\alpha) + 3t_d(\upsilon_A - \upsilon_B - h + \rho h + c\beta - \eta)\right)}{12t_d(9t_c t_d - 2(\gamma + \alpha)^2 - \gamma\alpha)}$ $n_{2,A}^* = \frac{3\left((9t_c t_d - 2(\gamma + \alpha)^2 - \gamma\alpha) + t_d(\upsilon_A - \upsilon_B - h + \rho h + c\beta - \eta)\right)}{4(9t_c t_d - 2(\gamma + \alpha)^2 - \gamma\alpha)}$
IV	$p_A^* = t_c - \gamma - \frac{\left(\begin{array}{l}(\gamma^2 + 2\gamma\alpha - 3t_c t_d) \cdot (\upsilon_A - \upsilon_B + \rho h + h + c\beta + 2\gamma\alpha - \eta) \\ +\alpha(2\alpha + \gamma)(h - 2\gamma^2) - 3t_c t_d(h - 2\gamma\alpha)\end{array}\right)}{9t_c t_d - 2(\gamma + \alpha)^2 - \gamma\alpha} + \frac{\eta \cdot \left((1 - \phi)\gamma\alpha(4t_c t_d - \gamma^2 - 2\gamma\alpha) + \phi t_c t_d(3t_c t_d - \gamma\alpha - \gamma^2) - \alpha^2 t_c t_d\right)}{(t_c t_d - \gamma\alpha)(9t_c t_d - 2(\gamma + \alpha)^2 - \gamma\alpha)\phi}$ $p_B^* = 2(t_c - \gamma) - m + c\beta + (1 + \rho)h - \eta + \frac{(\phi t_c t_d + (1 - \phi)\gamma\alpha)\eta}{(t_c t_d - \gamma\alpha)\phi} - p_A^*$ $F_A^* = \alpha - t_d - \frac{t_d(\gamma - \alpha) \cdot (\upsilon_A - \upsilon_B + \rho h - h + c\beta - \eta)}{9t_c t_d - 2(\gamma + \alpha)^2 - \gamma\alpha} + \frac{\eta \cdot t_d\left(\phi(\alpha - \gamma)(t_c t_d - \gamma\alpha) + \alpha(3t_c t_d - \alpha^2 - \gamma^2 - \gamma\alpha)\right)}{(t_c t_d - \gamma\alpha)(9t_c t_d - 2(\gamma + \alpha)^2 - \gamma\alpha)\phi}$ $F_B^* = \alpha - t_d + \frac{t_d(\gamma - \alpha)(\upsilon_A - \upsilon_B + \rho h - h + c\beta - \eta)}{9t_c t_d - 2(\gamma + \alpha)^2 - \gamma\alpha} - \frac{\eta \cdot t_d\left(\alpha(\alpha^2 + \gamma^2 + 4\gamma\alpha - 6t_c t_d) + \phi(\alpha - \gamma)(t_c t_d - \gamma\alpha)\right)}{(t_c t_d - \gamma\alpha)(9t_c t_d - 2(\gamma + \alpha)^2 - \gamma\alpha)\phi}$ $n_{1,A}^* = \frac{\begin{array}{l}(2\alpha + \gamma)\gamma\alpha\left(\eta + \phi(2\gamma + \alpha)\right) - 3\alpha\eta t_c t_d + \phi(2\alpha + \gamma)(t_c t_d - \gamma\alpha)(\upsilon_A - \upsilon_B + c\beta + h\rho - h) \\ +\phi t_c t_d(9t_c t_d - 2\alpha^2 - 14\gamma\alpha - 2\gamma^2)\end{array}}{2(t_c t_d - \gamma\alpha)(9t_c t_d - 2(\gamma + \alpha)^2 - \gamma\alpha)\phi}$ $n_{2,A}^* = \frac{\begin{array}{l}\alpha\left(\phi\gamma(2\alpha^2 + 5\gamma\alpha + 2\gamma^2) - \eta t_d(\alpha - \gamma)\right) + \phi t_c t_d(9t_c t_d - 2\gamma^2 - 14\gamma\alpha - 2\alpha^2) \\ +3\phi t_d(t_c t_d - \gamma\alpha)(\upsilon_A - \upsilon_B + c\beta + \rho h - h)\end{array}}{2(t_c t_d - \gamma\alpha)(9t_c t_d - 2(\gamma + \alpha)^2 - \gamma\alpha)\phi}$

Appendix C. Supplement for Table 2

We first show $3t_c t_d - \gamma^2 - 2\alpha\gamma > 0$ and then only demonstrate the impact of h because the others are straightforward after knowing $3t_c t_d - \gamma^2 - 2\alpha\gamma > 0$. Notice that $4t_c t_d - (\gamma + \alpha)^2 > 0$ and $t_c t_d > \alpha\gamma$ hold in this study. To begin with, $3t_c t_d - \gamma^2 - 2\alpha\gamma > 0$ holds in case $\alpha \geq \gamma$ because $t_c t_d > \alpha\gamma$. If $\alpha < \gamma$, we suppose $3t_c t_d - \gamma^2 - 2\alpha\gamma < 0$. Next, $4t_c t_d - (\gamma + \alpha)^2 > 0$ can imply $(t_c t_d - \gamma^2) + (3t_c t_d - 2\alpha\gamma - \alpha^2) > 0$. That is, $t_c t_d > \gamma^2$. However, $3t_c t_d - \gamma^2 - 2\alpha\gamma \geq (2t_c t_d + \gamma^2) - \gamma^2 - 2\alpha\gamma = 2(t_c t_d - \alpha\gamma) > 0$, which is a contradiction. Subsequently, letting $\Delta \equiv 9t_c t_d - 2(\gamma + \alpha)^2 - \gamma\alpha$ where $\Delta > 0$, we have the following results:

$\partial F_A/\partial h = t_d(1 - \rho)(\gamma - \alpha)/(2\Delta)$, $\partial F_B/\partial h = -\partial F_A/\partial h$, $\partial\omega/\partial h = (1 - \rho)/2 > 0$, $\partial n_{1,A}/\partial h = -(1 - \rho)(2\alpha + \gamma)/(4\Delta) < 0$, and $\partial n_{2,A}/\partial h = -3\,(1 - \rho)t_d/(4\Delta) < 0$. Moreover, $\partial p_A/\partial h = \big(3t_c t_d(5 + \rho) - (2\alpha + \gamma)(\rho\gamma + 3\gamma + 2\alpha)\big)/(2\Delta)$ could be positive or negative. Finally, given $\chi \equiv 6t_c t_d(2 + \rho) - (2\alpha + \gamma)(\gamma\rho + 3\gamma + \alpha\rho + \alpha)$, the sign of $\partial p_B/\partial h = \chi/2\Delta$ requires further examination. Notice that $\chi > 0$ when $\rho = 0$ and $\rho = 1$. In addition, $\partial\chi/\partial\rho > 0$; therefore, $\partial p_B/\partial h > 0$.

Appendix D. Proofs

D.1. Proof of Proposition 1

Before executing the backward induction to find the equilibrium for the direct selling model, the size of each group $n_{j,i}$ can be obtained by the following approach. First, solving $\pi_{1,A}(\hat{\theta}_1) = \pi_{1,B}(\hat{\theta}_1)$ and $u_{2,A}(\hat{\theta}_2) = u_{2,B}(\hat{\theta}_2)$, where $\hat{\theta}_1(n_{2,A}, n_{2,B})$ and $\hat{\theta}_2(n_{1,A}, n_{1,B})$ are the points of the [0, 1] line. Game developers with preference $\hat{\theta}_1$ (consumers with preference $\hat{\theta}_2$) are indifferent between choosing platform A and B. Second, solving $n_{1,A} = \hat{\theta}_1$, $n_{2,A} = \hat{\theta}_2$, $n_{1,B} = 1 - n_{1,A}$, and $n_{2,B} = 1 - n_{2,A}$ simultaneously yields the demands of both sides, which can then be used during the process of the backward induction. Third, after incorporating them into π_A, π_B, and π_C, we solve $\partial\pi_A/\partial p_A = 0$, $\partial\pi_B/\partial p_B = 0$, $\partial\pi_A/\partial F_A = 0$, and $\P p_B/\P F_B = 0$ simultaneously to yield p_A^*, p_B^*, F_A^*, and F_B^*. Fourth, we incorporate these decision variables to profit functions and then solve $\partial\pi_C(p_A^*, p_B^*, F)/\partial\omega = 0$ for obtaining ω^*. Moreover, solving $\partial\pi_B/\partial\rho = 0$ yields ρ^*; therefore, $\partial\pi_B/\partial\rho > 0$ when $\rho > \rho^*$, but the opposite holds when $\rho \leq \rho^*$ due to $\partial^2\pi_B/\partial\rho^2 = h^2 t_d/\big(4(9t_c t_d - 2(\gamma + \alpha)^2 - \gamma\alpha)\big) > 0$.

D.2. Proof of Lemma 1

$\partial\omega^*/\partial m = -1 < 0$. In addition, solving $\omega^* = 0$ yields $\hat{m}$.

D.3. Proof of Proposition 2

First, $\pi_{1,B,II}(\theta_1) - \pi_{1,B,I}(\theta_1) = \frac{(\gamma n_{2B,II}+F_{B,II})-(\gamma n_{1,B,I}+F_{B,I})}{n_{2,B,II}} = \frac{\gamma+2\alpha}{6} > 0$, which shows that game developers are better off in Model II. Second, $u_{2,B,II}(\theta_2) - u_{2,B,I}(\theta_2) = \frac{(\alpha n_{1,B,II}-p_{B,II})-(\alpha n_{1,B,I}-p_{B,I})}{n_{2,B,II}} = \frac{12t_c t_d-2\alpha^2-5\gamma\alpha-2\gamma^2}{6t_d} > 0$, which shows that consumers are better off in Model II. Finally, $\frac{\pi_{B+C,II}-\pi_{B+C,I}}{n_{2,B,II}} = \frac{(\gamma-\alpha)(\gamma-3t_d+2\alpha)}{18t_d}$. Notice that $\pi_{1,A,I}(\hat{\theta}_1) = \pi_{1,B,I}(\hat{\theta}_1) > 0$ holds. Otherwise, there is no price competition between platforms A and B when contracting with game developers. Therefore,

$\pi_{1,A,I}(\hat{\theta}_1) = \pi_{1,B,I}(\hat{\theta}_1) = F_A + \gamma \cdot n_{2,A} - t_d\hat{\theta}_1 - \kappa = \frac{1}{2}(\gamma - 3t_d + 2\alpha - 2\kappa) \geq 0$. In other words, this condition can imply $\gamma - 3t_d + 2\alpha \geq 2\kappa > 0$. As a result, $\pi_{B+C,II} > \pi_{B+C,I}$ holds if and only if $\alpha < \gamma$. Finally, $n_{2,B,II} - 2 \cdot n_{2,B,I} = 0$ and $n_{1,B,II} - 2 \cdot n_{1,B,I} = (\gamma - 3t_d + 2\alpha)/(6t_d) > 0$ hold; therefore, we confirm $n_{1,B,II} > n_{1,B,I}$ and $n_{2,B,II} > n_{2,B,I}$.

D.4. Proof of Proposition 3

Notice that the following second-order conditions indicating that $\pi_{B+C,III}$ is a convex function but $\pi_{B+C,IV}$ a concave function with respect to η:

$$\frac{\partial^2\pi_{B+C,III}}{\partial\eta^2} = \frac{t_d}{9t_c t_d-2(\gamma+\alpha)^2-\gamma\alpha} > 0 \text{ and } \frac{\partial^2\pi_{B+C,IV}}{\partial\eta^2} = \frac{-t_d\alpha(\gamma+\alpha)}{(t_c t_d-\gamma\alpha)(9t_c t_d-2(\gamma+\alpha)^2-\gamma\alpha)\phi} < 0.$$

Subsequently, the intersection of a concave function and a convex function can have at most two roots. Therefore, if $\underline{\eta}$ and $\bar{\eta}$ are the two roots such that $\pi_{B+C,III} = \pi_{B+C,IV}$ where $\bar{\eta} > \underline{\eta}$, we can confirm $\pi_{B+C,IV} \geq \pi_{B+C,III}$ when $\eta \in \left[\underline{\eta}, \bar{\eta}\right]$; otherwise, $\pi_{B+C,III}$ is not a concave function, which is a contradiction.