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# Video Platforms' Value-Added Service Investment Strategies for Viewers and Ad Pricing Strategies

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## Abstract

This paper develops a duopoly model in which two free video platforms compete for two groups of users, i.e., viewers and advertisers. We investigate video platforms' value-added service (VAS) investment strategies and ad pricing strategies under a situation where only one platform invests in value-added service for viewers. The results reveal that: 1) When marginal cost increases, the investment platform's VAS level and ad price first remain constant and then decrease; the non-investment platform's ad price first remains constant and then increases. 2) The impacts of the positive effect of viewers on the two platforms' VAS levels and ad prices are related to the marginal cost. 3) The investment platform's ad price is higher than the non-investment platform's. 4) The investment platform's ad price is higher in the situation with investment than in the situation without investment.

## Keywords

Video Platform, VAS Investment Strategy, Ad Pricing Strategy, Marginal Cost

## 1. Introduction

With the continuous maturation and wide application of Internet technology, the platform industry based on Internet technology has gradually developed and has become an important force in promoting economic growth (Yang, Diao, & Kang, 2020). Video platforms are typical representatives of the platform industry (Dimakopoulos & Sudaric, 2018), and have achieved rapid growth in recent years (Wang & Lobato, 2019). They provide content to viewers, ad space to advertisers, and rely on charging advertisers to generate profits. In recent years, in order to attract viewer engagement, some video platforms have offered value-added services (VASs) to viewers in addition to providing content to them. For example, Youku video platform can provide discussion areas for viewers to share their opinions, and Iqiyi video platform can also provide video recommendation functions for viewers to quickly find their favorite videos. These VASs can help video platforms gather more viewers, and indirectly, with the positive cross-network effect brought by viewers, also help the platforms attract more advertisers and earn more ad revenue. However, investing in these VASs also imposes additional costs for video platforms, such as labor costs and equipment costs to provide these services, and the investment costs typically increase with the VAS levels the platforms set. If video platforms cannot set appropriate VAS levels, then instead of gaining more ad revenue, the platforms will incur more VAS costs. Evidently, it is essential for video platforms to set appropriate VAS investment strategies. At the same time, video platforms should also set appropriate ad pricing strategies matching the VAS investment strategies; only in this way can the platforms effectively attract advertisers' participation and obtain more ad revenue.

Based on the above realistic background, this paper develops a duopoly model, which includes an investment platform and a non-investment platform, and discusses the following issues. 1) How should the investment platform set its VAS investment strategies for viewers and the corresponding ad pricing strategies? 2) How should the non-investment platform set ad pricing strategies? 3) What are the differences in ad pricing strategies between the investment platform and non-investment platform? 4) What is the difference between the investment platform's ad pricing strategies in situations with and without investment?

This study adds to the literature on platform investment strategies by examining the VAS investment strategies of video platforms. This study also adds to the literature on media platform pricing strategies by examining the impact of VASs on such pricing strategies.

The arrangement of the remaining parts of this paper is as follows. Section 2 reviews the related literature. Section 3 establishes the model and makes assumptions. Section 4 provides an equilibrium analysis. Section 5 provides an equilibrium comparison. Section 6 summarizes the conclusions and puts forward future research.

## 2. Literature Review

This paper is related to the research on media platform pricing strategies. Reisinger (Reisinger, 2012) explored the effect of horizontal differentiation levels on media platform pricing strategies. Their study found that when horizontal differentiation levels were relatively high, the two platforms' ads prices decreased with horizontal differentiation levels. Kodera (Kodera, 2015) compared the differences in media platform pricing strategies in a uniform price model and a price discrimination model. They found that the platforms' ad prices were lower in the price discrimination model than in the uniform price model. Lin et al.

(Lin, 2020) studied the effect of negative cross-network effect brought by advertisers on media platform pricing strategies. He hypothesized that media platforms could offer two products to advertisers, i.e., displaying ads to all viewers and displaying ads only to high-type viewers. He found that the price difference between the two ad products increased with the negative cross-network effect brought by advertisers. Pan (Pan, 2017) compared the ad price difference between a platform that charged for advertisers on a per-view basis and a platform that charged for advertisers on a lump-sum fee basis. They found that the ad price of the platform which charges for advertisers on a per-view basis is higher than that of the platform which charges for advertisers on a lump-sum fee basis. Kerkho & Münster (Kerkhof & Münster, 2015) studied the effect of ad restrictions on media platform pricing strategies. The study showed that media platforms' ad prices would increase due to ad restrictions.

This paper is related to the research on platform investment strategies. Hagiu & Spulber (Hagiu & Spulber, 2013) studied game platforms' content investment strategies. The study found that platforms' content investment strategies were related to two factors, namely the expectation of platforms and the relationship between platforms' own content and third-party content. Dou & He (Dou & He, 2017) studied a monopoly e-commerce platform' VAS investment strategy. Their study showed that when the marginal cost was below the threshold, the platform would invest all resources in VASs, and when the marginal cost was above the threshold, the platform would reduce its investment in VASs as the marginal cost increased. Gui et al. (Gui, Liu, & Gong, 2021) investigated logistics information platforms' VAS investment strategies. It was found that, in the case where both vehicle owners and cargo owners were single-homing, both platforms would adopt the same investment strategies only if the marginal cost was within a certain threshold. Furthermore, Gui et al. (Gui, Wu, & Gong, 2019) also studied e-commerce platforms' VAS investment strategies. They found that, in the case where both sellers and buyers were multi-homing, the e-commerce platforms' optimal investment satisfied a single-threshold strategy. Lei & Xiong (Lei & Xiong, 2018) analyzed e-commerce platforms' VAS investment strategies for buyers. When investment cost coefficients were large, the platforms' VAS levels would increase with investment conversion coefficients. Using an e-commerce platform as an example, Zhang & Dong (Zhang & Dong, 2018) analyzed the impact of VAS investments on the platform's market shares. Their study found that if horizontal differentiation levels were too small or large, the platform's market shares would increase after investing; if horizontal differentiation levels were moderate, then the platform's market shares would decrease after investing.

## 3. Models

In this paper, we develop a duopoly model, which includes two free video platforms, a group of viewers and a group of advertisers, as shown in **Figure 1**. Both video platforms provide video to viewers, ad space to advertisers, and generate profits by charging advertisers. In addition to providing viewers with videos,

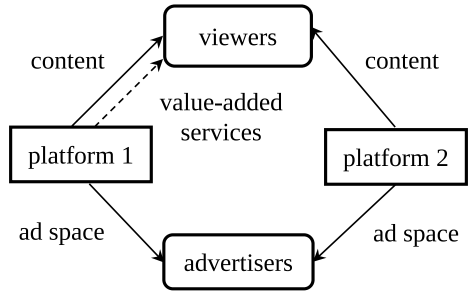


Figure 1. Research model.

platform 1 can also provide them with free VASs. For example, the platform provides discussion areas for viewers to share their opinions and video recommendation functions for viewers to quickly find their favorite content. Platform 2 only provides viewers with content.

### 3.1. Viewers Market

The number of viewers is normalized to 1. Following Dietl et al. (Dietl, Lang, & Lin, 2013) and Lin et al. (Lin, Hou, & Zhou, 2020), we assume that each viewer located at $x \in [0,1]$ can only choose one platform to obtain content, i.e., the viewers are single-homing. A viewer can get the basic utility $v_i$ from the content provided by platform *i*, $i = 1,2$. For computational convenience, it is assumed that $v_1 = v_2 = v_0$. If a viewer engages with platform 1, he can also gain utility of $q \cdot 1$ from the platform due to value-added services (VASs), where $q$ is platform 1's VAS level and "1" is the benefit the viewer receives from the unit VAS level. A viewer is affected by the negative cross-network effect brought by advertisers on platform *i*; therefore, his utility on platform *i* is reduced by $\beta a_i$. $\beta$ ($0 < \beta \le 1$) is the strength of the negative cross-network effect brought by advertisers, referred to as the negative effect of advertisers, and $a_i$ is platform *i*'s advertiser market share. A viewer joining on platform *i* also incurs a traffic cost of $t|x - x_i|$, where $t$ is the transportation cost incurred per unit distance (Reisinger, 2012), and $x_i$ is the location of platform *i*, $x_1 = 0$, $x_2 = 1$. According to the above assumptions, viewers' utilities for platform 1 and platform 2 can be described as $u_1 = v_0 + q - \beta a_1 - tx$, $u_2 = v_0 - \beta a_2 - t(1 - x)$, respectively.

### 3.2. Advertisers Market

The number of advertisers is normalized to 1. Each advertiser located at $x \in [0,1]$ can only choose to display ads through one of the platforms, i.e., the viewers are single-homing. The advertiser can obtain the basic utility $V_i$ on platform *i*. To facilitate the calculation, assume $V_1 = V_2 = V_0$. An advertiser can benefit from the positive cross-network effect brought by viewers; therefore, his utility on platform *i* is increased by $\gamma N_i$. $\gamma$ represents the strength of the positive cross-network effect brought by viewers, referred to as the positive effect of viewers, and $N_i$ is platform *i*'s viewer market share. An advertiser needs to pay a lump-sum ad fee $p_i$ to platform *i*. An advertiser joining on platform *i* also incurs a transportation cost $t|y-y_i|$, where $y_i$ is the location of platform *i*, $y_1=0$, $y_2=1$. Based on the above assumptions, advertisers' utilities for platform 1 and platform 2 can be expressed as $U_1=V_0+\gamma N_1-ty$, $U_2=V_0+\gamma N_2-t(1-y)$, respectively.

### 3.3. Video Platforms

There are two competing video platforms 1 and 2 in the market, and the two platforms are located at the 0 and 1 ends of a line of length 1, respectively. They provide content for viewers, ad space for advertisers, and profit by charging advertisers lump-sum fees. The lump-sum ad fee that platform $i$ ($i=1,2$) charges each advertiser is $p_i$. It is worth noting that in addition to providing content to viewers, platform 1 also provides VASs to them. Platform 1 provides these VASs incurring a cost of $\frac{kq^2}{2}$ (Dou, He, & Xu, 2016), where $k$ is the marginal VAS investment cost, referred to as the marginal cost. Through the above analysis, the two platforms' profit functions can be expressed as $\pi_1=p_1a_1-\frac{kq^2}{2}$, $\pi_2=p_2a_2$.

### 3.4. Timing

The timing of the game is as follows: Firstly, platform 1 decides its VAS level and ad price, and platform 2 decides its ad price. Secondly, each advertiser chooses which platform to advertise on. Thirdly, each viewer chooses which platform to obtain content on.

## 4. Equilibrium Analysis

According to the basic assumption in section 3, viewers' utilities for platform 1 and platform 2 can be expressed as $u_1=v_0+q-\beta a_1-tx$, $u_2=v_0-\beta a_2-t(1-x)$, respectively. Advertisers' utilities for platform 1 and platform 2 are expressed as $U_1=V_0+\gamma N_1-ty$, $U_2=V_0+\gamma N_2-t(1-y)$, respectively. The two platforms' profits are expressed as $\pi_1=p_1a_1-\frac{kq^2}{2}$, $\pi_2=p_2a_2$.

By solving $u_1=u_2$, we obtain that the marginal viewer locates at $\bar{x}=\frac{t+q-\beta a_1+\beta a_2}{2t}$. Therefore, the two platforms' viewer market shares, $N_1$, $N_2$, can be expressed as

$$N_1=\frac{t+q-\beta a_1+\beta a_2}{2t},\quad N_2=1-\frac{t+q-\beta a_1+\beta a_2}{2t}. \tag{1}$$

Similarly, by solving $U_1=U_2$, we obtain that marginal advertiser locates at $\bar{y}=\frac{p_2-p_1+t+\gamma N_1-\gamma N_2}{2t}$. Therefore, the two platforms' advertiser market shares, $a_1$, $a_2$, can be expressed as

$$a_1=\frac{p_2-p_1+t+\gamma N_1-\gamma N_2}{2t},\quad a_2=1-\frac{p_2-p_1+t+\gamma N_1-\gamma N_2}{2t}. \tag{2}$$

Combining Equations (1) and (2), we get the expressions for $N_1$, $N_2$, $a_1$, and $a_2$ regarding $q$, $p_1$, and $p_2$ as

$$N_1 = \frac{t^2 + qt + \beta p_1 - \beta p_2 + \beta\gamma}{2t^2 + 2\beta\gamma}, \quad N_2 = \frac{t^2 - qt - \beta p_1 + \beta p_2 + \beta\gamma}{2\left(t^2 + \beta\gamma\right)}. \tag{3}$$

$$a_1 = \frac{\beta\gamma - p_1 t + p_2 t + \gamma q + t^2}{2\left(t^2 + \beta\gamma\right)}, \quad a_2 = \frac{\beta\gamma + p_1 t - p_2 t - \gamma q + t^2}{2\left(t^2 + \beta\gamma\right)}. \tag{4}$$

The objectives of platforms 1 and 2 are to maximize their respective profits. Therefore, the decision problems of platforms 1 and 2 can be expressed as

$$\begin{aligned} \max \pi_1\left(p_1, q\right) &= \frac{p_1\left(\beta\gamma - p_1 t + p_2 t + \gamma q + t^2\right)}{2\left(t^2 + \beta\gamma\right)} - \frac{kq}{2}, \\ \max \pi_2\left(p_2\right) &= \frac{p_2\left(\beta\gamma + p_1 t - p_2 t - \gamma q + t^2\right)}{2\left(t^2 + \beta\gamma\right)}. \end{aligned} \tag{5}$$

Solving for the first-order partial derivatives of $\pi_1$ in Equation (5) regarding $p_1$ and $q$, and the first-order partial derivative of $\pi_2$ in Equation (5) regarding $p_2$, we get that

$$\frac{\partial \pi_1}{\partial p_1} = \frac{\beta\gamma - p_1 t + p_2 t + \gamma q + t^2}{2t^2 + 2\beta\gamma} - \frac{p_1 t}{2t^2 + 2\beta\gamma}, \quad \frac{\partial \pi_1}{\partial q} = \frac{p_1 \gamma}{2t^2 + 2\beta\gamma} - kq, \tag{6}$$

$$\frac{\partial \pi_2}{\partial p_2} = \frac{\beta\gamma + p_1 t - p_2 t - \gamma q + t^2}{2t^2 + 2\beta\gamma} - \frac{p_2 t}{2t^2 + 2\beta\gamma}. \tag{7}$$

Based on Equations (6) and (7), we further obtain the Hessian matrix

$$A_1 = \begin{bmatrix} \dfrac{-2t}{2t^2 + 2\beta\gamma} & \dfrac{\gamma}{2t^2 + 2\beta\gamma} \\ \dfrac{r}{2t^2 + 2\beta\gamma} & -k \end{bmatrix}. \tag{8}$$

The first-order principal sub-equation of the Hessian matrix is $\frac{-2t}{2t^2 + 2\beta\gamma}$, and the second-order principal sub-equation is $\frac{-\gamma^2 + 4\beta k\gamma t + 4kt^3}{4\left(t^2 + \beta\gamma\right)^2}$. It is clear that $\frac{-2t}{2t^2 + 2\beta\gamma}$ is less than zero, $\frac{-\gamma^2 + 4\beta k\gamma t + 4kt^3}{4\left(t^2 + \beta\gamma\right)^2}$ is greater than zero at $\frac{\gamma^2}{4t^3 + 4\beta\gamma t} < k \le 1$, and less than or equal to zero at $0 < k \le \frac{\gamma^2}{4t^3 + 4\beta\gamma t}$. The second-order derivative of $\pi_2$ regarding $p_2$ is $\frac{-2t}{2t^2 + 2\beta\gamma}$, which is less than zero. Further analysis can be discussed in the following two scenarios.

1) When $\frac{\gamma^2}{4t^3 + 4\beta\gamma t} < k \le 1$, $|A| > 0$, the Hessian matrix in Equation (8) negative definite, and the optimal solutions are obtained from the first-order partial derivatives. The optimal solutions can be expressed as

$$q^* = \frac{3\gamma\left(t^2+\beta\gamma\right)}{-\gamma^2+6\beta k\gamma t+6kt^3}, p_1^* = \frac{6\left(t^2+\beta\gamma\right)\left(kt^2+\beta k\gamma\right)}{-\gamma^2+6\beta k\gamma t+6kt^3},$$
$$p_2^* = \frac{2\left(t^2+\beta\gamma\right)\left(-\gamma^2+3\beta k\gamma t+3kt^3\right)}{t\left(-\gamma^2+6\beta k\gamma t+6kt^3\right)}. \tag{9}$$

i) When $\frac{3\beta\gamma^2+3\gamma t^2+\gamma^2}{6t^3+6\beta\gamma t} < k \le 1$, $q^*$ in Equation (9) is within the feasible region $[0,1]$; thus, $q^*$ and $p_1^*$ in Equation (9) are platform 1's optimal decisions, and $p_2^*$ in Equation (9) is platform 2's optimal decision. Further, we can get

$$N_1^* = \frac{2\beta\gamma^2+6kt^4+3\gamma t^2-\gamma^2 t+6\beta k\gamma t^2}{2t\left(-\gamma^2+6\beta k\gamma t+6kt^3\right)},$$

$$N_2^* = \frac{6kt^4-2\beta\gamma^2-3\gamma t^2-\gamma^2 t+6\beta k\gamma t^2}{2t\left(-\gamma^2+6\beta k\gamma t+6kt^3\right)},$$

$$a_1^* = \frac{3kt\left(t^2+\beta\gamma\right)}{-\gamma^2+6\beta k\gamma t+6kt^3}, \quad a_2^* = \frac{-\gamma^2+3\beta k\gamma t+3kt^3}{-\gamma^2+6\beta k\gamma t+6kt^3},$$

$$\pi_1^* = \frac{9k\left(t^2+\beta\gamma\right)^2\left(-\gamma^2+4\beta k\gamma t+4kt^3\right)}{2\left(-\gamma^2+6\beta k\gamma t+6kt^3\right)^2},$$

$$\pi_2^* = \frac{2\left(t^2+\beta\gamma\right)\left(-\gamma^2+3\beta k\gamma t+3kt^3\right)^2}{t\left(-\gamma^2+6\beta k\gamma t+6kt^3\right)^2}.$$

ii) When $\frac{\gamma^2}{4t^3+4\beta\gamma t} < k \le \frac{3\beta\gamma^2+3\gamma t^2+\gamma^2}{6t^3+6\beta\gamma t}$, $q^*$ in Equation (9) is not in the feasible region $[0,1]$. Substituting $q^*=1$ into Equation (5) and solving, the optimal solutions can be obtained as follows:

$$p_1^* = \frac{3t^2+\gamma+3\beta\gamma}{3t}, \quad p_2^* = \frac{3t^2-\gamma+3\beta\gamma}{3t},$$

$$N_1^* = \frac{3t^3+3t^2+3\beta\gamma t+2\beta\gamma}{6\left(t^2+\beta\gamma\right)t}, \quad N_2^* = \frac{3t^3-3t^2+3\beta\gamma t-2\beta\gamma}{6\left(t^2+\beta\gamma\right)t},$$

$$a_1^* = \frac{3t^2+\gamma+3\beta\gamma}{6\left(t^2+\beta\gamma\right)}, \quad a_2^* = \frac{3t^2-\gamma+3\beta\gamma}{6\left(t^2+\beta\gamma\right)},$$

$$\pi_1^* = \frac{9\beta^2\gamma^2+6\beta\gamma^2+18\beta\gamma t^2-9k\beta\gamma t+\gamma^2+6\gamma t^2+9t^4-9kt^3}{18t\left(t^2+\beta\gamma\right)},$$

$$\pi_2^* = \frac{\left(3t^2-\gamma+3\beta\gamma\right)^2}{18t\left(t^2+\beta\gamma\right)}.$$

2) When $0 < k \le \frac{\gamma^2}{4t^3+4\beta\gamma t}$, $|A| \le 0$, the Hessian matrix in Equation (8) is neither positive nor negative. Since $\pi_1$ is continuous and bounded, and $\pi_1$ has a unique stationary point, the optimal solution may be $q=0$ or $q=1$.

When $q=0$, $\pi_1=\frac{\left(t^2+\beta\gamma\right)^2}{t\left(2t^2+2\beta\gamma\right)}$; when $q=1$, $\pi_1=\frac{9\beta^2\gamma^2+6\beta\gamma^2+18\beta\gamma t^2-9k\beta\gamma t+\gamma^2+6\gamma t^2+9t^4-9kt^3}{18t\left(t^2+\beta\gamma\right)}$. After comparison, it is found that $\pi_1$ is relatively higher when $q=1$. Thus, $q^*=1$.

From the above analysis, Proposition 1 can be obtained.

**Proposition 1** In equilibrium, platform 1's VAS level, platform *i*'s ($i=1,2$) ad price, viewer market share, advertiser market share, and profit are as follows:

a) When $0<k\le\frac{3\beta\gamma^2+3\gamma t^2+\gamma^2}{6t^3+6\beta\gamma t}$, then

$$q^*=1,\quad p_1^*=\frac{3t^2+\gamma+3\beta\gamma}{3t},\quad p_2^*=\frac{3t^2-\gamma+3\beta\gamma}{3t},$$

$$N_1^*=\frac{3t^3+3t^2+3\beta\gamma t+2\beta\gamma}{6\left(t^2+\beta\gamma\right)t},\quad N_2^*=\frac{3t^3-3t^2+3\beta\gamma t-2\beta\gamma}{6\left(t^2+\beta\gamma\right)t},$$

$$a_1^*=\frac{3t^2+\gamma+3\beta\gamma}{6\left(t^2+\beta\gamma\right)},\quad a_2^*=\frac{3t^2-\gamma+3\beta\gamma}{6\left(t^2+\beta\gamma\right)},$$

$$\pi_1^*=\frac{9\beta^2\gamma^2+6\beta\gamma^2+18\beta\gamma t^2-9k\beta\gamma t+\gamma^2+6\gamma t^2+9t^4-9kt^3}{18t\left(t^2+\beta\gamma\right)},$$

$$\pi_2^*=\frac{\left(3t^2-\gamma+3\beta\gamma\right)^2}{18t\left(t^2+\beta\gamma\right)}.$$

b) When $\frac{3\beta\gamma^2+3\gamma t^2+\gamma^2}{6t^3+6\beta\gamma t}<k\le1$, then

$$q^*=\frac{3\gamma\left(t^2+\beta\gamma\right)}{-\gamma^2+6\beta k\gamma t+6kt^3},$$

$$p_1^*=\frac{6\left(t^2+\beta\gamma\right)\left(kt^2+\beta k\gamma\right)}{-\gamma^2+6\beta k\gamma t+6kt^3},\quad p_2^*=\frac{2\left(t^2+\beta\gamma\right)\left(-\gamma^2+3\beta k\gamma t+3kt^3\right)}{t\left(-\gamma^2+6\beta k\gamma t+6kt^3\right)},$$

$$N_1^*=\frac{2\beta\gamma^2+6kt^4+3\gamma t^2-\gamma^2t+6\beta k\gamma t^2}{2t\left(-\gamma^2+6\beta k\gamma t+6kt^3\right)},$$

$$N_2^*=\frac{6kt^4-2\beta\gamma^2-3\gamma t^2-\gamma^2t+6\beta k\gamma t^2}{2t\left(-\gamma^2+6\beta k\gamma t+6kt^3\right)},$$

$$a_1^*=\frac{3kt\left(t^2+\beta\gamma\right)}{-\gamma^2+6\beta k\gamma t+6kt^3},\quad a_2^*=\frac{-\gamma^2+3\beta k\gamma t+3kt^3}{-\gamma^2+6\beta k\gamma t+6kt^3},$$

$$\pi_1^*=\frac{9k\left(t^2+\beta\gamma\right)^2\left(-\gamma^2+4\beta k\gamma t+4kt^3\right)}{2\left(-\gamma^2+6\beta k\gamma t+6kt^3\right)^2},$$

$$\pi_2^*=\frac{2\left(t^2+\beta\gamma\right)\left(-\gamma^2+3\beta k\gamma t+3kt^3\right)^2}{t\left(-\gamma^2+6\beta k\gamma t+6kt^3\right)^2}.$$

From Proposition 1, the two platforms' equilibrium outcomes differ in conditions of $0 < k \le \frac{3\beta\gamma^2 + 3\gamma t^2 + \gamma^2}{6t^3 + 6\beta\gamma t}$ and $\frac{3\beta\gamma^2 + 3\gamma t^2 + \gamma^2}{6t^3 + 6\beta\gamma t} < k \le 1$.

Further, we analyze the effect of marginal cost $k$ on the two platforms' equilibrium outcomes and obtain Corollary 1.

**Corollary 1** In equilibrium, the effect of marginal cost $k$ on platform $i$'s ($i = 1, 2$) ad price, viewer market share, and advertiser market share are as follows:

a) When $0 < k \le \frac{3\beta\gamma^2 + 3\gamma t^2 + \gamma^2}{6t^3 + 6\beta\gamma t}$, then

$$\frac{\partial q^*}{\partial k} = 0, \quad \frac{\partial p_1^*}{\partial k} = 0, \quad \frac{\partial p_2^*}{\partial k} = 0,$$

$$\frac{\partial N_1^*}{\partial k} = 0, \quad \frac{\partial N_2^*}{\partial k} = 0, \quad \frac{\partial a_1^*}{\partial k} = 0, \quad \frac{\partial a_2^*}{\partial k} = 0.$$

b) When $\frac{3\beta\gamma^2 + 3\gamma t^2 + \gamma^2}{6t^3 + 6\beta\gamma t} < k \le 1$, then

$$\frac{\partial q^*}{\partial k} < 0, \quad \frac{\partial p_1^*}{\partial k} < 0, \quad \frac{\partial p_2^*}{\partial k} > 0,$$

$$\frac{\partial N_1^*}{\partial k} < 0, \quad \frac{\partial N_2^*}{\partial k} > 0, \quad \frac{\partial a_1^*}{\partial k} < 0, \quad \frac{\partial a_2^*}{\partial k} > 0.$$

**Proof:** When $0 < k \le \frac{3\beta\gamma^2 + 3\gamma t^2 + \gamma^2}{6t^3 + 6\beta\gamma t}$, then

$$\frac{\partial q^*}{\partial k} = 0, \quad \frac{\partial p_1^*}{\partial k} = 0, \quad \frac{\partial p_2^*}{\partial k} = 0,$$

$$\frac{\partial N_1^*}{\partial k} = 0, \quad \frac{\partial N_2^*}{\partial k} = 0, \quad \frac{\partial a_1^*}{\partial k} = 0, \quad \frac{\partial a_2^*}{\partial k} = 0.$$

When $\frac{3\beta\gamma^2 + 3\gamma t^2 + \gamma^2}{6t^3 + 6\beta\gamma t} < k \le 1$, then

$$\frac{\partial q^*}{\partial k} = \frac{-3\gamma\left(6t^3 + 6\beta\gamma t\right)\left(t^2 + \beta\gamma\right)}{\left(-\gamma^2 + 6\beta k\gamma t + 6kt^3\right)^2} < 0,$$

$$\frac{\partial p_1^*}{\partial k} = \frac{-6\gamma^2\left(t^2 + \beta\gamma\right)^2}{\left(-\gamma^2 + 6\beta k\gamma t + 6kt^3\right)^2} < 0, \quad \frac{\partial p_2^*}{\partial k} = \frac{6\gamma^2\left(t^2 + \beta\gamma\right)^2}{\left(-\gamma^2 + 6\beta k\gamma t + 6kt^3\right)^2} > 0,$$

$$\frac{\partial N_1^*}{\partial k} = \frac{-3\gamma\left(3t^2 + 2\beta\gamma\right)\left(t^2 + \beta\gamma\right)}{\left(-\gamma^2 + 6\beta k\gamma t + 6kt^3\right)^2} < 0, \quad \frac{\partial N_2^*}{\partial k} = \frac{3\gamma\left(3t^2 + 2\beta\gamma\right)\left(t^2 + \beta\gamma\right)}{\left(-\gamma^2 + 6\beta k\gamma t + 6kt^3\right)^2} > 0,$$

$$\frac{\partial a_1^*}{\partial k} = \frac{-\left(3\gamma^2 t\left(t^2 + \beta\gamma\right)\right)}{\left(-\gamma^2 + 6\beta k\gamma t + 6kt^3\right)^2} < 0, \quad \frac{\partial a_2^*}{\partial k} = \frac{3\gamma^2 t\left(t^2 + \beta\gamma\right)}{\left(-\gamma^2 + 6\beta k\gamma t + 6kt^3\right)^2} > 0.$$

It follows that Corollary 1 holds. □

From Proposition 1, the effect of marginal cost $k$ on the equilibrium outcomes is different under the two conditions of $0 < k \le \frac{3\beta\gamma^2 + 3\gamma t^2 + \gamma^2}{6t^3 + 6\beta\gamma t}$ and $\frac{3\beta\gamma^2 + 3\gamma t^2 + \gamma^2}{6t^3 + 6\beta\gamma t} < k \le 1$. Specifically, when $0 < k \le \frac{3\beta\gamma^2 + 3\gamma t^2 + \gamma^2}{6t^3 + 6\beta\gamma t}$, platform 1's VAS level, as well as both platforms' ad prices, viewer market shares, and advertiser market shares, are not affected by the marginal cost. When $\frac{3\beta\gamma^2 + 3\gamma t^2 + \gamma^2}{6t^3 + 6\beta\gamma t} < k \le 1$, platform 1's VAS level, ad price, viewer market share, and advertiser market share decrease with the marginal cost; platform 2's ad price, viewer market share, and advertiser market share increase with the marginal cost.

The impact of the marginal cost $k$ on platform 1's VAS level may be interpreted as follows. When $0 < k \le \frac{3\beta\gamma^2 + 3\gamma t^2 + \gamma^2}{6t^3 + 6\beta\gamma t}$, the cost of the platform investing in VASs for viewers is low; therefore, the optimal VAS level invested by platform 1 is always maintained at the maximum, i.e. $q^* = 1$. When $\frac{3\beta\gamma^2 + 3\gamma t^2 + \gamma^2}{6t^3 + 6\beta\gamma t} < k \le 1$, the cost of the platform investing in VASs for viewers is high; therefore, the VAS level invested by platform 1 decreases with the marginal cost.

Based on Proposition 1, we also analyze the positive effect of viewers $\gamma$ on the equilibrium outcomes, and we obtain Corollary 2.

**Corollary 2** In equilibrium, the effect of the positive effect of viewers $\gamma$ on platform $i$'s ($i = 1,2$) ad price, viewer market share, and advertiser market share are as follows:

a) When $0 < k \le \frac{3\beta\gamma^2 + 3\gamma t^2 + \gamma^2}{6t^3 + 6\beta\gamma t}$, then

$$\frac{\partial q^*}{\partial \gamma} = 0;\ \frac{\partial p_1^*}{\partial \gamma} > 0;\ \frac{\partial p_2^*}{\partial \gamma} \le 0 \text{ if } 0 < \beta \le \frac{1}{3}, \text{ and } \frac{\partial p_2^*}{\partial \gamma} > 0$$
$$\text{if } \frac{1}{3} < \beta \le 1;\ \frac{\partial N_1^*}{\partial \gamma} < 0;\ \frac{\partial N_2^*}{\partial \gamma} > 0;\ \frac{\partial a_1^*}{\partial \gamma} > 0;\ \frac{\partial a_2^*}{\partial \gamma} < 0.$$

b) When $\frac{3\beta\gamma^2 + 3\gamma t^2 + \gamma^2}{6t^3 + 6\beta\gamma t} < k \le 1$, then

$$\frac{\partial q^*}{\partial \gamma} > 0;\ \frac{\partial p_1^*}{\partial \gamma} > 0;\ \frac{\partial p_2^*}{\partial \gamma} \ge 0 \text{ if } 0 \le \gamma \le \gamma_1,\ \frac{\partial p_2^*}{\partial \gamma} < 0 \text{ if } \gamma_1 < \gamma \le 1;$$
$$\frac{\partial N_1^*}{\partial \gamma} > 0;\ \frac{\partial N_2^*}{\partial \gamma} < 0;\ \frac{\partial a_1^*}{\partial \gamma} > 0;\ \frac{\partial a_2^*}{\partial \gamma} < 0,$$

where

$$\begin{aligned} f(\gamma_1) = {} & (2\beta)\gamma_1^4 + ((-24)\beta^2 kt)\gamma_1^3 + (36\beta^3 k^2 t^2 - 36\beta kt^3)\gamma_1^2 \\ & + (72\beta^2 k^2 t^4 - 12kt^5)\gamma_1 + 36\beta k^2 t^6 \end{aligned}.$$

**Proof:** When $0 < k \le \frac{3\beta\gamma^2 + 3\gamma t^2 + \gamma^2}{6t^3 + 6\beta\gamma t}$, then

$$\frac{\partial q^*}{\partial \gamma} = 0, \quad \frac{\partial p_1^*}{\partial \gamma} = \frac{3\beta + 1}{3t}, \quad \frac{\partial p_2^*}{\partial \gamma} = \frac{3\beta - 1}{3t}, \quad \frac{\partial N_1^*}{\partial \gamma} = \frac{-\beta t}{6\left(t^2 + \beta\gamma\right)^2},$$

$$\frac{\partial N_2^*}{\partial \gamma} = \frac{\beta t}{6\left(t^2 + \beta\gamma\right)^2}, \quad \frac{\partial a_1^*}{\partial \gamma} = \frac{t^2}{6\left(t^2 + \beta\gamma\right)^2}, \quad \frac{\partial a_2^*}{\partial \gamma} = \frac{-t^2}{6\left(t^2 + \beta\gamma\right)^2}.$$

When $\frac{3\beta\gamma^2 + 3\gamma t^2 + \gamma^2}{6t^3 + 6\beta\gamma t} < k \le 1$, then

$$\frac{\partial q^*}{\partial \gamma} = \frac{3t\left(6k\beta^2\gamma^2 + 12k\beta\gamma t^2 + \gamma^2 t + 6kt^4\right)}{\left(-\gamma^2 + 6\beta k\gamma t + 6kt^3\right)^2},$$

$$\frac{\partial p_1^*}{\partial \gamma} = \frac{12kt\left(t^2 + \beta\gamma\right)\left(3k\gamma\beta^2 + 3k\beta t^2 + \gamma t\right)}{\left(-\gamma^2 + 6\beta k\gamma t + 6kt^3\right)^2},$$

$$\frac{\partial p_2^*}{\partial \gamma} = \frac{2\left(18\beta^3k^2\gamma^2t^2 + 36\beta^2k^2\gamma t^4 - 12\beta^2k\gamma^3t + 18\beta k^2t^6 - 18\beta k\gamma^2t^3 + \beta\gamma^4 - 6k\gamma t^5\right)}{t\left(-\gamma^2 + 6\beta k\gamma t + 6kt^3\right)^2},$$

$$\frac{\partial N_1^*}{\partial \gamma} = \frac{2k\left(6\beta^2\gamma^2 + 12\beta\gamma t^2 + 9t^4\right) + 3\gamma^2 t}{2\left(-\gamma^2 + 6\beta k\gamma t + 6kt^3\right)^2},$$

$$\frac{\partial N_2^*}{\partial \gamma} = \frac{-3\left(4k\beta^2\gamma^2 + 8k\beta\gamma t^2 + \gamma^2 t + 6kt^4\right)}{2\left(-\gamma^2 + 6\beta k\gamma t + 6kt^3\right)^2},$$

$$\frac{\partial a_1^*}{\partial \gamma} = \frac{-3k\gamma t\left(2t^2 + \beta\gamma\right)}{\left(-\gamma^2 + 6\beta k\gamma t + 6kt^3\right)^2}, \quad \frac{\partial a_2^*}{\partial \gamma} = \frac{-3k\gamma t\left(2t^2 + \beta\gamma\right)}{\left(-\gamma^2 + 6\beta k\gamma t + 6kt^3\right)^2}.$$

Under the assumptions in Section 3, we can obtain Corollary 2 based on the above equations. □

From Corollary 2, the effect of the positive effect of viewers on the equilibrium outcome is different for the conditions of $0 < k \le \frac{3\beta\gamma^2 + 3\gamma t^2 + \gamma^2}{6t^3 + 6\beta\gamma t}$ and $\frac{3\beta\gamma^2 + 3\gamma t^2 + \gamma^2}{6t^3 + 6\beta\gamma t} < k \le 1$.

Corollary 2(a) captures the effect of the positive effect of viewers on the equilibrium outcomes in the condition of $0 < k \le \frac{3\beta\gamma^2 + 3\gamma t^2 + \gamma^2}{6t^3 + 6\beta\gamma t}$. For platform 1, its VAS level is independent of the positive effect of viewers, its ad price and advertiser market share increase with the positive effect, and its viewer market share decreases with the positive effect. For platform 2, as the positive effect of viewers increases, its ad price decreases if the negative effect of advertisers is low and increases if the negative effect is high; its viewer market share and advertiser market share increase and decrease, respectively.

Corollary 2(b) captures the effect of the positive effect of viewers $\gamma$ on equilibrium outcomes in the condition of $\frac{3\beta\gamma^2+3\gamma t^2+\gamma^2}{6t^3+6\beta\gamma t}<k\le 1$. For platform 1, as the positive effect of viewers increases, its VAS level, ad price, viewer market share, and advertiser market share increase. For platform 2, as the positive effect of viewers increases, its ad price increases and then decreases, and its viewer and advertiser market shares decrease.

## 5. Equilibrium Comparisons

This section compares the difference in equilibrium outcomes between the investment and non-investment platforms in the situation with investment, as well as the difference in equilibrium outcomes between the investment platform in the situations with and without investment.

### 5.1. Comparison between Investment and Non-Investment Platforms

Based on Proposition 1, we analyze the differences in ad prices, viewer market shares, and advertiser market shares between the two platforms in the situation with investment, drawing Corollary 3.

**Corollary 3** In equilibrium, the comparison between the investment and non-investment platforms in terms of ad price, viewer market share, and advertiser market share is as follows:

$$\forall c\in[0,1],\quad p_1^*>p_2^*,\quad N_1^*>N_2^*,\quad a_1^*>a_2^*.$$

**Proof:** When $0<k\le\frac{3\beta\gamma^2+3\gamma t^2+\gamma^2}{6t^3+6\beta\gamma t}$, then

$$p_1^*-p_2^*=\frac{2\gamma}{3t}>0,\quad N_1^*-N_2^*=\frac{3t^2+2\beta\gamma}{3t\left(t^2+\beta\gamma\right)}>0,\quad a_1^*-a_2^*=\frac{\gamma}{3\left(t^2+\beta\gamma\right)}>0.$$

When $\frac{3\beta\gamma^2+3\gamma t^2+\gamma^2}{6t^3+6\beta\gamma t}<k\le 1$, then

$$p_1^*-p_2^*=\frac{2\gamma^2\left(t^2+\beta\gamma\right)}{t\left(-\gamma^2+6\beta k\gamma t+6kt^3\right)}>0,$$

$$N_1^*-N_2^*=\frac{\gamma\left(3t^2+2\beta\gamma\right)}{t\left(-\gamma^2+6\beta k\gamma t+6kt^3\right)}>0,\quad a_1^*-a_2^*=\frac{\gamma^2}{-\gamma^2+6\beta k\gamma t+6kt^3}>0.$$

It follows that Corollary 3 holds. □

Corollary 3 shows that platform 1's ad price, viewer market share, and advertiser market share are higher than platform 2's. The logic behind this result is as follows: since platform 1 can bring not only content but also VASs to viewers, while platform 2 can only bring content to viewers; therefore, viewers' utility and demand for platform 1 are higher than that for platform 2. Indirectly, due to the positive effect of viewers, advertisers' demand for platform 1 is also higher than that for platform 2, and at the same time, platform 1's ad price is higher than platform 2's.

### 5.2. Comparison of Situations with and without Investment

This section compares the investment platform's equilibrium outcomes in situations with and without investment. Prior to the comparison, we perform an equilibrium analysis in the situation without investment and obtain the corresponding equilibrium outcomes (see the proof of Corollary 5). Further, we compare the investment platform's outcomes in two situations and obtain Corollary 5.

**Corollary 4** The differences in platform 1's equilibrium outcomes between situations with and without investment are as follows:

$$\forall c \in [0,1],\ p_1^* > p_{1W}^*,\ N_1^* > N_{1W}^*,\ a_1^* > a_{1W}^*.$$

**Proof:** In the situation with investment, viewers' utility on platform $i$ is $u_{iW} = v_0 - \beta a_{iW} - t|x - x_i|$ where $W$ denotes the situation without investment; advertiser's utility on platform $i$ is $U_{iW} = V_0 + \gamma N_{iW} - t|y - y_i|$; platform $i$'s profit is $\pi_{iW} = p_{iW} a_{iW}$. Similar to the equilibrium analysis in the situation with investment, the equilibrium analysis in the situation without investment is also carried out, and the following equilibrium outcomes are obtained:

$$p_{1W}^* = \frac{t^2+\beta\gamma}{t},\ p_{2W}^* = \frac{t^2+\beta\gamma}{t},\ N_{1W}^* = \frac{1}{2},\ N_{2W}^* = \frac{1}{2},$$

$$a_{1W}^* = \frac{1}{2},\ a_{2W}^* = \frac{1}{2},\ \pi_{1W}^* = \frac{\left(t^2+\beta\gamma\right)^2}{t\left(2t^2+2\beta\gamma\right)},\ \pi_{2W}^* = \frac{\left(t^2+\beta\gamma\right)^2}{t\left(2t^2+2\beta\gamma\right)}.$$

When $0 < k \le \frac{3\beta\gamma^2+3\gamma t^2+\gamma^2}{6t^3+6\beta\gamma t}$, then $p_1^* - p_{1W}^* = \frac{\gamma}{3t} > 0$, $N_1^* - N_{1W}^* = \frac{3t^2+2\beta\gamma}{6t\left(t^2+\beta\gamma\right)} > 0$, $a_1^* - a_{1W}^* = \frac{\gamma}{6\left(t^2+\beta\gamma\right)} > 0$.

When $\frac{3\beta\gamma^2+3\gamma t^2+\gamma^2}{6t^3+6\beta\gamma t} < k \le 1$, then $p_1^* - p_{1W}^* = \frac{\gamma^2\left(t^2+\beta\gamma\right)}{t\left(-\gamma^2+6\beta k\gamma t+6kt^3\right)} > 0$, $N_1^* - N_{1W}^* = \frac{\gamma\left(3t^2+2\beta\gamma\right)}{2t\left(-\gamma^2+6\beta k\gamma t+6kt^3\right)} > 0$, $a_1^* - a_{1W}^* = \frac{\gamma^2}{2\left(-\gamma^2+6\beta k\gamma t+6kt^3\right)} > 0$.

It follows that Corollary 4 holds. □

Corollary 4 suggests that platform 1's ad price, viewer market share, and advertiser market share are higher in the situation with investment than in the situation without investment. However, platform 2's ad price, viewer market share, and advertiser market share are lower in the situation with investment than in the situation without investment.

## 6. Conclusion

This paper investigates duopoly video platforms' VAS investment strategies for viewers and ad pricing strategies. The conclusions are as follows: 1) When the marginal cost is low, the investment platform's VAS level and ad price, as well as the non-investment platform's ad price are independent of the marginal cost. 2) The impact of the positive effect of viewers on VAS investment strategies and ad pricing strategies is related to the value of the marginal cost. If the marginal cost is low, the investment platform's VAS level is independent of the positive effect of viewers, and its ad price increases with the positive effect; the non-investment platform's ad price decreases with the positive effect when the negative effect of advertisers is low and increases with the positive effect when the negative effect is high. If the marginal cost is high, the investment platform's VAS level and ad price increase with the positive effect of viewers, while the non-investment platform's ad price first increases and then decreases with the positive effect. 3) The investment platform's ad price is higher than the non-investment platform's. 4) The investment platform's ad price is higher in the situation with investment than in the situation without investment.

This study has important management implications for a video platform regarding setting VAS investment strategies. The video platform needs to consider the impact of positive effects of viewers on VAS investment strategies only when the marginal cost is high. Specifically, when the marginal cost is high, the video platform should increase the VAS level as the positive effect of viewers increases. This study also has important management implications for a video platform regarding setting ad pricing strategies. The video platform should increase the ad price as the positive effect of viewers increases.

The conclusions of this paper enrich the research of platform investment strategies by illustrating how video platforms should develop VAS investment strategies. The conclusions also enrich the research of media platform pricing strategies by illustrating how video platforms should develop ad pricing strategies while investing in VASs for viewers.

Our study has two major limitations that point to future research. 1) This paper assumes that viewers are single-homing, while in reality, viewers may obtain content from multiple platforms, i.e., viewers are multi-homing. Therefore, future research will explore video platforms' VAS investment and pricing strategies based on the assumption that advertisers are multi-homing. 2) This paper only considers the case that video platforms invest in VASs for viewers, while in reality, video platforms not only invest in VASs for viewers, but also invest in VASs for advertisers. Therefore, future research will investigate video platforms' VAS investment and pricing strategies in the case of platforms investing in VASs for viewers and advertisers.

## Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

## References

Dietl, H., Lang, M., & Lin, P. (2013). Advertising Pricing Models in Media Markets:

Lump-Sum versus Per-Consumer Charges. *Information Economics and Policy, 25,* 257-271. https://doi.org/10.1016/j.infoecopol.2013.06.003

Dimakopoulos, P. D., & Sudaric, S. (2018). Privacy and Platform Competition. *International Journal of Industrial Organization, 61,* 686-713. https://doi.org/10.1016/j.ijindorg.2018.01.003

Dou, G., & He, P. (2017). Value-Added Service Investing and Pricing Strategies for a Two-Sided Platform under Investing Resource Constraint. *Journal of Systems Science and Systems Engineering, 26,* 609-627. https://doi.org/10.1007/s11518-016-5319-z

Dou, G., He, P., & Xu, X. (2016). One-Side Value-Added Service Investment and Pricing Strategies for a Two-Sided Platform. *International Journal of Production Research, 54,* 3808-3821. https://doi.org/10.1080/00207543.2016.1148275

Gui, Y., Liu, D., & Gong, B. (2021). Investment Strategy and Evolution Analysis on Value-Added Service of Logistics Information Platform. *Journal of Southwest Jiaotong University, 56,* 1-8.

Gui, Y., Wu, Z., & Gong, B. (2019). Value-Added Service Investment Decision of B2C Platform in Competition. *Control and Decision, 34,* 395-405.

Hagiu, A., & Spulber, D. (2013). First-Party Content and Coordination in Two-Sided Markets. *Management Science, 59,* 933-949. https://doi.org/10.1287/mnsc.1120.1577

Kerkhof, A., & Münster, J. (2015). Quantity Restrictions on Advertising, Commercial Media Bias, and Welfare. *Journal of Public Economics, 131,* 124-141. https://doi.org/10.1016/j.jpubeco.2015.09.004

Kodera, T. (2015). Discriminatory Pricing and Spatial Competition in Two-Sided Media Markets. *The B.E. Journal of Economic Analysis & Policy, 15,* 891-926. https://doi.org/10.1515/bejeap-2013-0178

Lei, H., & Xiong, D. (2018). Research on the Influence of Two-Sided Platform's Investment Behavior on the Equilibrium of Competitive Market. *Business and Management Journal, 40,* 134-151.

Lin, S. (2020). Two-Sided Price Discrimination by Media Platforms. *Marketing Science, 39,* 317-338. https://doi.org/10.1287/mksc.2019.1211

Lin, X., Hou, R., & Zhou, Y. (2020). Platform Competition for Advertisers and Viewers in Media Markets with Endogenous Content and Advertising. *Journal of Systems Science and Systems Engineering, 29,* 36-54. https://doi.org/10.1007/s11518-019-5439-3

Pan, L. (2017). Endogenous Choice on Advertising Pricing of Media Platforms: Lump-Sum Fee vs. Proportional Fee. *Hitotsubashi Journal of Economics, 58,* 21-40.

Reisinger, M. (2012). Platform Competition for Advertisers and Users in Media Markets. *International Journal of Industrial Organization, 30,* 243-252. https://doi.org/10.1016/j.ijindorg.2011.10.002

Wang, W. Y., & Lobato, R. (2019). Chinese Video Streaming Services in the Context of Global Platform Studies. *Chinese Journal of Communication, 12,* 356-371. https://doi.org/10.1080/17544750.2019.1584119

Yang, Z., Diao, Z., & Kang, J. (2020). Customer Management in Internet-Based Platform Firms: Review and Future Research Directions. *Marketing Intelligence & Planning, 38,* 957-972. https://doi.org/10.1108/MIP-01-2020-0012

Zhang, Q., & Dong, X. (2018). Pricing Strategy of Internet Platform Providing Value-Added Services. *Systems Engineering, 36,* 47-54.