Effect of advertising targeting fit and consumer privacy protection on the profits of media platforms

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Abstract: A game model is proposed to examine the effects of advertising targeting fit and consumer privacy protection on media platforms' price strategies and profits, as well as advertisers' advertising strategies in monopoly and competition environments based on the two-sided market theory, providing theoretical references for media platforms and advertising operators to make correct management decisions. The results show that the equilibrium advertising price of a media platform is independent of advertising targeting fit and the degree of consumer privacy protection in a monopoly environment. While in a competition situation, when advertisers are single-homing, advertising price and profits at equilibrium on the media platform will decrease with the increase in advertising targeting fit, and the influence of consumer privacy protection on the advertising volume of the media platform at equilibrium will depend on the contrast of advertising targeting fit between the media platform and its competitor. When advertisers are multi-homing, the advertisement price, advertising, and profits of competition on the media platform at equilibrium are proportional to advertising targeting fit and inversely proportional to its competitor's advertising targeting fit. The media platform should consider its advertising targeting fit and other factors comprehensively when the enterprise is involved in market competition, meanwhile making a careful choice about price strategy at different stages of its development.
Key words: advertising targeting fit; consumer privacy protection; profits of media platform; two-sided market
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With the high-speed development of mobile internet and communication technology, the platforms can track the behaviors of consumers, such as clicking, browsing, and purchasing through the targeting technology, identify their interests and preference characteristics, and push the targeted advertisement to comply with consumers' demands based on the analysis results. The targeting fits of launching advertisements become a more important factor for advertisers to choose whether to launch advertisements on this platform or not. The advertising targeting fit of media platforms mainly relies on the capacities of acquiring, processing, and applying information and the attitude and willingness of consumers to share and provide their personal information.

The capture and use of consumers' behavior data by media platforms have inevitably aroused consumers' concern about the disclosure of their private information. Regulators have sanctioned some well-known media platforms for improperly using users' privacy data in a desperate attempt to increase the advertising targeting fit and reap more business profits. For example, in May 2022, Twitter was fined 150 million dollars by the Federal Trade Commission after deceptively using users' emails and phone numbers to target specific ads to specific consumers to increase corporate profits. Meta was also fined 390 million Eurodollars in January 2023 by the Irish Data Protection Commission for using user data to target ads that violate the law. Consumers' concentration on their privacy protection influences the advertising targeting fit of media platforms, and the advertising targeting fit also influences the launching effects of advertising, thus affecting the advertisement launching willingness for advertisers and platform profit. Therefore, it is necessary to reveal the internal influencing mechanism of advertising targeting fit and consumers' privacy protection on the media platform competition.

Advertisement targeting technology mainly analyzes the impact of advertisement targeting techniques and targeting capabilities on ad market competition, ad model selection, media platforms' pricing strategies and profits, and users' utility. For example, Athey et al.[1] examined how targeting technology affects the advertising market and media competition, identifying that advertising targeting could better distribute scarce advertising space. Bergemann et al.[2] showed that traditional media advertising profits would decrease with online advertising targeting capacity in a competitive equilibrium. Kim[3] identified that the targeting technology and production-sales integration policy could significantly improve social welfare

while increasing the number of users and content providers on both sides of the platform. Carroni et al. [4] illustrated that the stronger the advertising targeting capacity of an online media platform, the stronger its persuasiveness function and market competition. Hao et al. [5] stressed that improving advertising precision and effectiveness will inspire media platforms and sellers to offer higher-level advertisements in the free advertising model, and it will result in higher profits for media platforms and sellers in the paid advertising model. Gong et al. [6] indicated that media platforms with high targeting capacity would attract more advertisers and consumers and found that the enhancement of media platforms' targeting capabilities would improve the economic benefits of advertising companies with weak profitability. However, Kox et al. [7] found that media platforms will become more competitive, and their profits will decline with improved advertising targeting accuracy.

With respect to the impact of consumer privacy concerns and the use of private information on media platform competition, it mainly analyzes the influence of user's platform homing strategy, privacy cost, information disclosure level, and privacy protection policy of platforms on the media platform's pricing strategy and profit, and the utility of users and advertisers. For example, Gal-Or et al. [8] indicated that choosing a dual platform homing strategy without considering privacy loss would reduce the competition degree between media platforms in the consumer market. Lin et al. [9] found that platforms that practice quality discrimination are less profitable than those who do not when the users' privacy cost was increased in intensive market competition. Duan et al. [10] identified that a medium level of information disclosure will maximize the surplus of users and advertisers and that the profits of media platforms will first decrease and then increase with the increase in user privacy concerns. Duan et al. [11] also found that the price increases with the efficiency of efforts and decreases with the initial nuisance cost of advertisements to users when users attach fewer concerns to privacy, and vice versa. Philipp et al. [12] found that the mitigation of competition among advertisers and among users will lead media platforms to collect more users' private data. Kox et al. [7] found that the media platforms' privacy protection policy would benefit both consumers and advertising websites during the competition.

Unlike previous research, considering that consumers' privacy concerns affect the media platforms' capacity to acquire data on consumer behaviors and individual characteristics, which in turn influence the advertising targeting fit of media platforms and enterprise profit, and the typical two-sided market characteristics of media platforms, this paper researches the influences of advertising targeting fit and consumers' privacy protection on the advertising and pricing strategies of the media platform based on the two-sided market theory model.

1 Basic Assumption and Variable Description

1.1 Media platforms

Media platforms allow consumers free access to news information and viewing experience while making a profit from advertisers by charging advertising fees, such as Tencent free videos and Baidu Search. Because the operation and advertising costs of media platforms do not affect the analysis results of this paper, it is assumed that the operation and advertising costs of media platforms are zero. We also assume that the advertising price is p, and the number of advertisers accessing media platforms is represented by a to indicate the advertising volume, and the profit of the media platform is $\Pi = pa$.

1.2 Consumers

We assume that consumers are not aware of whether they have been identified accurately when they visit the media platform. Consumers select a single-homing strategy of simultaneously accessing a media platform. The total number of consumers is standardized to 1 and is evenly distributed between $[0, 1]$ based on their preference for media platforms x. The media platform preferred by advertisers is usually the media platform preferred by consumers who pay attention to the advertiser's products or services. For example, car dealers prefer to place targeted advertisements about cars on commercial websites, such as Auto Home and Aika Auto, where consumers who are willing to buy cars usually browse and patronize such websites. Therefore, it is assumed that the difference between consumers' preference for media platforms and advertisers' preference for media platforms is the same, both are t, which can also be understood as the degree of platform differentiation[13]. It is assumed that the targeting fit of media platforms is λ, and the utility of λ percentage of consumers receiving targeted advertising after being accurately identified by the platform is $v - tx$ (the disutility of advertising is not generated to consumers by advertisements at this moment). While the utility of $1 - \lambda$ percentage of consumers who are not accurately identified and access the media platforms is $v - ra - tx$, in which $v > 0$ denotes the basic utility of consumers who access the media platforms, $r > 0$ denotes the disutility of advertising to the consumer[14]. The degree of consumer privacy protection δ influences the targeting fit of advertising λ. The greater the degree of consumer privacy protection δ, the weaker the media platform's ability to obtain consumers' personalized data and profile users[15], and the weaker the media platform's targeting fit. In other words, the lower consumer privacy protection δ, the stronger the targeting fit of the media platform, that is $\frac{\partial \lambda}{\partial \delta} < 0$.

1.3 Advertisers

The number of advertisers in the market is standardized to 1, which is evenly distributed between [0, 1] according to their preferences for media platforms z. The targeting fit of advertising, consumers' private information acquisition, and application capacity of the media platforms influence the advertising effectiveness, and these also become important factors for advertisers to choose media platforms. It is assumed that the number of consumers accessing the two media platforms is n_1 and n_2, respectively. When the advertiser whose preference is located at point z chooses a single-homing strategy, its net utility of placing ads on media platforms 1 and 2 is $\alpha n_1 - tz - p_1$ and $\alpha n_2 - t(1 - z) - p_2$, respectively. The net utility of the advertiser who chooses a multi-homing strategy and places ads on both media platforms is $\alpha - t - p_1 - p_2$, in which $\alpha > 0$ denotes the marginal gross benefit that an advertiser derives from each media consumer[14] and is used to measure the impact of the scale of consumers accessing the media platforms on advertisers' willingness to launch advertisements.

2 Analysis of Media Platform Monopoly

Assuming that there is a single monopoly media platform with a targeting fit in the market, the advertiser's advertising volume on the media platform is a[14], and the consumer's preference for the media platform is located at point x. Then, the utility of λ percentage of consumers accessing media platforms is $U_\lambda = v - tx$. The utility of $1 - \lambda$ percentage of consumers accessing media platforms is $U_{1-\lambda} = v - ra - tx$. After the advertising price p is determined, advertisers choose to access the media platform. Discussing the advertising and pricing strategies in a monopoly environment, the following conclusions are obtained.

Theorem 1 The equilibrium advertising price of the media platform in a monopoly environment is $p^m = \dfrac{\alpha v}{2t}$, the equilibrium advertising volume placed by advertisers is $a^m = \dfrac{\alpha v}{2[t^2 + \alpha r(1 - \lambda)]}$, and the equilibrium profit of the media platform is $\Pi^m = \dfrac{\alpha^2 v^2}{4t[t^2 + \alpha r(1 - \lambda)]}$.

Proof Only when $U_\lambda \geq 0$ or $U_{1-\lambda} \geq 0$, consumers may select to join the media platforms. The critical values for consumers who receive targeted ads after being accurately identified by the platform and consumers who are not accurately identified are $x_\lambda = \dfrac{v}{t}$ and $x_{1-\lambda} = \dfrac{v - ra}{t}$, respectively. The total number of consumers who chose to join the media platform is

$$n = \lambda x_\lambda + (1 - \lambda) x_{1-\lambda} = \lambda \frac{v}{t} + (1 - \lambda) \frac{v - ra}{t} \quad (1)$$

The utility of the advertiser with the preference for the media platform z to join the media platform is $U_a = \alpha n - p - tz$. Under the condition that the advertiser's utility is $U_a \geq 0$, the critical value for advertisers who join the media platform is

$$z' = a = \frac{\alpha n - p}{t} \quad (2)$$

The number of advertisers by substituting Eq. (1) into Eq. (2) is

$$a = \frac{\alpha v - tp}{t^2 + \alpha r(1 - \lambda)} \quad (3)$$

The profit function of media platforms is

$$\Pi = \frac{p(\alpha v - tp)}{t^2 + \alpha r(1 - \lambda)} \quad (4)$$

The equilibrium advertising price $p^m = \dfrac{\alpha v}{2t}$ can be acquired when $\dfrac{\partial \Pi}{\partial p} = 0$, and $\dfrac{\partial^2 \Pi}{\partial p^2} < 0$ can be verified. Substituting the solved p^m into Eqs. (3) and (4), respectively, the theorem can be proved.

We can obtain Corollary 1 by analyzing the influences of the fit degree of advertisements on the equilibrium advertising quantity, equilibrium advertising price, and equilibrium profit for the media platforms.

Corollary 1 Under a monopolistic environment, the equilibrium ad price of the media platform does not depend on the advertising targeting fit. The equilibrium ad volume and equilibrium profit both increase monotonically with the advertising targeting fit, that is, $\dfrac{\partial p^m}{\partial \lambda} = 0$, $\dfrac{\partial a^m}{\partial \lambda} > 0$, $\dfrac{\partial \Pi^m}{\partial \lambda} > 0$.

Because there is only one single media platform in the market, the media platforms determine the monopoly price by relying on their monopoly position in the market to squeeze the maximum amount of advertisers' surplus. Therefore, their advertising pricing strategy is not influenced by the targeting fit degree. With an increase in the targeting fit degree for media platforms, it is naturally able to attract more and more advertisers to join in. In the absence of a change in pricing strategy, the profit of the media platform is increased correspondingly with an increase in the number of advertisements launched on the platform. Corollary 1 reveals that monopoly media platforms should continuously improve the targeting fit of their advertising placements without changing their pricing strategies in order to gain more profits.

The impact of consumer privacy protection behavior on the equilibrium advertising price, equilibrium advertising volume, and equilibrium profit of the media platform is analyzed to obtain Corollary 2.

Corollary 2 The equilibrium advertising price of the

media platform does not rely on the degree of consumer privacy protection in a monopoly environment. If consumers strengthen the degree of protection of their privacy, it may reduce the number of advertisements launched by advertisers and the equilibrium profits made by media platforms, that is, $\dfrac{\partial p^m}{\partial \delta} = 0$, $\dfrac{\partial a^m}{\partial \delta} < 0$, and $\dfrac{\partial \Pi^m}{\partial \delta} < 0$.

There is a negative correlation between the integrating degree of targeting fit for advertisements launched on media platforms and the degree of consumers' protection of their privacy. Hence, the equilibrium advertising price of media platforms does not rely on the integrating degree of targeting fit for advertisements. Meanwhile, there is a positive correlation between the equilibrium advertising quantity, equilibrium profit, and the integrating degree of targeting fit for advertisements. Therefore, the equilibrium advertising price of the media platform does not rely on the degree of consumers' protection of their privacy. The equilibrium advertising quantity and equilibrium profit may be reduced with the degree of consumer privacy protection strengthened.

3　Analysis of Media Platform Competition

It is assumed that in the market, there are two competitive media platforms i ($i = 1, 2$) with the targeting fit λ_1 and λ_2, respectively, λ_i can also be regarded as the matching ability for the platform to each consumer. The amount of advertising launched on these two competitive media platforms i ($i = 1, 2$) is a_1 and a_2, respectively. The consumer groups are divided into four parts based on the targeting fit. The $\lambda_1 \lambda_2$ proportion of consumers is precisely identified by these two media platforms and receives targeted advertisements. Thus, the utilities for consumers whose preference is located at point x and who access media platforms 1 and 2 are $v - tx$ and $v - t(1 - x)$, respectively, and the point of indifference of utilities for consumers who access media platforms 1 and 2 is $x_1 = 1/2$. The $\lambda_1 (1 - \lambda_2)$ proportion of consumers is precisely identified by media platform 1 and receives targeted advertisements, but they are not precisely identified by media platform 2. Thus, the utilities for consumers whose preference is located at point x and who access media platforms 1 and 2 are $v - tx$ and $v - ra_2 - t(1 - x)$, respectively, and the point of indifference of utilities for consumers who access media platforms 1 and 2 is $x_2 = \dfrac{1}{2} + \dfrac{ra_2}{2t}$. The $\lambda_2 (1 - \lambda_1)$ proportion of consumers is precisely identified by media platform 2 and receives targeted advertisements, but they are not precisely identified by media platform 1. Thus, the utilities for consumers whose preference is located at point x and who access to the media platforms 1, 2 is $v - ra_1 - tx$ and $v - t(1 - x)$, respectively, and the point of indifference of utilities for

consumers who access the media platforms 1, 2 is $x_3 = \dfrac{1}{2} - \dfrac{ra_1}{2t}$. The $(1 - \lambda_1)(1 - \lambda_2)$ proportion of consumers is not receiving targeted advertisements launched by these two media platforms. Thus, the utilities for consumers whose preference is located at point x and who access media platforms 1 and 2 is $v - ra_1 - tx$ and $v - ra_2 - t(1 - x)$, respectively, and the point of indifference of utilities for consumers who access media platforms 1 and 2 is $x_4 = \dfrac{1}{2} + \dfrac{ra_2 - ra_1}{2t}$.

The number of people who are selected to access media platform 1 is

$$n_1 = \frac{1}{2}\lambda_1 \lambda_2 + \lambda_1 (1 - \lambda_2)\left(\frac{1}{2} + \frac{ra_2}{2t}\right) +$$
$$\lambda_2 (1 - \lambda_1)\left(\frac{1}{2} - \frac{ra_1}{2t}\right) +$$
$$(1 - \lambda_1)(1 - \lambda_2)\left(\frac{1}{2} + \frac{ra_2 - ra_1}{2t}\right) =$$
$$\frac{1}{2} + \frac{(1 - \lambda_2) ra_2}{2t} - \frac{(1 - \lambda_1) ra_1}{2t} \tag{5}$$

The number of people who are selected to access media platform 2 is

$$n_2 = \frac{1}{2} + \frac{(1 - \lambda_1) ra_1}{2t} - \frac{(1 - \lambda_2) ra_2}{2t} \tag{6}$$

3.1　Single-homing of advertisers

Upon determining the advertising prices of the two media platforms, advertisers select a single-homing strategy and launch advertisements only on one media platform. The following conclusions can be drawn upon analyzing the competitive equilibrium of media platforms under the influences of targeting fit of advertisements.

Theorem 2　Under a competitive environment, if advertisers select a single-homing strategy, the equilibrium advertising prices and equilibrium amounts of advertisements for these two media platforms are $p_i^{cs} = t + \dfrac{\alpha r(3 - \lambda_i - 2\lambda_j)}{3t}$ and $a_i^{cs} = \dfrac{3t^2 + \alpha r(3 - \lambda_i - 2\lambda_j)}{6t^2 + 3\alpha r(2 - \lambda_i - \lambda_j)}$, respectively, and the equilibrium profits of media platforms are $\Pi_i^{cs} = \dfrac{[3t^2 + \alpha r(3 - \lambda_i - 2\lambda_j)]^2}{9t[2t^2 + \alpha r(2 - \lambda_i - \lambda_j)]}$ ($i \neq j$; $i, j = 1, 2$).

Proof　The net utility acquired by marginal advertisers $\bar{z}$ who select to launch advertisements on media platforms 1 and 2 is $\alpha n_1 - t\bar{z} - p_1$ and $\alpha n_2 - t(1 - \bar{z}) - p_2$, respectively. The point of indifference of utilities for advertisers who access media platforms 1 and 2 is $\bar{z} = \dfrac{1}{2} + \dfrac{\alpha(n_1 - n_2) + (p_2 - p_1)}{2t}$. Advertisers located at $[0, \bar{z}]$ will select to launch the advertisements on the media platform

1, and advertisers located at $[\bar{z}, 1]$ will select to launch the advertisements on the media platform 2. The amounts of advertisements launched by advertisers on the media platforms 1 and 2 are $a_1 = \bar{z}$ and $a_2 = 1 - \bar{z}$, respectively. The equations below are determined upon making a simultaneous equation with Eqs. (5) and (6):

$$a_1 = \frac{t^2 + t(p_2 - p_1) + \alpha r(1 - \lambda_2)}{2t^2 + \alpha r(2 - \lambda_1 - \lambda_2)} \tag{7}$$

$$a_2 = \frac{t^2 + t(p_1 - p_2) + \alpha r(1 - \lambda_1)}{2t^2 + \alpha r(2 - \lambda_1 - \lambda_2)} \tag{8}$$

The profit functions for these two media platforms are obtained as seen below upon substituting Eqs. (7) and (8) into the profit function of media platforms $\Pi_i = p_i a_i$:

$$\Pi_1 = p_1 \left[\frac{t^2 + t(p_2 - p_1) + \alpha r(1 - \lambda_2)}{2t^2 + \alpha r(2 - \lambda_1 - \lambda_2)} \right] \tag{9}$$

$$\Pi_2 = p_2 \left[\frac{t^2 + t(p_1 - p_2) + \alpha r(1 - \lambda_1)}{2t^2 + \alpha r(2 - \lambda_1 - \lambda_2)} \right] \tag{10}$$

Making derivation for p_1, p_2, respectively, yields that $p_i^{cs} = t + \frac{\alpha r(3 - \lambda_i - 2\lambda_j)}{3t}$ ($i \neq j; i, j = 1, 2$), and $\frac{\partial^2 \Pi_i}{\partial p_i^2} < 0$ can be verified. The theorem can be proved by substituting the solved p_i^{cs} into Eqs. (7) and (8) and Eqs. (9) and (10) successively.

Upon analyzing the influences of targeting fit of advertisements on the equilibrium advertising prices, equilibrium amounts of advertisements, and equilibrium profits for the two competitive media platforms, we can get Corollary 3.

Corollary 3 Under a competitive environment, if advertisers select a single-homing strategy, then equilibrium advertising prices and equilibrium profits of media platforms are monotonically decreasing with their own targeting fit of advertisements and their competitors' targeting fit of advertisements. The equilibrium number of advertisements is monotonically increasing with their own targeting fit and monotonically decreasing with the competitors' targeting fit. That is $\frac{\partial p_i^{cs}}{\partial \lambda_i} < 0$, $\frac{\partial p_i^{cs}}{\partial \lambda_j} < 0$, $\frac{\partial \Pi_i^{cs}}{\partial \lambda_i} < 0$, $\frac{\partial \Pi_i^{cs}}{\partial \lambda_j} < 0$, $\frac{\partial a_i^{cs}}{\partial \lambda_i} > 0$, $\frac{\partial a_i^{cs}}{\partial \lambda_j} < 0$.

Further verification is conducted for the influences of media platforms and their competitors' targeting fit of advertisements on the equilibrium advertising price, equilibrium amount of advertising, and equilibrium profit under the circumstance that advertisers select single-homing strategies by means of examples. If $\alpha = 2$, $r = 2.5$, $t = 1$, λ_i and λ_j varies between $[0, 1]$, then it is able to obtain the variation diagrams for advertising price, amount of advertising, and equilibrium profit with their own targeting fit of advertisements and competitors' targeting fit of advertisements (see Fig. 1).
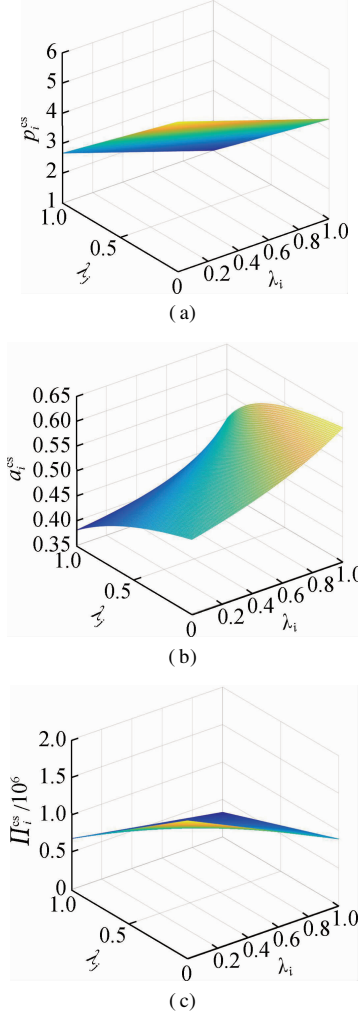

Fig. 1 Variation diagram for equilibrium results with targeting fit. (a) Advertising price; (b) Number of ads; (c) Platform's profit

As shown in Fig. 1, if the media platforms' own targeting fit of advertisements λ_i and the competitors' targeting fit of advertisements λ_j are progressively increasing, then the equilibrium advertising prices and equilibrium profits for media platforms are progressively decreasing. However, the equilibrium number of advertisements is increasing with a progressive increase in their own targeting fit and decreasing with a progressive increase in the competitors' targeting fit.

The only source of profit for the media platform is advertisers' advertising fees. Under a competitive environment, if advertisers select a single-homing strategy and access only one media platform, with an increase in the competitors' targeting fit and winning market competitive strengths, media platforms still need to reduce their own advertising prices to attract more advertisers to visit, even though their own targeting fit is improved. This leads to the phenomenon that the media platforms' equilibrium advertising price is monotonically decreasing with their own targeting fit of advertisements and competitors' targeting fit of advertisements. Advertisers are always rational in the process of adjusting prices. They will select

to launch the advertisements at the media platforms with a relatively high targeting fit to enhance the launching effect of advertisements. Therefore, the media platforms' equilibrium number of advertisements will be monotonically increasing with their own targeting fit and monotonically decreasing with the competitors' targeting fit. If the decreasing range for advertising price with an increase in the media platforms' own targeting fit is higher than the increasing range of equilibrium amount of advertising with an increase in the media platforms' own targeting fit, the media platforms' equilibrium profit will be monotonically decreasing with their own targeting fit of advertisements. With an increase in the competitors' targeting fit, the media platforms apply the "price-off promotions" strategy, which leads to the phenomenon that the media platforms' equilibrium profit will decrease with an increase in the competitors' targeting fit. According to Corollary 3, it is inspired that when advertisers select a single-homing strategy, the media platforms should reduce the targeting fit of advertisements while applying the "price-off promotions" strategy to win the market competition.

Upon analyzing the influences of consumer privacy protection on the media platforms' equilibrium advertising prices, equilibrium amounts of advertisements, and equilibrium profits, we can obtain Corollary 4.

Corollary 4 Under a competitive environment, if advertisers select a single-homing strategy, the equilibrium advertising prices and equilibrium profits of media platforms are monotonically increasing with consumer privacy protection. If the media platforms' own targeting fit is higher than the competitors' targeting fit, the media platforms' equilibrium number of advertisements is monotonically decreasing with consumer privacy protection. However, the media platforms' equilibrium number of advertisements is monotonically increasing with consumer privacy protection. That is,

1) $\dfrac{\partial p_i^{\text{cs}}}{\partial \delta} > 0$, $\dfrac{\partial \varPi_i^{\text{cs}}}{\partial \delta} > 0$.

2) If $\lambda_i > \lambda_j$, $\dfrac{\partial a_i^{\text{cs}}}{\partial \delta} < 0$; if $\lambda_i < \lambda_j$, $\dfrac{\partial a_i^{\text{cs}}}{\partial \delta} > 0$.

Under a competitive environment, if advertisers select a single-homing strategy because of the media platforms' targeting fit of advertisements being in a negative correlation with consumer privacy protection, the media platforms' equilibrium advertising price and equilibrium profit are also in a negative correlation with their own targeting fit of advertisements and competitors' targeting fit of advertisements. Therefore, with the reinforcement of consumer privacy protection, the media platforms' equilibrium advertising price and equilibrium profit will also be enhanced. If the media platforms' own targeting fit is higher than the competitors' targeting fit, the marginal effect for influences of media platforms' own targeting fit of advertisements on the equilibrium number of advertisements is higher than the marginal effect for influences of competitors' targeting fit of advertisements on the equilibrium number of advertisements. In addition, the equilibrium number of advertisements is in a positive correlation with the media platforms' own targeting fit and in a negative correlation with the competitors' targeting fit; thus, the media platforms' equilibrium number of advertisements will decrease with the reinforcement of consumer privacy protection, and vice versa.

3.2 Multi-homing of advertisers

When determining the prices for advertisements on two media platforms, advertisers select a multi-homing strategy and launch advertisements on two media platforms. The following conclusions are drawn upon analyzing the competitive equilibrium of media platforms under the influences of targeting fit of advertisements.

Theorem 3 Under a competitive environment, if advertisers select a multi-homing strategy, the equilibrium advertising prices and equilibrium amounts of advertisements for these two media platforms are

$$p_i^{\text{cm}} = \frac{\alpha[\alpha^2 r^2(1-\lambda_i)(1-\lambda_j) + \alpha r t^2(5-2\lambda_i-3\lambda_j) + 4t^4]}{3\alpha^2 r^2(1-\lambda_i)(1-\lambda_j) + 8\alpha r t^2(2-\lambda_i-\lambda_j) + 16t^4}$$

$$a_i^{\text{cm}} = \frac{\alpha[2t^2 + \alpha r(1-\lambda_j)][\alpha^2 r^2(1-\lambda_i)(1-\lambda_j) + \alpha r t^2(5-2\lambda_i-3\lambda_j) + 4t^4]}{t[2t^2 + \alpha r(2-\lambda_i-\lambda_j)][3\alpha^2 r^2(1-\lambda_i)(1-\lambda_j) + 8\alpha r t^2(2-\lambda_i-\lambda_j) + 16t^4]}$$

respectively, and the equilibrium profits of media platforms are

$$\varPi_i^{\text{cm}} = \frac{\alpha^2[2t^2 + \alpha r(1-\lambda_j)][\alpha^2 r^2(1-\lambda_i)(1-\lambda_j) + \alpha r t^2(5-2\lambda_i-3\lambda_j) + 4t^4]^2}{t[2t^2 + \alpha r(2-\lambda_i-\lambda_j)][3\alpha^2 r^2(1-\lambda_i)(1-\lambda_j) + 8\alpha r t^2(2-\lambda_i-\lambda_j) + 16t^4]^2} \qquad i \neq j;\ i, j = 1, 2$$

Proof The net utilities acquired by the marginal advertisers $\bar{z}_1$ who select to launch the advertisements on media platform 1 and simultaneously at two media platforms are $\alpha n_1 - t\bar{z}_1 - p_1$ and $\alpha - t - p_1 - p_2$, respectively. The point of indifference of utilities for advertisers who access media platform 1 and simultaneously access two media platforms is $\bar{z}_1 = 1 + \dfrac{p_2 - \alpha n_2}{t}$. The net utilities ac-

quired by the marginal advertisers $\bar{z}_2$ who select to launch the advertisements on media platform 2 and simultaneously on two media platforms are $\alpha n_2 - t(1 - \bar{z}_2) - p_2$ and $\alpha - t - p_1 - p_2$, respectively. The point of indifference of utilities for advertisers who access media platform 2 and simultaneously access two media platforms is $\bar{z}_2 = \dfrac{\alpha n_1 - p_1}{t}$. Advertisers located at $[0, \bar{z}_1]$ will select to

launch advertisements on media platform 1 only. Advertisers located at $[\bar{z}_1, \bar{z}_2]$ will select to launch advertisements on two media platforms, and advertisers located at $[\bar{z}_2, 1]$ will select to launch advertisements on media platform 2. The amounts of advertisements launched by advertisers on media platforms 1 and 2 are $a_1 = \bar{z}_2 = \dfrac{\alpha n_1 - p_1}{t}$

and $a_2 = 1 - \bar{z}_1 = \dfrac{\alpha n_2 - p_2}{t}$, respectively. Equations below are obtained upon making a simultaneous equation with Eqs. (5) and (6):

$$a_1 = \frac{\alpha t^2 + \alpha^2 r(1 - \lambda_2) - \alpha r(1 - \lambda_2)p_2 - [2t^2 + \alpha r(1 - \lambda_2)]p_1}{2t^3 + \alpha rt(2 - \lambda_1 - \lambda_2)} \tag{11}$$

$$a_2 = \frac{\alpha t^2 + \alpha^2 r(1 - \lambda_1) - \alpha r(1 - \lambda_1)p_1 - [2t^2 + \alpha r(1 - \lambda_1)]p_2}{2t^3 + \alpha rt(2 - \lambda_1 - \lambda_2)} \tag{12}$$

Substituting Eqs. (11) and (12) into the profit function of media platforms $\Pi_i = p_i a_i$, the profit functions for these two media platforms are obtained as below:

$$\Pi_1 = p_1 \frac{\alpha t^2 + \alpha^2 r(1 - \lambda_2) - \alpha r(1 - \lambda_2)p_2 - [2t^2 + \alpha r(1 - \lambda_2)]p_1}{2t^3 + \alpha rt(2 - \lambda_1 - \lambda_2)} \tag{13}$$

$$\Pi_2 = p_2 \frac{\alpha t^2 + \alpha^2 r(1 - \lambda_1) - \alpha r(1 - \lambda_1)p_1 - [2t^2 + \alpha r(1 - \lambda_1)]p_2}{2t^3 + \alpha rt(2 - \lambda_1 - \lambda_2)} \tag{14}$$

Making derivation for p_1 and p_2 yields

$$p_i^{cm} = \frac{\alpha[\alpha^2 r^2(1 - \lambda_i)(1 - \lambda_j) + \alpha rt^2(5 - 2\lambda_i - 3\lambda_j) + 4t^4]}{3\alpha^2 r^2(1 - \lambda_i)(1 - \lambda_j) + 8\alpha rt^2(2 - \lambda_i - \lambda_j) + 16t^4} \qquad i \neq j;\ i, j = 1, 2$$

and $\dfrac{\partial^2 \Pi_i}{\partial p_i^2} < 0$ can be verified. The theorem can be proved by substituting the solved p_i^{cm} into Eqs. (11) and (12), Eqs. (13) and (14), successively.

Corollary 5 can be obtained by analyzing the influences of the targeting fit of advertisements on the equilibrium advertising prices, equilibrium amounts of advertisements, and equilibrium profits for the two competitive media platforms.

Corollary 5 Under a competitive environment, if advertisers select a multi-homing strategy, the equilibrium advertising prices, equilibrium amounts of advertisements, and equilibrium profits of media platforms are in a positive correlation with their own targeting fit of advertisements and in a negative correlation with the competitors' targeting fit of advertisements. That is $\dfrac{\partial p_i^{cm}}{\partial \lambda_i}$ > 0, $\dfrac{\partial a_i^{cm}}{\partial \lambda_i} > 0$, $\dfrac{\partial \Pi_i^{cm}}{\partial \lambda_i} > 0$; $\dfrac{\partial p_i^{cm}}{\partial \lambda_j} < 0$, $\dfrac{\partial a_i^{cm}}{\partial \lambda_j} < 0$, $\dfrac{\partial \Pi_i^{cm}}{\partial \lambda_j} < 0$.

Further verification is conducted for the influences of media platforms' own targeting fit of advertisements and competitors' targeting fit of advertisements on the equilibrium advertising price, equilibrium amount of advertising, and equilibrium profit under the circumstance that advertisers select the multi-homing strategy by means of examples. If $\alpha = 2$, $r = 2.5$, $t = 1$, λ_i and λ_j vary between $[0, 1]$, they are able to obtain the variation diagrams for advertising price, amount of advertising, and equilibrium profit with the targeting fit of advertisements (see Fig. 2).
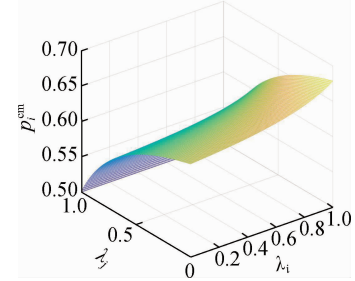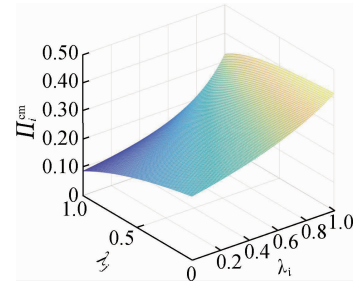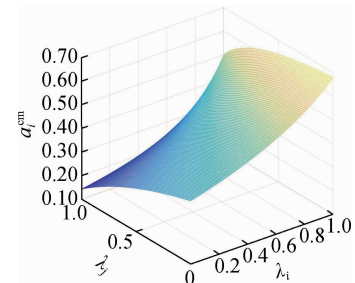

Fig. 2 Variation diagram for equilibrium results with targeting fit. (a) Advertising price; (b) Number of ads; (c) The platform's profit

As shown in Fig. 2, if the media platform's own targeting fit of advertisements λ_i is progressively increasing, the equilibrium advertising price, equilibrium amount of advertising, and equilibrium profit of the media platform are progressively increasing. However, if the competitors' targeting fit of advertisements λ_j is progressively increasing, the equilibrium advertising price, equilibrium amount of advertising, and equilibrium profit of the media platform are progressively decreasing.

Under a competitive environment, if advertisers select a multi-homing strategy, they can select to launch advertisements at one or two media platforms. To enhance the advertising effect, advertisers will select to launch advertisements at the media platforms with a higher targeting fit. Therefore, the media platforms' equilibrium number of advertisements will increase with an increase in their own targeting fit and will decrease with an increase in the competitors' targeting fit. Advertisers may select to launch advertisements simultaneously at two media platforms if selecting the multi-homing strategy. Competition among platforms may become more intensive with an increase in their own and competitor's targeting fits of advertisements. For the sake of winning more profits, if the competitor's targeting fit is increasing, the media platform may select to decrease their advertising price, and they will increase the advertising price if their own targeting fit is increasing. Because the targeting fit plays its role in the influences on equilibrium advertising price and equilibrium amount of advertising simultaneously, the media platforms' equilibrium profit increases with an increase in their own targeting fit and decreases with an increase in the competitor's targeting fit. According to Corollary 5, when advertisers select a multi-homing strategy, the media platforms should enhance the targeting fit of advertisements while increasing the advertisement price to win the market competition.

Corollary 6 Under a competitive environment, and advertisers select a multi-homing strategy, if the marginal effect for the influence of media platforms' own targeting fit of advertisements on the equilibrium advertising price, the equilibrium amount of advertising and equilibrium profit is higher than the marginal effect for the influence of competitors' targeting fit of advertisements on these three factors, then consumer privacy protection has a negative influence on the media platforms' equilibrium advertising price, equilibrium amount of advertising, and equilibrium profit. However, if the marginal effect for the influence of media platforms' own targeting fit of advertisements on the equilibrium advertising price, the equilibrium amount of advertising, and equilibrium profit is lower than the marginal effect for influences of competitors' targeting fit of advertisements on these three factors, then consumer privacy protection has a positive influence on the media platforms' equilibrium advertising price, equilibrium amount of advertising, and equilibrium profit.

That is,

1) If $\left| \dfrac{\partial p_i^{cm}}{\partial \lambda_i} \right| > \left| \dfrac{\partial p_i^{cm}}{\partial \lambda_j} \right|$, $\dfrac{\partial p_i^{cm}}{\partial \delta} < 0$; whereas, $\dfrac{\partial p_i^{cm}}{\partial \delta} > 0$.

2) If $\left| \dfrac{\partial a_i^{cm}}{\partial \lambda_i} \right| > \left| \dfrac{\partial a_i^{cm}}{\partial \lambda_j} \right|$, $\dfrac{\partial a_i^{cm}}{\partial \delta} < 0$; whereas, $\dfrac{\partial a_i^{cm}}{\partial \delta} > 0$.

3) If $\left| \dfrac{\partial \Pi_i^{cm}}{\partial \lambda_i} \right| > \left| \dfrac{\partial \Pi_i^{cm}}{\partial \lambda_j} \right|$, $\dfrac{\partial \Pi_i^{cm}}{\partial \delta} < 0$; whereas, $\dfrac{\partial \Pi_i^{cm}}{\partial \delta} > 0$.

Under a competitive environment, if advertisers select a multi-homing strategy, then the media platforms' equilibrium advertising prices, equilibrium amounts of advertisements, and equilibrium profits are in a positive correlation with their own targeting fit of advertisements and in a negative correlation with the competitors' targeting fit of advertisements. Therefore, with the negative influence of consumer privacy protection on the targeting fit of advertisements, if the marginal effect for the influence of media platforms' own targeting fit of advertisements on the equilibrium advertising price, equilibrium amount of advertising, and equilibrium profit is higher than that of competitors, then the media platforms' equilibrium advertising price, equilibrium amount of advertising, and equilibrium profit are decreasing with a reinforcement of consumer privacy protection. However, these three factors will increase with a reinforcement of consumer privacy protection.

4 Comparative Analysis of Results

This section analyzes the pricing strategies of media platforms and advertising strategies of advertisers under different homing strategies, as well as the equilibrium profit, to provide theoretical references for the media platforms to choose the appropriate pricing strategies in different development stages. To simplify research and facilitate comparative analysis, it is assumed that the two media platforms have the same advertisement targeting fit ($\lambda_i = \lambda_j = \lambda$).

Corollary 7 When the marginal benefit obtained by advertisers from each media platform consumer is low, the equilibrium advertising volume of the media platform in the case that advertisers are single-homing is larger than that under the case that advertisers are multi-homing. When the marginal benefit obtained by advertisers from each media platform consumer is moderate, with the enhancement of advertisement targeting fit of the media platform, the equilibrium advertising volume of the media platform under the case that advertisers are single-homing is first greater and then less than that under the case that advertisers are multi-homing. When the marginal benefit obtained by advertisers from each media platform consumer is significant, the equilibrium advertising volume of the media platform in the case that advertisers are single-homing is smaller than that in the case that advertisers are multi-homing.

Proof   When $\lambda_i = \lambda_j = \lambda$, $a_1^{cs} = a_2^{cs} = a^{cs} = \dfrac{1}{2}$, $a_1^{cm} =$

$a_2^{cm} = a^{cm} = \dfrac{\alpha^2 r(1-\lambda) + 2\alpha t^2}{6\alpha r t(1-\lambda) + 8t^3}$, $a^{cs} - a^{cm} = \dfrac{1}{2} -$

$\dfrac{\alpha^2 r(1-\lambda) + 2\alpha t^2}{6\alpha r t(1-\lambda) + 8t^3} = \dfrac{(1-\lambda)(3\alpha r t - \alpha^2 r) + 4t^3 - 2\alpha t^2}{2t[3\alpha r(1-\lambda) + 4t^2]}$.

1) When $\alpha < 2t$, $(1-\lambda)(3\alpha r t - \alpha^2 r) + 4t^3 - 2\alpha t^2 > 0$, and $a^{cs} > a^{cm}$.

2) When $2t < \alpha < 3t$, if $0 < \lambda < 1 - \dfrac{2t^2(\alpha - 2t)}{\alpha r(3t - \alpha)}$, $(1-\lambda)(3\alpha r t - \alpha^2 r) + 4t^3 - 2\alpha t^2 > 0$, and $a^{cs} > a^{cm}$, if $1 - \dfrac{2t^2(\alpha - 2t)}{\alpha r(3t - \alpha)} < \lambda < 1$, $(1-\lambda)(3\alpha r t - \alpha^2 r) + 4t^3 - 2\alpha t^2 < 0$, and $a^{cs} < a^{cm}$.

3) When $\alpha > 3t$, $(1-\lambda)(3\alpha r t - \alpha^2 r) + 4t^3 - 2\alpha t^2 < 0$, and $a^{cs} < a^{cm}$.

When the marginal benefit obtained by advertisers from each media platform consumer is low, or when the marginal benefit obtained by advertisers is moderate, but the targeting fit of the media platforms is weak, the advertising effectiveness of advertisers on the media platform is poor, and the willingness of advertisers to choose to access a single media platform is strong. While the marginal benefit obtained by advertisers from each media platform consumer is high, or the marginal benefit obtained by advertisers is moderate, the targeting fit of the media platforms is strong, the advertising effectiveness of advertisers on the media platform is geater, and rational advertisers will naturally choose a multi-homing strategy, and advertise on two media platforms.

Corollary 8   When the marginal benefit obtained by advertisers from each media platform consumer is low, the equilibrium advertising price and profit of the media platform in the case that advertisers are single-homing are greater than that in the case that advertisers are multi-homing. When the marginal benefit obtained by advertisers from each media platform consumer is high, with the enhancement of the advertisement targeting fit of the media platform, the equilibrium advertising price and profit of the media platform in the case that advertisers are single-homing are first greater and then less than that in the case that advertisers are multi-homing.

Proof   When $\lambda_i = \lambda_j = \lambda$, $p_1^{cs} = p_2^{cs} = p^{cs} =$

$\dfrac{t^2 + \alpha r(1-\lambda)}{t}$, $\Pi_1^{cs} = \Pi_2^{cs} = \Pi^{cs} = \dfrac{1}{2}\left[t + \dfrac{\alpha r(1-\lambda)}{t}\right]$, p_1^{cm}

$= p_2^{cm} = p^{cm} = \dfrac{\alpha^2 r(1-\lambda) + \alpha t^2}{3\alpha r(1-\lambda) + 4t^2}$, $\Pi_1^{cm} = \Pi_2^{cm} = \Pi^{cm} =$

$\dfrac{\alpha^2[\alpha r(1-\lambda) + t^2][\alpha r(1-\lambda) + 2t^2]}{2t[3\alpha r(1-\lambda) + 4t^2]^2}$.

1) $p^{cs} - p^{cm} = \dfrac{t^2 + \alpha r(1-\lambda)}{t} - \dfrac{\alpha^2 r(1-\lambda) + \alpha t^2}{3\alpha r(1-\lambda) + 4t^2} = \dfrac{[\alpha r(1-\lambda) + t^2][3\alpha r(1-\lambda) + 4t^2 - \alpha t]}{t[3\alpha r(1-\lambda) + 4t^2]}$.

① When $\alpha < 4t$, $3\alpha r(1-\lambda) + 4t^2 - \alpha t > 0$, and $p^{cs} > p^{cm}$.

② When $\alpha > 4t$, if $0 < \lambda < 1 - \dfrac{\alpha t - 4t^2}{3\alpha r}$, $3\alpha r(1-\lambda) + 4t^2 - \alpha t > 0$, and $p^{cs} > p^{cm}$; if $1 - \dfrac{\alpha t - 4t^2}{3\alpha r} < \lambda < 1$, $3\alpha r(1-\lambda) + 4t^2 - \alpha t < 0$, and $p^{cs} < p^{cm}$.

2) $\Pi^{cs} - \Pi^{cm} = \dfrac{1}{2}\left[t + \dfrac{\alpha r(1-\lambda)}{t}\right] - \dfrac{\alpha^2[\alpha r(1-\lambda) + t^2][\alpha r(1-\lambda) + 2t^2]}{2t[3\alpha r(1-\lambda) + 4t^2]^2} = \dfrac{[\alpha r(1-\lambda) + t^2]\{[3\alpha r(1-\lambda) + 4t^2]^2 - \alpha^2[\alpha r(1-\lambda) + 2t^2]\}}{2t[3\alpha r(1-\lambda) + 4t^2]^2}$.

① When $\alpha < 2\sqrt{2}t$, $[3\alpha r(1-\lambda) + 4t^2]^2 - \alpha^2[\alpha r(1-\lambda) + 2t^2] > 0$, and $\Pi^{cs} > \Pi^{cm}$.

② When $\alpha > 2\sqrt{2}t$, if $0 < \lambda < 1 - \dfrac{\alpha\sqrt{\alpha^2 + 24t^2} + \alpha^2 - 24t^2}{18\alpha r}$, $[3\alpha r(1-\lambda) + 4t^2]^2 - \alpha^2[\alpha r(1-\lambda) + 2t^2] > 0$, and $\Pi^{cs} > \Pi^{cm}$; if $1 - \dfrac{\alpha\sqrt{\alpha^2 + 24t^2} + \alpha^2 - 24t^2}{18\alpha r} < \lambda < 1$, $[3\alpha r(1-\lambda) + 4t^2]^2 - \alpha^2[\alpha r(1-\lambda) + 2t^2] < 0$, and $\Pi^{cs} < \Pi^{cm}$.

Corollaries 7 and 8 show that media platforms should consider factors such as advertisements targeting fit in the process of participating in market competition and cautiously formulate advertising pricing strategies at different stages of the growth of media platforms. At the initial stage of operation, because of the weak advertising targeting technology, low popularity and influence, and the small number of consumers accessing the media platform, higher advertising prices should be set appropriately to maintain the steady operation of the media platforms. When the development of media platforms is relatively mature, with the enhancement of the media platform's ability to excavate consumer data and information, further improvement of the advertising targeting technology, and the increasing social influence and public awareness of the media platforms, media platforms should reduce the advertising prices to gain more profits.

5   Conclusions

1) The equilibrium advertising price of the media platform does not depend on the degree of advertising targeting fit and consumer privacy protection under a monopoly environment.

2) Under a competitive environment, when advertisers are single-homing, the equilibrium advertising price and profit of the media platform will decrease with the enhancement of their own and competitors' advertising targeting fits. When the advertising targeting fit of the media platform itself is greater than that of the competitor, the equilibrium advertising volume of the media platform decreases monotonically with the degree of consumer privacy protection and vice versa. When advertisers are multi-homing, the equilibrium advertising price, equilibrium advertising volume, and equilibrium profit of the

media platform are positively correlated with their own advertising targeting fit and negatively correlated with the competitor's targeting fit.

3) The influences of consumer privacy protection on the equilibrium advertising price, equilibrium advertising volume, and equilibrium profit of the media platform depend on the comparison between the marginal effect of the media platform's own advertising targeting fit on the equilibrium advertising price, equilibrium advertising volume, and equilibrium profit and the marginal effect of competitors' advertising targeting fit on them.

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广告定向契合度和消费者隐私保护对媒体平台收益的影响

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摘要: 基于双边市场理论模型和博弈分析方法, 分析了垄断、竞争 2 种环境下广告定向契合度和消费者隐私信息保护对媒体平台价格策略、均衡利润和广告商广告策略的影响, 以期为媒体平台和广告运营商做出正确的管理决策提供理论参考. 研究结果表明, 垄断环境下, 媒体平台的均衡广告价格不依赖于广告定向契合度和消费者隐私信息保护程度. 竞争环境下, 当广告商单归属时, 随着自身广告定向契合度和竞争对手广告定向契合度的增强, 媒体平台的均衡广告价格和均衡利润将降低, 消费者隐私信息保护程度对媒体平台均衡广告量的影响取决于媒体平台自身广告定向契合度与竞争对手广告定向契合度的对比; 当广告商多归属时, 媒体平台的均衡广告价格、均衡广告量、均衡利润与自身广告定向契合度呈正相关关系, 与竞争对手的广告定向契合度呈负相关关系. 媒体平台在参与市场竞争过程中, 应综合考虑其广告定向契合度等因素, 在其成长的不同时期, 审慎制定价格策略.

关键词: 广告定向契合度; 消费者隐私保护; 媒体平台收益; 双边市场