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Pricing strategy selection for content platforms considering cash subsidies

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Abstract: Three pricing strategy models—free, charge, and cash subsidy—are constructed for content platforms in a multilateral market based on the game theory. The optimal pricing strategy for a platform is identified by comparing the parameters under each pricing strategy. The results reveal that ad interference cost and ad marginal revenue affect a platform's pricing strategy selection and the cash subsidy amount. The cash subsidy strategy is used when both are within a certain range of thresholds; the charge strategy is adopted when the ad interference cost is very high; and the free strategy is adopted in other cases. In addition, under the cash subsidy strategy, the amount of cash subsidy is negatively correlated to ad interference cost and positively related to ad marginal revenue. Under the same conditions, adopting the cash subsidy strategy is better for all stakeholders and social welfare than the other two pricing schemes. Moreover, ad marginal revenue affects some parameters in the cash subsidy strategy and the free strategy in opposite directions.

Key words: content platform; pricing strategy; choice; charge; free; cash subsidy

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Multilateral platforms that connect consumers, advertisers, and content suppliers are common in the content platform industry (hereinafter platforms). Platforms receive videos or texts from content producers, and customers view ads as they receive information. Advertising fees are a significant source of revenue for platforms[1–2]. The platforms under consideration in this study refer to mobile apps that accomplish functions such as reading text, watching movies, listening to books, and receiving news or social information[3–4], which generally use either a free strategy or a fee-charging strategy (charge strategy). Examples of platforms that offer free plans to users include Tencent Weibo, WeChat Moment, and Sohu News. On the other hand, Himalaya and Youku charge a membership fee but offer ad-free services[5–6].

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However, as e-commerce develops, an increasing number of content platforms, such as Toutiao, Baidu, iQIYI, TikTok, Kwai, and Sina Weibo, offer financial incentives to draw in sinking markets[7]. This strategy provides consumers cash subsidies in the form of gold coins or red envelopes that may be withdrawn if they reach a certain value. It benefits the content platform by increasing the number of consumers and their retention[8–9]. Thus, platforms can be categorized as using cash subsidy, free, or charge strategy—three cohabitation strategies. It is worthwhile to explore how to choose a pricing strategy under the premise of profit maximization.

This study is connected to the literature on content platform pricing strategies and consumer subsidies. The topic of consumer subsidies has been studied by numerous scholars. According to Refs. [10 – 11], two-sided markets have cross-network externalities, and the revenue gained by users on one side of the platform grows with the number of users on the other side[10–11]. Furthermore, Caillaud and Jullien claimed that two-sided market pricing has a "divide and conquer" tendency. Free pricing or even subsidies are provided to one side to expand the number of users and persuade the other side to join, while high prices are set to compensate for the loss generated by free products or subsidies[11]. However, until recently, platforms have used free or low-cost tactics to subsidize users[12–13]. Further, platforms offered consumers positive financial subsidies—that is, cash subsidies—as a means of attracting users in the sinking market.

Some academics are interested in the problem of cash subsidies. For example, Wang and Xin[8] discussed the common phenomenon of price subsidies in the bilateral market and discovered that subsidies increased platform scale but decreased platform profit, which is a transitional strategy in the early formation stage of the bilateral market. Wang et al.[14] investigated the economic compensation provided to users by advertising agencies for privacy violations and discovered that the utility of all organizations involved increased. Zhang[9] investigated the pricing model under monopoly and competition and concluded that it is reasonable for the media to use the reverse incentive pricing approach to maximize profit.

Several scholars have also investigated pricing strategy selection for platforms. The studies can be broadly classified into 1) free or charge[12,15–16]; 2) free or freemium[17–18]; 3) free, charge, or freemium[13]; 4) unilateral or bilateral fee-based[19–20]; and 5) switching challenges of pricing models[1,16]. Other aspects to examine are audi-

ence size[12], information disclosure level[19], social effect[17], service or content quality[13, 17, 20], and advertising interference[15, 18].

In this regard, Carroni and Paolini[12] noticed that platforms choose a pure subscription revenue model after the audience size reaches a threshold and that platforms are motivated to enhance advertising intensity and quality upgrades as audience numbers grow. Li et al.[17] observed that when paid service quality is too low (too high), advertising (freemium) methods predominate on every platform. Chi et al.[18] revealed that a platform should select the advertising model if user interference costs are low and the strength of cross-network externalities is large; otherwise, the hybrid model should be selected. According to Duan et al.[19], if a platform employs a bilateral pricing strategy, it can strategically decide on price depending on the extent of information sharing. When choosing the best pricing strategy for monopolistic media for unilateral and bilateral charging, Cheng[20] discovered that the relative value ratio effect index between advertisers and consumers plays a role. Additionally, Huotari and Ritala[16] indicated that varying between a subscription-based business model and an ad-sponsored business model yields more lifecycle revenue than continuously employing only one business model.

Although the research findings offer significant theoretical frameworks and research directions for the development of pricing strategies in content bilateral marketplaces, the aforementioned literature is not without flaws. First, there are not many academic publications on the cash subsidy strategy and even fewer on the requirements for adopting the strategy, the size of the cash subsidy, and the factors influencing it. Second, regarding using the cash subsidy strategy as a pricing model, there are not many books or articles that explain how to choose a pricing strategy on a platform. Furthermore, research contrasting the three pricing strategies of charge, free, and cash subsidies is scarce.

Because of the aforementioned flaws, this study refers to the research frameworks of Chi et al.[18] and Dietl et al.[21] to investigate the free and fee-based models. It develops three pricing models—free, charge, and cash subsidy strategy—and compares their pricing strategies. It also investigates the problem of selecting pricing strategies for platforms and factors affecting the level of cash subsidies and analyzes the differences between the cash subsidy and the other two strategies in terms of ad price, content cost, number of ads, number of consumers, consumer surplus, advertiser surplus, and social welfare.

This study is innovative in that 1) it argues that the cash subsidy strategy is not only a transition strategy during the early stages of market development but also an established pricing strategy like free and charge, and 2) it compares the three pricing strategies and examines the selection of pricing strategies.

1 Models Setup

In this study, platforms link content providers, consumers, and advertisers. The platform's content is provided by the content provider, and consumers access it to satisfy their needs for information and entertainment. Moreover, the platform sets up an advertising space where businesses can place advertisements for goods or services to draw in customers.

In this study, we examine a monopolistic content market with just one content firm. The set of possible pricing strategies consists of $i = \{\mathrm{m}, \mathrm{f}, \mathrm{c}\}$, where m represents charge strategy; f denotes free strategy; and c indicates cash subsidy strategy. The consumer pays a subscription price P^{m} while obtaining an ad-free service under the charge strategy[20] (see Fig. 1(a)). The advertiser pays the platform an ad price $P_{\mathrm{a}}^{\mathrm{f}}$, while the consumer receives the platform's content with ads in the free strategy[20] (see Fig. 1(b)). In the cash subsidy strategy[8] (see Fig. 1(c)), the platform pays the customer a cash subsidy c while charging advertisers an advertising cost $P_{\mathrm{a}}^{\mathrm{c}}$. Furthermore, the platform's content cost to content providers in each strategy is P_{s}^{i}, and the number of platform users and advertisers are n_{u}^{i} and n_{a}^{i}, respectively.

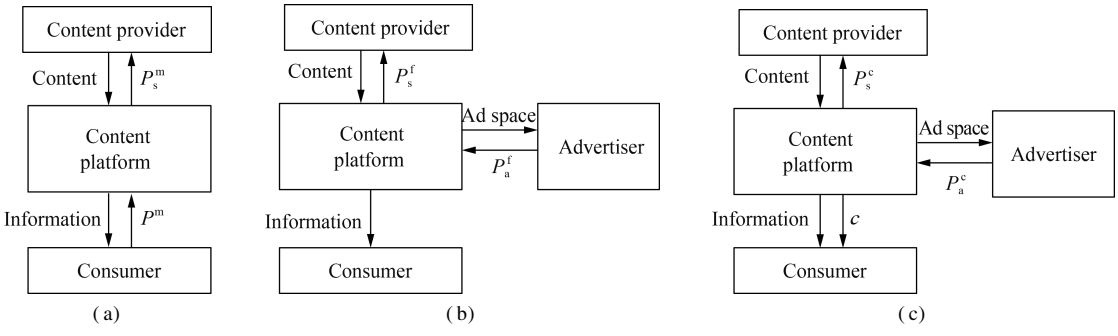

Fig. 1 Three pricing strategies on a platform. (a) Charge strategy; (b) Free strategy; (c) Cash subsidy strategy

Based on the studies by Peitz and Valletti[15] and Chi et al.[18], the following hypotheses are presented in this study: 1) as each advertiser may only place one ad on a platform, the number of advertisers equals the ad number; 2) consumers dislike all ads, and each advertisement has the same interference cost; and 3) content providers and the information they provide are all homogeneous.

1.1 Charge strategy

According to Dietl et al.[21], the utility function of customers under the charging strategy can be expressed as

$$U_u^m = \theta v + \lambda N - P^m \quad (1)$$

where v is often referred to as the value users receive from the platform, and θ is a measure of how much the platform users enjoy its content. Consumers' levels of preference for the platform's content vary; hence, it is assumed that $\theta \sim U[0,1]$ and θv represent the value utility attained by consumers who have a preference level of θ for the platform. Thus, the platform has full market coverage if v is large enough for all possible viewers to be likely to enroll. λ is the strength of cross-network externalities, and N is the number of content providers. Consumers only utilize the platform if $U_u^m \geqslant 0$ is true. The consumer demand function is given as $n_u^m = \dfrac{v + \lambda N - P^m}{v}$.

Content suppliers offer varying levels of material and payment mechanisms. A content provider first pays a platform occupancy fee, which is paid in the following ways: 1) consumers purchase the content directly from the platform; 2) consumers pay a subscription fee to the platform, and the platform pays the charge based on consumers' access; and 3) the platform purchases the content's copyright and pays the fee to the content provider in advance. Referring to Chi et al. [18], to simplify the model for this study, it is assumed that the platform pays a content provider according to the number of viewers who access the content; thus, the more views a piece of content receives, the more money the content provider gets.

The content provider's utility function is as follows:

$$U_s^m = P_s^m \alpha n_u^m - s \quad (2)$$

where s is the creation cost, and α is the probability that the content is viewed[18]. When the content provider's utility $U_s^m \geqslant 0$, the content provider delivers platform content.

Therefore, the anticipated profit maximization model of the content platform when the platform implements the charge strategy is as follows:

$$\begin{aligned} &\max \pi^m(P^m, P_s^m) = P^m n_u^m - P_s^m \alpha n_u^m N \\ &\text{s.t. } P_s^m \alpha n_u^m - s \geqslant 0 \end{aligned} \quad (3)$$

Proposition 1 is produced by solving the aforementioned optimization model.

Proposition 1 Once a platform employs the charge strategy, the maximum profit obtained by the platform is $\pi^{m*} = \dfrac{(v+N\lambda)^2}{4v} - Ns$; the subscription fee is $P^{m*} = \dfrac{v+N\lambda}{2}$; the number of consumers is $n_u^{m*} = \dfrac{v+N\lambda}{2v}$; the content cost is $P_s^{m*} = \dfrac{2vs}{v\alpha + N\alpha\lambda}$; the consumer surplus is $C_s^m = \dfrac{(v+N\lambda)^2}{8v}$; and the social welfare is $S_w^m = \dfrac{3(v+N\lambda)^2}{8v} - Ns$.

1.2 Free strategy

The utility function for consumers under the free strategy can be expressed as follows:

$$U_u^f = \theta v + \lambda N - \gamma n_a^f \quad (4)$$

where γ is the ad interference cost. When $U_u^f \geqslant 0$, consumers will use the platform. At this point, the demand function of the platform consumers is $n_u^f = \dfrac{v - \gamma n_a^f + \lambda N}{v}$.

Advertisers are typically product or service manufacturers who hope to attract potential buyers by advertising on platforms. According to Chi et al. [18], an advertiser's utility function might be stated as follows:

$$U_a^f = (\beta - P_a^f) n_u^f - \eta \quad (5)$$

where η is the heterogeneity of the advertisement, which can be viewed as the heterogeneity of the advertisement production cost[15, 18]. It is assumed that it is distributed equally across the interval $[0, 1]$. β is the ad marginal revenue[18]. Advertisers will display advertisements on the platform when $U_a^f \geqslant 0$. The demand function for platform advertisers is $n_a^f = n_u^f(\beta - P_a^f)$.

Platform content providers have the following utility function:

$$U_s^f = P_s^f \alpha n_u^f - s \quad (6)$$

If $U_s^f \geqslant 0$, they supply material for the content platform.

The expected profit-maximizing model of a platform when it chooses the free strategy is as follows:

$$\begin{aligned} &\max \pi^f(P_a^f, P_s^f) = P_a^f n_u^f n_a^f - P_s^f \alpha n_u^f N \\ &\text{s.t. } P_s^f \alpha n_u^f - s \geqslant 0 \end{aligned} \quad (7)$$

By solving the aforementioned optimization model, Proposition 2 is obtained.

Proposition 2 When the platform utilizes the free strategy, it generates a maximum profit of $\pi^{f*} = \dfrac{\beta^2(v+N\lambda)^2}{4v(v+\beta\gamma)} - Ns$; the ad price is $P_a^{f*} = \dfrac{\beta(v+\beta\gamma)}{2v+\beta\gamma}$; the content cost is $P_s^{f*} = \dfrac{2v(v+\beta\gamma)s}{\alpha(2v+\beta\gamma)(v+N\lambda)}$; the number of consumers is $n_u^{f*} = \dfrac{(2v+\beta\gamma)(v+N\lambda)}{2v(v+\beta\gamma)}$; the number of ads is $n_a^{f*} = \dfrac{\beta(v+N\lambda)}{2(v+\beta\gamma)}$; the consumer surplus is $C_s^f = \dfrac{(2v+\beta\gamma)^2(v+N\lambda)^2}{8v(v+\beta\gamma)^2}$; the advertiser surplus is $A_s^f = \dfrac{\beta^2(v+N\lambda)^2}{8(v+\beta\gamma)^2}$; and the social welfare is $S_w^f = \dfrac{(4v^2+\beta^2\gamma(2\beta+\gamma)+v\beta(3\beta+4\gamma))(v+N\lambda)^2}{8v(v+\beta\gamma)^2} - Ns$.

1.3 Cash subsidy strategy

When the platform adopts the cash subsidy strategy, the utility function of the consumer may be indicated as follows:

$$U_u^c = \theta v + \lambda N - \gamma n_a^c + c \quad (8)$$

where c is the subsidy that the consumer obtains from the

platform. Consumers use the platform only when $U_u^c \geqslant 0$. Here, the demand function of the platform users is $n_u^c = \frac{v - \gamma n_a^c + \lambda N + c}{v}$.

The utility function for advertisers can be expressed as follows:

$$U_a^c = (\beta - P_a^c) n_u^c - \eta \tag{9}$$

When $U_a^c \geqslant 0$, advertisers use the platform. The advertiser demand function of the content platform is $n_a^c = n_u^c(\beta - P_a^c)$.

A platform content provider's utility function is as follows:

$$U_s^c = P_s^c \alpha n_u^c - s \tag{10}$$

In the absence of the content provider utility $U_s^c \geqslant 0$, the content provider does not supply content to the platform.

The intended profit maximization model for the platform when it implements the cash subsidy strategy is as follows:

$$\begin{aligned} \max \pi^c(P_a^c, P_s^c, c) &= P_a^c n_u^c n_a^c - P_s^c \alpha n_u^c N - c n_u^c \\ \text{s.t. } & P_s^c \alpha n_u^c - s \geqslant 0 \end{aligned} \tag{11}$$

When the profit optimization model is solved, Proposition 3 is revealed.

Proposition 3 Upon employing the cash subsidy strategy, the maximum profit of the platform is $\pi^{c*} = \frac{(v + N\lambda)^2}{4v - (\beta - \gamma)^2} - Ns$; the ad price is $P_a^{c*} = \frac{\beta + \gamma}{2}$; the content cost is $P_s^{c*} = \frac{(4v - (\beta - \gamma)^2)s}{2\alpha(v + N\lambda)}$; the cash subsidy is $c^* = \frac{(\beta(\beta - \gamma) - 2v)(v + N\lambda)}{4v - (\beta - \gamma)^2}$; the number of consumers is $n_u^{c*} = \frac{2(v + N\lambda)}{4v - (\beta - \gamma)^2}$; the number of ads is $n_a^{c*} = \frac{(\beta - \gamma)(v + N\lambda)}{4v - (\beta - \gamma)^2}$; the consumer surplus is $C_s^c = \frac{2v(v + N\lambda)^2}{(-4v + (\beta - \gamma)^2)^2}$; the advertiser surplus is $A_s^c = \frac{(\beta - \gamma)^2(v + N\lambda)^2}{2(4v - (\beta - \gamma)^2)^2}$; and social welfare is $S_w^c = \frac{(12v - (\beta - \gamma)^2)(v + N\lambda)^2}{2(-4v + (\beta - \gamma)^2)^2} - Ns$.

Proposition 3 demonstrates that if the platform applies the cash subsidy strategy, the value of c^* must be positive, i.e. $c^* > 0$. The analysis of c^* provides Corollary 1.

Corollary 1 1) A platform can adopt a cash subsidy strategy only when $\gamma \in (\gamma_1, \gamma_2)$, where $\gamma_1 = \beta - 2\sqrt{v}$, $\gamma_2 = \frac{\beta^2 - 2v}{\beta}$; and 2) $\frac{\partial c^*}{\partial \gamma} < 0$, $\frac{\partial c^*}{\partial \beta} > 0$.

According to Corollary 1 (1), a platform is fit for a cash subsidy strategy when the ad marginal revenue is high, and the ad interference cost is within a threshold range. Furthermore, the amount of cash subsidy is higher when ad interference is higher, but contrary to general belief, Corollary 1 (2) indicates that the amount of subsidy is lower when ad interference is higher.

2 Analysis and Discussion

Based on Propositions 1-3 and Corollary 1, this study compares the ad price, content cost, number of ads, number of consumers, consumer surplus, and profit of content platforms under the three pricing strategies, and the following corollaries can be drawn.

2.1 Platform pricing strategy selection

By contrasting the maximum revenue of a platform under the three pricing strategies, the optimum price strategy for the platform can be determined. Thus, Corollary 2 is obtained.

Corollary 2 The optimal pricing strategy for platforms is as follows: 1) when $\gamma \in (\gamma_1, \gamma_2)$, $\pi^{c*} > \pi^{m*}$ and $\pi^{c*} \geqslant \pi^{f*}$, the cash subsidy strategy is the optimal strategy; 2) when $\gamma \in (0, \gamma_1] \cup [\gamma_2, \gamma_3]$, $\pi^{f*} > \pi^{m*}$, the free strategy is the optimal strategy; and 3) when $\gamma \in (\gamma_3, +\infty)$, $\pi^{m*} > \pi^{f*}$, the charge strategy is the optimal strategy, where $\gamma_3 = \frac{\beta^2 - v}{\beta}$.

In the data experiments, we set $v = 1$, $\lambda = 2$, $N = 1$, $s = 0.1$, $\alpha = 0.3$, $\gamma = 1$ as proposed by Carroni and Paolin[12] and Chi et al.[18]. Fig. 2 depicts the optimal pricing strategy for platforms, which is a close reflection of Corollary 2.

Fig. 2 depicts that the optimal pricing strategy used by a platform differs when the ad interference cost and ad marginal revenue are in a different threshold range. Specifically, as in Region Ⅰ, when the ad interference cost is higher and the ad marginal revenue is not so high, platforms should adopt a charging strategy, such as iQIYI, QQLive, and Youku, as the annual income of the members continues to increase. In Region Ⅲ, when the ad interference cost is not so high and the ad marginal revenue is high, a cash subsidy strategy should be utilized, such as TikTok, Kwai, and Toutiao, to retain consumers and

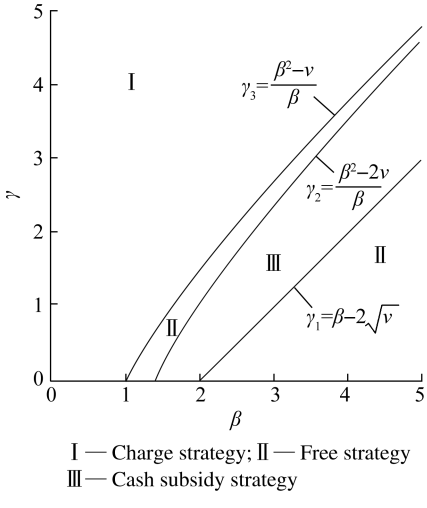

Fig. 2 Regional distribution of the optimal pricing strategy

maintain the platform's marketing revenue. The remaining cases in Region Ⅱ, where ad interference cost is lower, and the ad marginal revenue is high, should employ a free strategy, such as WeChat Moments, Tencent Weibo, and Sohu News.

2.2 Comparison of pricing strategies

Corollary 3 When a platform adopts a cash subsidy strategy, compared with the other two pricing strategies, the following occurs: 1) $P_a^{c*} < P_a^{f*}$, $P_s^{c*} < P_s^{f*} < P_s^{m*}$; 2) $n_a^{c*} > n_a^{f*}$, $n_u^{c*} > n_u^{f*} > n_u^{m*}$; 3) $C_s^c > C_s^f > C_s^m$, $A_s^c > A_s^f$, $S_w^c > S_w^m > S_w^f$.

Corollary 3 indicates that compared with other strategies, the cash subsidy strategy 1) increases the number of consumers and ads while decreasing content costs, 2) increases consumer surplus, 3) decreases the price of ads while increasing advertisers' surplus, and 4) increases social welfare. Thus, the use of a cash subsidy strategy by platforms benefits all parties with interests and the entire society. Therefore, platforms should implement this pricing strategy if the conditions for its use are met, and relevant authorities should encourage the use of this pricing strategy.

Comparing the cash subsidy method to the free strategy, we find that both charge advertisers, but the main difference is whether a platform gives consumers cash subsidies. Further comparison results are presented in Corollary 4.

Corollary 4 1) When adopting the free strategy, $\frac{\partial P_s^{f*}}{\partial \beta} > 0$, $\frac{\partial n_u^{f*}}{\partial \beta} < 0$, $\frac{\partial C_s^f}{\partial \beta} < 0$, and 2) when the cash subsidy strategy is adopted, $\frac{\partial P_s^{c*}}{\partial \beta} < 0$, $\frac{\partial n_u^{c*}}{\partial \beta} > 0$, $\frac{\partial C_s^c}{\partial \beta} > 0$.

Corollary 4 indicates that whena platform uses a free strategy, the cost of content rises as the ad marginal revenue rises, while the number of consumers and consumer surplus fall. However, when a platform uses a cash subsidy method, the exact opposite occurs. This is illustrated in Fig. 3, where the following values are set: $v = 1$, $\lambda = 2$, $N = 1$, $s = 0.1$, $\alpha = 0.3$, $\gamma = 1$.

3 Conclusions

1) This study discusses the pricing strategy that a platform should adopt. We create mathematical models for three pricing strategies—charge, free, and cash subsidy—assess the factors that impact a platform's ideal pricing strategy and the amount of cash subsidy and investigate the differences between the cash subsidy strategy and the other strategies. We discover that ad interference cost and ad marginal revenue impact a platform's optimal pricing strategy and cash subsidy amount; the cash subsidy strategy is better than other pricing strategies for all stakeholders and society; and ad marginal revenue affects some parameters of the free and cash subsidy strategies differently.

2) This study has managerial implications for content platform operators. By examining platform data, one may determine the platform's ad interference cost and ad marginal revenue. Modifying these two variables can lead to changes in the platform's pricing strategy. Video platforms (Youku, iQIYI, etc.) can increase the number and diversity of platform content to increase user stickiness and scale, thereby adjusting ad marginal revenue. Moreover, a platform can filter advertisers or modify ad formats to make ads more relevant to the video content, thereby lowering the cost of ad interference.

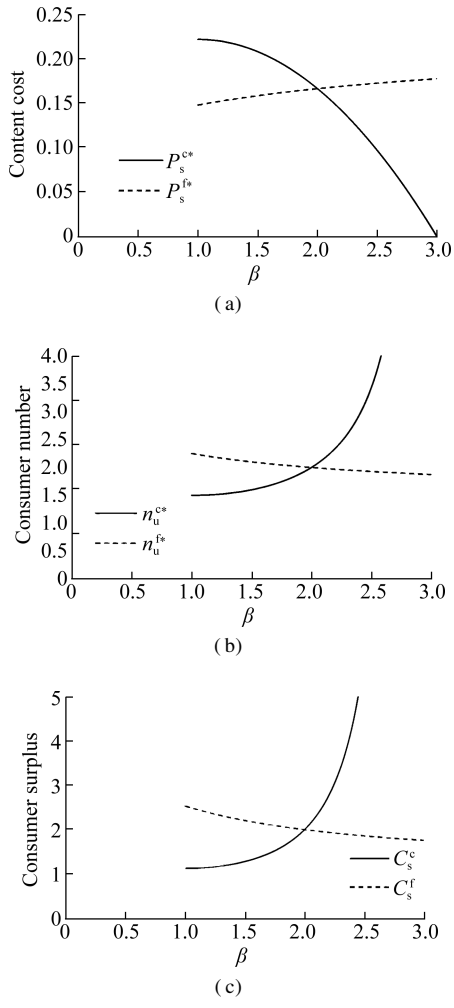

Fig. 3 Three parameters affected by ad marginal revenue. (a) Content cost; (b) Consumer number; (c) Consumer surplus

3) This study has some limitations. For example, we only evaluate platforms that use a single pricing strategy, although consumers' needs vary and a single strategy cannot meet all their needs. Therefore, future research on platforms can consider the coexistence of diverse strategies, such as multiple versions and membership categories.

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考虑现金补贴的内容平台定价策略选择

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摘要:基于多边市场和博弈论理论,针对内容平台建立了免费、收费和现金补贴3种定价策略模型,并通过对各定价策略下的参数进行比较,确定平台最优定价策略.结果表明:广告干扰成本和广告边际收益影响平台定价策略的选择和现金补贴额度的设置,当两者处于特定阈值范围内时采用现金补贴策略,当广告干扰成本非常高时采用收费策略,其他情况下采用免费策略;现金补贴策略下,现金补贴额度与广告干扰成本负相关,与广告边际收益正相关;相同条件下,采用现金补贴策略比其他2种定价策略对各方利益主体和社会福利更好;现金补贴策略和免费策略下的一些参数受广告边际收益的影响趋势相反.

关键词:内容平台;定价策略;选择;收费;免费;现金补贴

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