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The Study on Supervision Model for Online Advertising Click Fraud

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Abstract
Considering the click fraud in the online advertising market, a basic game theoretic model for click fraud is built firstly. In this model, the Ads Network can choose to make click fraud supervision or trust, and advertising publishers can choose to publish advertisement honestly or to cheat. In this paper, we get the result of the mixed strategy Nash equilibrium solution firstly and then we extend the model to the 2-supervision game model, and then discuss the effect factors when the Ads network is punished due to click fraud. Further more, the model considers the influence on click fraud caused by the competitions between the multi-publishers and then get the new result of the Nash equilibrium solution. Based on the analysis above, click fraud can be effectively prevented in the following ways: intensifying the supervision and control process, implementing penalty on advertising network, reducing information asymmetry, choosing the honest publisher to publish advertisement, building the competitive mechanism, evaluating the online advertising effectiveness in time, and signing detailed operational contract in advance.

Key words: Online advertising; Click fraud; Supervision model; Nash equilibrium

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INTRODUCTION
With the growth of the web as a marketing medium, online advertising has become increasingly important for advertisers to promote their products and services, and for numerous websites to get significant cash flow. Since search engine tycoon Google implemented the business model of click charges, click charge has become popular. However, there brings out a great amount of advertising click fraud in internet advertising market with the emergence of click charge. Click fraud refers to a natural person or organization with fraud intent to obtain illegitimate interests or consume rival's advertising budget using automation scripts, computer programs or employing natural persons to imitate legitimate web users to click on the online advertising. You never know if the other end of Internet is your real customers, or a click fraud dog! This is a great irony on click fraud phenomenon for the Internet advertising market. Nowadays, click fraud may be the main fraud behavior in online advertisement market[1-3]. This kind of fraud behavior not only severely harms the interests of the advertisers, but also causes negative influence for the reputation of network media, and at the same time, seriously hinders the development of e-commerce and Internet advertising market.

The Internet tycoon Yahoo was complained for not fully protecting the interests of advertisers, and thus advertisers suffered from the click fraud in 2005. According to the settlement, Yahoo would not only pay about $5 million legal fees, but also to postpone the deadline for accepting click fraud complaints from its advertisers. Search engine tycoon Google was also complained by several companies in the same year.

Google agreed to pay $90 million fees in mediating a settlement in March 2006[4]. Zhong Bei Wei Ke, a medical research institute in Beijing, protested malicious click fraud of Baidu Company and took Baidu to court in August 2006[5]. The network advertising click frauds attracted extensive attention of the society.

The researchers in Outsell Inc Company announced a random survey results about 407 advertisers in June2006, which showed that in the previous year, click fraud accounted for almost 14.6% of total expenditures of online advertising, amounted to $0.8 billion. 27% of advertisers have to reduce or stop the mode of CPC, and 16% of customers claimed that they had completely stopped CPC online advertising. 75% of respondents claimed that they had suffered from click fraud, 7% of respondents had requested for refund, and got the $9507 back on average[4].

As suggested by the data analysis above, click fraud makes advertisers and network media suffer huge losses, and the pay-per-click model has been questioned because of click fraud, which gives rise to credibility crisis in Internet enterprises. This phenomenon hinders healthy development for online advertising. Many scholars are paying research attentions on how to protect online advertising from click fraud and how to monitor web advertising click fraud

The paper is organized as follows. In Section 2, we review the literature regarding online advertisements involving click fraud. We also discuss operation in reality between Ads network and publisher. In Section 3, we first build the basic click fraud supervision model between Ads network and publisher, and then we extend the basic model to the 2-supervision between Ads network, publisher and advertiser. At last we extend the 2-supervision model to the supervision model with competition .We provide the managerial insights from click fraud supervision for Ads network and advertisers in Section 4. We make a summery of the study and point out the limits of the study and give a perspective in future further relating studies in Section 5.

1. LITERATURE REVIEW

Domestic and foreign scholars have done a lot of research on how to effectively get rid of click fraud. There are four strategies, according to these researches: (1) to prevent click fraud by new techniques. Andrew Bortzt and Erika Chin (2009) established a set of detection system, which is built upon practical experience and desired objective, to prevent click fraud. They also simulated and developed the Camelot system to test click fraud, and this system is now used in the Google search engine[6]. Xuhua Ding (2010) developed a technique which combines cryptography and probability. By using this technology, click fraud that advertiser deceives the advertising media is prevented[7]. Bobji Mungamuru and Stephen Weis (2008) set up the advertising economic model of pay-per-click, which stated the importance of filtering invalid click fraud from Ads network[8]. Hamed Haddadi (2010) presented Bluff Ads, a set of ads which are designed to be detected and clicked only by machines, or poorly trained click-fraud work force. This simple set of ads, mixed with ordinary ads, works as a litmus test, or a “Captcha” for the user legitimacy[9]. YuanJian and Zhang Jinsong (2009) et al proposed a strategy based on the graphic verification code to prevent click fraud[10], Zhang Zu-Lian proposed a combined algorithm based on verification code, viewing time and click frequency to prevent click fraud[11]. These strategies can effectively shield click fraud that is similar to the Trojan horse click software, therefore effectively shield browsers’ accidental unconscious invalid clicks, and significantly reduce the efficiency of artificial click fraud. (2) To prevent click fraud based on the legal sanctions and self-discipline .Wang Xianlin (2007) and Liu Chunnian (2008) et al deeply analyzed click fraud based on the unjust enrichment in terms of legal quality. On the basis of analysis, they proposed prevention measures, from the legal sanctions and self-discipline that aim at click fraud for network advertisement[12-13]. (3) To avoid click fraud based on management insights. Benjamin Edelman (2009) studied the commission which deferred payment to agents, and found it could reduce about 71% click fraud without lowering their profits[14]. Joshua Goodman (2005) proposed a method based on prior-match and display advertising in a random proportion, and the method can effective avoid click fraud and impression fraud[15]. Nicole Immorlica and Kamal Jain (2005) proposed a kind of learning algorithm based on click that can identify click fraud for a specific advertising slot[16]. (4) To prevent click fraud by introducing the third-party monitoring organizations. Sanjay Mittal and Rahul Gupta (2009) studied the impact of click fraud on the search engine business’ return under the full information and uncertain information, and they found that the interests of search engine industry would depend on the identification algorithm due to neutral third-party audit report with respect to click fraud[17]. Gao Zhijian thought that using the Internet advertising monitoring software of third-party to monitor the published network advertising can get the information on click ads. However, this approach might face the challenge of search engine enterprise; they would refuse to open backend data and explain questions, and even to challenge the monitoring results of third-party monitoring organizations[18].

Although there are many researches on click fraud, there is still inadequacy: because click fraud involves multi-stakeholders, which are advertisers, publishers and Ads network. In reality, advertisers are mostly dependent on professional Ads network or advertising agent to make and publish advertising. Ads network has rich advertising media resources. Ads network signs a contract on publishing advertisement with advertising media to finish the publishing. Therefore, click fraud involves stakeholders, advertisers, and a third party. The

aforementioned studies did not put the interests of the three parties as a whole to consider. This paper is trying to study the supervision issues of click fraud according to the three parties' interest and propose some valuable management insights for Internet advertising market.

This paper mainly focuses on the following issues: (1) Introduce ideas of supply chain management, taking advertisers, Ads network and publisher as a whole stakeholder to study new ways of monitoring click fraud. (2) To measure the probability that publisher implemented click fraud by introducing measurable coefficient of advertising service effect, technology level coefficient of monitoring and credibility coefficient of publisher in the model. (3) To set a basic supervision game model between publisher and Ads network to derive Nash equilibrium solution of monitoring probability and discuss the relation of factors which affect click fraud by Nash equilibrium solution. (4) To extend the basic game model to 2-supervision model between advertisers, Ads network and publisher, and discuss the influence on click fraud when Ads network is punished. (5) Introduce competition mechanism among multi-publishers based on the 2-supervision model and discuss the influence of introducing competition mechanism for click fraud. We have meaningful enlightenment of online advertising management by the analysis of three supervision game model.

2. MODEL SETTING AND ANALYSIS

2.1 Basic Symbols and Instructions

Table1
Basic Symbols and Instructions

Symbol	Instructions
A	Ads network (or advertising agent)
P	Online Advertising media (advertising publisher)
α	Measurement coefficient of advertisement effectiveness
β	Technology level coefficient of monitor
ω	Credibility factor coefficient of advertising media
n	Impression number of online advertising
p	Impression cost of online advertising
c	Clicks ratio of advertising
σ	Clicks cost of web advertising
a	Marginal profit of Ads network
b	Marginal cost of publisher
C	Supervision costs of Ads network
ρ	The discovered probability of Click fraud
χ	The probability of supervision for Ads network
y	The probability of publisher publish ads honestly
Φ	Additional benefit due to Click fraud for publisher
θ	Penalty due to Click fraud for publisher
ψ	Penalty that Ads network suffered from advertisers
δ	Discount factor
η	The benefits after Ads network was punished by advertiser

2.2 Setting 1-Supervision Game Model and Analysis

We assume that an Ads network A cooperates with a publisher P, while the publisher provides publishing advertisement in his website. Ads networks are dominant because they own rich media resources and advertisers, therefore they can choose publisher to match ads. However, advertising is the main profitable way for publisher. Publisher has two kinds of actions to choose when he publishes the advertising on Ads network: publish advertisement honestly or implement click fraud. The Ads network has also two kinds of actions: implement supervision or trust publisher. If the Ads network supervises the publisher then we can set supervision game model for click fraud.

Because of characteristics with disguise and invisibility for click fraud, we should consider difficulties of monitoring factors in the supervision of click fraud, and we might as well assume the measuring coefficient of advertising effectiveness is $\alpha(0 < \alpha < 1)$, and α is relevant to features of advertising service and system of ads evaluation. In addition, we assume monitor technology level of Ads network is β.The higher is β, the lower is the possibility of click fraud; and vice versa. Meanwhile, the Ads network should consider the reputation and social comprehensive evaluation factors of publishers when it outsources advertising publishing to publisher. These factors will affect the Ads network's choice of publisher and further influence quality of advertising publishing. We might as well name it as credibility factors $\omega(0 < \omega < 1)$ for publisher. The higher is ω, the bigger is the probability that publisher publishes advertising honestly.

Supposing the advertiser outsources the advertisement business to Ads network completely, and then Ads network redistributes advertising business to publisher. Assuming Ads network and publisher distribute income according to the contract in advance, which is based on hybrid compensation of the impression and click-through rate, assuming the number of impression is n, impression cost is P, click-through rate is c and click cost is σ. Supposing a is marginal profit due to click-through rate of product or service, $a > 0$. Assuming b is cost coefficient of publisher publishing ad, i.e. marginal cost ,and $b > 0$. If Ads network chooses supervision with cost C, publisher chooses to publish ads honestly, and then we can write the net profit for Ads network as:

$$\pi_{A1} = -pn - \sigma cn + a\sigma cn - C \tag{1}$$

And net profit for publisher is:

$$\pi_{P1} = pn + \sigma cn - bpn \tag{2}$$

If Ads network chooses supervision with cost C, publisher chooses to implement click fraud and the extra costs with E for publisher. The publisher gets the

additional net benefit with Φ by deducting the extra effort cost. We assume the probability of click fraud is found with $\rho(0 < \rho < 1)$ for publisher, which is closely related to monitor coefficient α, monitor technology level β and credibility factor ω, higher α, β and ω, then higher the ρ, we might as well define $\rho = \alpha\beta\omega$. We define that publisher suffers penalty θ from click fraud, then the benefit of Ads network and publisher respectively are:

$$\pi_{A2} = -pn - \sigma cn + a\sigma cn - C + \alpha\beta\omega\theta \quad (3)$$

$$\pi_{P2} = pn + \sigma cn - bpn + \Phi - \alpha\beta\omega\theta \quad (4)$$

If Ads network chooses to believe publisher which publish advertising honestly, then the revenue of Ads network and publisher respectively are as follows:

$$\pi_{A3} = -pn - \sigma cn + a\sigma cn \quad (5)$$

$$\pi_{P3} = pn + \sigma cn - bpn \quad (6)$$

Formulas (5) and (6) show that Ads network trusts the publisher who publishes advertisement honestly, Ads network and publisher get normal income. This is the ideal situation that market pursues, and the social welfare maximizes at this point.

Assuming the Ads network chooses to trust publisher who chooses to make click fraud, then we can write the benefit of Ads network as:

$$\pi_{A4} = -pn - \sigma cn + a\sigma cn \quad (7)$$

And the benefit for publisher is:

$$\pi_{P4} = pn + \sigma cn - bpn + \Phi \quad (8)$$

Therefore, we set extensive-form representation model 1 as follows:

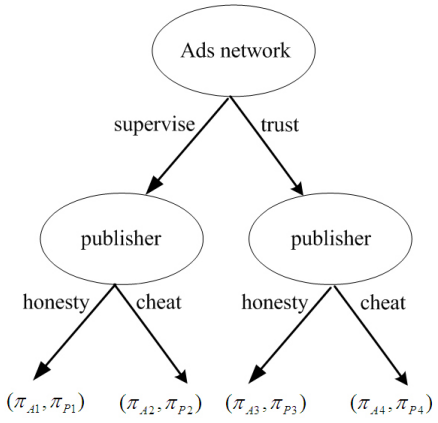

Figure1
1-Supervision Game Model1on Click Fraud

Assuming ads network chooses supervision with probability χ, and the probability of taking no supervision is $1-\chi$. Assuming publisher chooses to publish honestly with probability y, and then probability of click fraud is $1-y$. So the expected benefit of Ads network can be expressed as follows:

$$\pi_A(\chi, y) = \chi y\pi_{A1} + \chi(1-y)\pi_{A2} + (1-\chi)y\pi_{A3} + (1-\chi)(1-y)\pi_{A4} \quad (9)$$

Put formulas (1), (3), (5) and (7) into formula (9), and then differentiating (9) with respect to , we have the first-order conditions and can get the formula (10):

$$\frac{\partial \pi_A(x,y)}{\partial x} = y(\pi_{A1} - \pi_{A3}) + (1-y)(\pi_{A2} - \pi_{A4}) = 0$$
$$-yC + (1-y)(-C + \alpha\beta\omega\theta) = 0 \quad (10)$$

Solving equation (10), we can get y^* as follows:

$$y^* = 1 - \frac{C}{\alpha\beta\omega\theta}$$

Expected benefit of publisher can be expressed as formula (11):

$$\pi_P(x,y) = xy\pi_{P1} + x(1-y)\pi_{P2} + x(1-y)\pi_{P2} + (1-x)y\pi_{P3} + (1-x)(1-y)\pi_{P4} \quad (11)$$

Put formula (2), (4), (6) and (8) into formula (11), and then differentiating (11) with respect to , we have the first-order conditions and can get the formula (12):

$$\frac{\partial \pi_P(x,y)}{\partial y} = 0$$
$$x(\alpha\beta\omega\theta - \Phi) - (1-x)\Phi = 0 \quad (12)$$

Solving equation (12), we can get χ^* as follows:

$$x^* = \frac{\Phi}{\alpha\beta\omega\theta}$$

So we get mixed strategy Nash equilibrium solution as formula (13):

$$(x^*, y^*) = \left(\frac{\Phi}{\alpha\beta\omega\theta}, 1 - \frac{C}{\alpha\beta\omega\theta}\right) \quad (13)$$

Proposition 1 Supervision probability χ for Ads network is in inversely proportional to α, β, ω, θ and proportional to Φ; probability of publishing honesty for publisher is proportional to α, β, ω, θ and is inversely proportional to C.

Proof. we can get proposition 1 from formula $x^* = \frac{\Phi}{\alpha\beta\omega\theta}$ and $y^* = 1 - \frac{C}{\alpha\beta\omega\theta}$, the conclusion is obvious.

With the measurable degree α of advertising service easy to measure, the higher is the monitor technology level β,so is the credibility factor ω for publisher, and the cost of penalty θ for the publisher ,but the supervision

probability is lower for the Ads network, and the probability y is higher that publisher publishes online advertising honestly. Therefore, in cooperation with the process of publisher, the Ads network should study seriously identifiable system for the publishers' behavior in order to increase identification probability α; Ads network should improve monitor technology level β to reduce the possibility of fraud; cooperate with reputable and the high qualified publisher as much as possible. On the other hand, Ads network should add the penalty in order to encourage publisher to publish advertisement honestly, and reduce the cost of supervision for Ads network.

Proposition 2 The basic conditions are $C \le \alpha\beta\omega\theta$ according to the contract in which Ads network cooperate with publisher.

Proof. As probability that publisher publishes online advertising honestly without doing click fraud must meet the conditions as following:

$$y = 1 - \frac{C}{\alpha\beta\omega\theta} \ge 0, \text{ i.e. it must meet } \frac{C}{\alpha\beta\omega\theta} \le 1,$$

So, we can get the conclusion:

$C \le \alpha\beta\omega\theta$ (QED)

Proposition 2 shows that supervision costs for Ads network must not be more than the compensation of click fraud $\alpha\beta\omega\theta$. Otherwise, once the supervision costs are more than $\alpha\beta\omega\theta$, both parties of contract can't guarantee publishing advertising according to the contract.

Proposition 3 The more additional revenue Φ, the more supervision probability χ; the more supervision cost C, the lower probability that publisher accomplishes the publishing ads honestly.

If the benefit of click fraud is greater for publisher, then the publisher has greater motivation to make click fraud, so it is more necessary to supervise publisher for the Ads network; publisher knows that supervision cost is higher and anticipates the possibility of supervision is lower for Ads network, then the possibility in which publisher makes click fraud is higher without publishing advertising honestly.

2.3 Setting 2-Supervision Game Model and Analysis

Now we extend further the model 1 to2-supervision game model, for the service supply chain, as illustrated with figure2, in the process of cooperation with publisher, not only does the Ads network consider supervising and working out a penalty θ to publisher, but also advertiser consider working out a penalty ψ to Ads network. Now we consider the impact with ψ for supervision of click fraud.

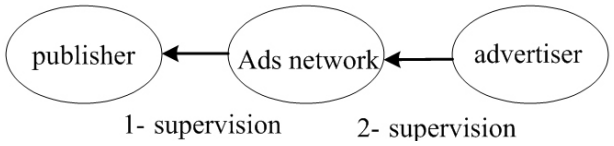

Figure 2
2-Supervision of Click Fraud

If Ads network chooses supervision with cost C and publisher chooses to publish honestly, therefore, we can write the net profit for Ads network as follows:

$$\pi'_{A1} = -pn - \sigma cn + a\sigma cn - C \tag{14}$$

And net profit for publisher is:

$$\pi'_{P1} = pn + \sigma cn - bpn \tag{15}$$

If the publisher chooses to make click fraud, then the publisher can get additional benefit Φ. If Ads network chooses supervision, then the probability of click fraud is found with for $\alpha\beta\omega$ publisher. We assume the penalty is θ for publisher now. And probability of not finding click fraud is $1 - \alpha\beta\omega$, if the Ads network suffers penalty from advertiser with the penalty ψ, and then the benefit of Ads network and publisher respectively are as follows:

$$\pi'_{A2} = -pn - \sigma cn + a\sigma cn - C + \alpha\beta\omega\theta - (1 - \alpha\beta\omega)\psi \tag{16}$$

$$\pi'_{P2} = pn + \sigma cn - bpn + \Phi - \alpha\beta\omega\theta \tag{17}$$

If Ads network chooses to trust publisher which publish advertising honestly, then the benefit of Ads network and publisher respectively are as follows:

$$\pi'_{A3} = -pn - \sigma cn + a\sigma cn \tag{18}$$

$$\pi'_{P3} = pn + \sigma cn - bpn \tag{19}$$

Assuming the Ads network chooses to trust publisher which chooses to implement click fraud, then we can write the benefit of Ads network as follows:

$$\pi'_{A4} = -pn - \sigma cn + a\sigma cn - \psi \tag{20}$$

And benefit for publisher is:

$$\pi'_{P4} = pn + \sigma cn - bpn + \Phi \tag{21}$$

Therefore, we set extensive-form representation model 2 as follows:

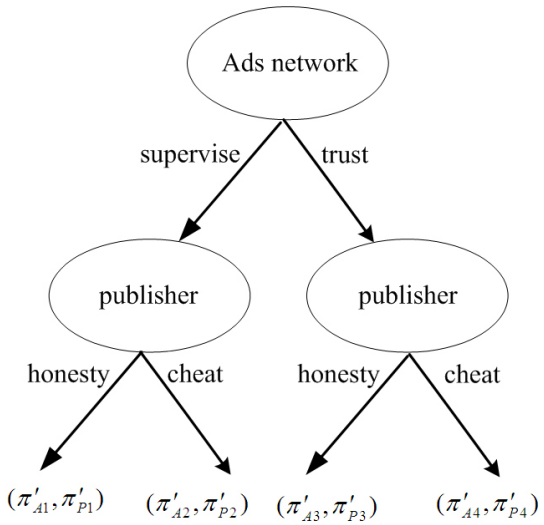

Figure 3
2-Supervision Game Model1on

Assuming ads network chooses supervision with probability χ, and then trusting publisher without supervising probability is $1-\chi$, assuming publisher chooses to publish honestly with probability y, and then probability of click fraud is $1-y$, so the expected benefit of Ads network can be expressed as follows:

$$\pi'_A(\chi,y)=\chi y\pi'_{A1}+\chi(1-y)\pi'_{A2}+(1-\chi)y\pi'_{A3}+(1-\chi)(1-y)\pi'_{A4} \quad (22)$$

Put formula (14), (16), (18) and (20) into formula (22), and we can rewrite formula (22) as follows:

$$\pi'_A(x,y)=xy(\pi'_{A3}-C)+x(1-y)(\pi'_{A3}-C+\alpha\beta\omega\theta -(1-\alpha\beta\omega)\Psi)+(1-x)y\pi'_{A3}+(1-x)(1-y)(\pi'_{A3}-\Psi) \quad (23)$$

And then differentiating (23) with respect to , we have the first-order conditions and get the formula as follows:

$$\frac{\partial\pi'_A(x,y)}{\partial x}=0$$

Solving equation above, we can get y'^* as follows:

$$y'^*=1-\frac{C}{\alpha\beta\omega(\theta+\Psi)}$$

Expected benefit of publisher can be expressed as formula (24):

$$\pi'_p(\chi,y)=\chi y\pi'_{p1}+\chi(1-y)\pi'_{p2}+(1-\chi)y\pi'_{p3}+(1-\chi)(1-y)\pi'_{p4} \quad (24)$$

Put formulas (15), (17), (19) and (21) into formula (24), and we can rewrite formula (24) as formula (25):

$$\pi'_p(x,y)=xy\pi'_{p3}+x(1-y)(\pi'_{p3}+\Phi-\alpha\beta\omega\theta) +(1-x)\left[y\pi'_{p3}+(1-y)(\pi'_{p3}+\Phi)\right] \quad (25)$$

And then differentiating (25) with respect to y, we have the first-order conditions and get the formula as follows:

$$\frac{\partial\pi'_A(x,y)}{\partial y}=0$$

Solving equation above, we can get χ'^* as follows

$$x(\alpha\beta\omega\theta-\Phi)-(1-x)\Phi=0$$

$$x'^*=\frac{\Phi}{\alpha\beta\omega\theta}$$

So we get mixed strategy Nash equilibrium solution as formula (26):

$$(x'^*,y'^*)=\left\{\frac{\Phi}{\alpha\beta\omega\theta},1-\frac{C}{\alpha\beta\omega(\theta+\Psi)}\right\} \quad (26)$$

Proposition 4 It can reduce probability of supervision for Ads network and probability of click fraud for publisher if advertiser makes penalty to Ads network, and the higher ψ, the smaller the probability of click fraud.

Proof. As advertiser makes penalty ψ to Ads network A, without loss of generality, the penalty θ is greater than θ_0 which Ads network punishes publisher before publisher has not been suffered from penalty. We might as well suppose $\theta_1 = \theta_0 + \zeta$, without considering the advertiser punishes the Ads network with penalty ψ, so, there is the formula as follows:

$$(x_0^*,y_0^*)=\left(\frac{\Phi}{\alpha\beta\omega\theta_0},1-\frac{C}{2B+\alpha\beta\omega\theta_0}\right)$$

When advertisers punish Ads network with penalty ψ, there is a formula as following:

$$(x'^*,y'^*)=\left(\frac{\Phi}{\alpha\beta\omega\theta_1},1-\frac{C}{\alpha\beta\omega(\theta_1+\Psi)}\right) =\left(\frac{\Phi}{\alpha\beta\omega(\theta_0+\zeta)},1-\frac{C}{\alpha\beta\omega(\theta_0+\zeta+\Psi)}\right)$$

Correspondingly, Compare χ_0^*, y_0^* with χ'^*, y'^* it is obvious that in the case of Φ, C, α, ω given, there must have the formulas that $\chi'^*<\chi_0^*$, $y'^*>y_0^*$ and $\chi'^*<\chi_0^*$, $1-y'^*<1-y_0^*$, i.e. Probability of supervision for Ads network and probability of click fraud for publisher are reduced.

Publisher publishes advertisement honestly with probability from formula (26), we know the formula , $y=1-\frac{C}{\alpha\beta\omega(\theta+\Psi)}$ when ψ is increasing, then the probability of click fraud $1-y=\frac{C}{\alpha\beta\omega(\theta+\Psi)}$ will reduce. (QED)

2.4 Setting Supervision Model and Analysis with Competition

We will further extend the model as shown in the figure 4 on online advertising service supply chain with two selected publisher P_1 and P_2, we now consider the influence due to the existence of P_2 for P_1, we now might as well suppose that Ads network takes the penalty

strategy as follows: if P_1 can't publish advertisement honestly, i.e. P_1 makes click fraud, then the Ads network will choose P_2, and give up cooperation with P_1. According to the Folk Theorem, if players are patient enough in a multi-stage game, then there is a sub-game refined Nash equilibrium which is better than single-stage. Publisher will choose the scheme that maximizes total revenue in the long run. We define δ as the discount rate.

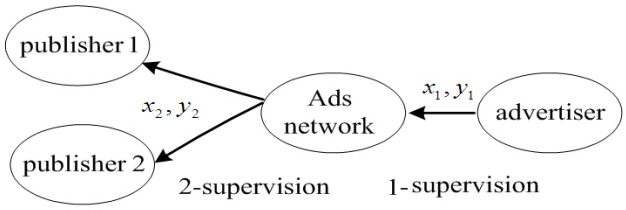

Figure 4
Supervision of Click Fraud with Competition

Assuming publisher chooses to publish advertisement honestly, then publisher' net benefit is $\pi_{P1} = pn + \sigma cn - bpn$, assuming that publisher chooses to make click fraud and obtain additional benefit with Φ; if Ads network chooses supervision, publisher making click fraud is found with probability $\alpha\beta\omega$. Then the publisher suffers one-off from penalty θ, after Ads network found publisher made click fraud, taking additional penalty, i.e. cooperation with publisher in the subsequent, Ads network will reduce the benefit for publisher, supposing the benefit for publisher is only η and $0 \le \eta \le pn + \sigma cn - bpn$.

In the case that Ads network chooses supervision, if the publisher chooses to publish advertisement honestly, assuming π_L^1 is the expected long-term benefits for publisher, if publisher chooses making click fraud, then its expected benefits is π_S^1, so we can get the formulas (27) and (28) respectively as follows:

$$\pi_L^1 = \pi_{P_1} + \pi_{P_1}\delta + \pi_{P_1}\delta^2 + \ldots\ldots = \frac{\pi_{P_1}}{1-\delta} \tag{27}$$

$$\pi_S^1 = \pi_{P_1} + \Phi - \alpha\beta\omega\theta + \eta\delta + \eta\delta^2 + \ldots = \pi_{P_1} + \Phi - \alpha\beta\omega\theta + \frac{\eta\delta}{1-\delta} \tag{28}$$

In the case that Ads network doesn't choose supervision, if the publisher chooses publishing advertising honestly, assuming π_L^2 is the expected long-term benefits for publisher, if publisher chooses to make click fraud, then its expected benefits is π_S^2, so we can get the formulas (29) and (30) respectively as follows:

$$\pi_L^2 = \pi_L^1 = \frac{\pi_{P_1}}{1-\delta} \tag{29}$$

$$\pi_S^2 = \pi_{P_1} + \Phi + \eta\delta + \eta\delta^2 + \ldots = \pi_{P_1} + \Phi + \frac{\eta\delta}{1-\delta} \tag{30}$$

So the expected benefit for the publisher is P_1 as follows:

$$\begin{aligned}(x,y) &= x\left[y\pi_L^1 + (1-y)\pi_S^1\right] + (1-x)\left[y\pi_L^2 + (1-y)\pi_S^2\right] \\ &= xy\frac{\pi_{P_1}}{1-\delta} + x(1-y)\left(\pi_{P_1} + \Phi - \alpha\beta\omega\theta + \frac{\eta\delta}{1-\delta}\right) \\ &\quad + (1-x)y\frac{\pi_{P_1}}{1-\delta} + (1-x)(1-y)\left(\pi_{P_1} + \Phi + \frac{\eta\delta}{1-\delta}\right) \\ &= y\frac{\pi_{P_1}}{1-\delta} + (1-y)(\pi_{P_1} + \Phi) - x(1-y)\alpha\beta\omega\theta + (1-y)\frac{\eta\delta}{1-\delta}\end{aligned} \tag{31}$$

Because the Ads network has multi-publisher available, the revenue function is unchanged for Ads network. And then differentiating formula (31) with respect to y, we have the first-order conditions and get the formula as follows:

$$\begin{aligned}&\frac{\partial \pi_{P1}(x,y)}{\partial y} = 0 \\ &\frac{\pi_{P_1}}{1-\delta} - (\pi_{P_1} + \Phi) + x\alpha\beta\omega\theta - \frac{\eta\delta}{1-\delta} = 0 \\ &x = \frac{\eta\delta}{(1-\delta)\alpha\beta\omega\theta} + \frac{\pi_{P_1} + \Phi}{\alpha\beta\omega\theta} - \frac{\pi_{P_1}}{(1-\delta)\alpha\beta\omega\theta}\end{aligned} \tag{32}$$

Proposition 5 The more severe additional penalty η, the greater discount rate δ, and then the lower probability of supervision for the Ads network.

Proof. Formula (32) consists of three terms: the first term represents the contribution for additional penalty; the 2nd term represents the contribution for revenue of click fraud; and the third term represents the contribution for the publisher publishing advertising honestly. The more severe additional penalty i.e. η is, then the smaller contribution additional penalty factor, therefore, χ is smaller.

Differentiating formula (32) with respect to δ, we have

$$\begin{aligned}\frac{\partial x}{\partial \delta} &= \frac{\eta}{\alpha\beta\omega\theta}\frac{1}{(1-\delta)^2} - \frac{\pi_{P_1}}{\alpha\beta\omega\theta}\frac{1}{(1-\delta)^2} \\ &= \frac{1}{(1-\delta)^2}\frac{\eta - \pi_{P_1}}{\alpha\beta\omega\theta}\end{aligned}$$

Therefore, we can get $\frac{\partial x}{\partial \delta} < 0$ due to assumption $0 \le \eta \le \pi_{P1}$ So, with the increased discount rate δ, the lower probability of supervision that Ads network chooses supervision.

3. MANAGEMENT INSIGHTS

Monitoring click fraud is very difficult and complicated for Ads network, due to characteristics with concealment and across time-space for network, especially owing to advances in modern information technology which provide much convenience for the click fraud. Therefore, it needs the support of technology and management mechanism designed for supervising click fraud. It will

flow easily in theory because of backward technology of supervision, and unsound management mechanism of monitoring. According to the analysis of the model above, we propose the management insights as following:

(1) Ads network needs to invest certain human and material costs, to improve advanced technology and set up effective supervision system and management mechanism to prevent click fraud.

(2) Strengthen the supervision and control in the process of cooperation with publisher and reducing the information asymmetry. Information asymmetry is the main factor which causes click fraud when Ads network assigns publishing advertising to publisher. Therefore, it can reduce the probability of click fraud by decreasing the information asymmetry on both sides. It can reinforce the supervision and control over publisher by strengthening the comprehensive analysis of qualification, credibility and historical information, and by building shared management information system,

(3) Build appropriate competition mechanism. The Ads network should make more publishers join in Ads network, and keep in touch with advertiser. It can foster competition mechanism and competitive pressure by assigning advertisement publishing to different publishers. And at the same time, Ads network should build comprehensive evaluation system and appropriate elimination mechanism to encourage publisher to publish advertisement honestly and reduce the probability of click fraud.

(4) Combine the penalty mechanism that advertiser uses to punish the Ads network with the mechanism that the Ads network uses to punish publisher. Only when all the members of supply chain have gained the benefits must they make efforts on supervision to maximize the profit. Therefore, all situations should be taken into consideration in advance of prior-contract. In the contract, it must define the rights and obligations which the partners must abide by in the contract, and specify clear penalty standard, too. For standards on contract ensure execution in argument of parties.

(5) Evaluate the performance of online advertising in the process of publishing. Check the effectiveness of advertising periodically, and find the issues existing in click fraud in time. If there is click fraud, the Ads network should make punishment immediately according to the contract or suspend cooperation with the publisher to avoid suffering more losses for the advertiser.

CONCLUSIONS AND PROSPECTS

Click fraud is currently the most threatening challenge in online advertising market. Only by strengthening the supervision and management can the advertisers avoid suffering loss, and can Internet advertising market be made sound and clean. We build the basic supervision model of click fraud among the Ads network, publisher and advertisers based on the game theory, extend the basic game model to 2-supervision model among advertisers, Ads network and publisher, and extend the basic game model to 2-supervision model accompany with competition. Our studies focus on the relationship between α, β, ω, θ, Φ, ψ on the probability of supervision for Ads network and probability of click fraud respectively.

This study is limited to the supervision game among advertisers, Ads networks and publisher without consideration supervision for competitors of advertisers and competitors of Ads network and other stakeholders, which will involve the supervision of the multi-dimensional game and will also be worthy of further study. In the process of actual publishing advertising, there is possibility that the Ads network unite for publisher to make click fraud. Therefore, it is worthy of further research on co-click fraud.

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