# The Advertising in Free-to-play Games: A Game Theory Analysis

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## ABSTRACT

With the rapid market growth of free-to-play games, how to choose a proper revenue model becomes an important problem for the game provider. The classical method is the in-game purchase. To utilize the large install base of the free-to-play games, numerous game providers have also adopted advertising. This paper analyzes the mixing revenue model of the in-game purchase (premium subscription) and advertising. Taken the player's snobbery into consideration, we prove the mixing revenue model existing equilibrium in a two-stage Stackelberg model. The experimental result provides theoretical support in the design of the revenue model of the free-to-play games.

## CCS CONCEPTS

• **Applied computing** → **Economics**; **Computer games**.

## KEYWORDS

free-to-play, in-game purchase, videogame, game theory

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## 1 INTRODUCTION

The game industry witnesses rapid market growth in recent years, especially mobile games, which shows great chances for game providers. It is reported that over 75% of APPs revenue came from mobile game purchases in 2018 [6]. On the mobile platform, the free-to-play (F2P) games are the most popular revenue model. In the F2P model, the game provider offers the free service simultaneously with the premium service. The premium services can be a part of the gameplay or a better game experience that cannot be accessed without the payment of players. The method to set the discrimination is not the key point of this work. Simultaneously, we mainly pay attention to how the player enters the premium and the economic model under these circumstances.

The in-game purchase is the most general method applied by game providers. Under this revenue model, the player would use real currency to exchange virtual currency or unblock premium modules through the micro-transaction (e.g., Pokemon GO [1] and Clash of Clans [2]). The profit of this revenue model is only contributed by a small number of players, where there is a report that pointed only 1-5 percent of users purchase virtual items in F2P games [13]. These players are called "whales." It is reported that 0.19% whales contribute half of the revenue in F2P games [2]. However, most players are freeloaders. These players cannot profit directly to game providers and suffer a reduced game experience compared with those premium players. With the stiff competition in the F2P game market, the game providers start thinking about monetizing the large install base of the F2P player.

To solve the fore-mentioned problem, the game providers adopt the advertising incentive by introducing the advertisers into the market. The advertising incentive method monetizes the player's playtime, which means the players can access the premium modules by watching in-game ads. Theoretically, players contribute to the profit of the game provider so long as players spend time in the game. This kind of revenue model is distinguished in the F2P games, which is relatively easy to place ads. A large and stable install base can support the long run of the advertising revenue model.

Some off-the-shelve games also adopt the mixed revenue model of both in-game purchase and advertising like the Tuski [3] and the Summer Pop [4]. In this revenue model, the players can either monetize the playtime by ads watching or directly pay with real currency [9]. The profit comes from the willingness of those "whales" and the playtime of the freeloaders. The success of the commercial application has proved this model. However, few academic research discussed the mixed freemium revenue model (hereafter, we call this revenue model the mixed model). The theoretical analysis of the mixed model is emerging and vital with the growth of the market. In this paper, we use the game theory to analyze the mixed model and prove the game provider, players, and advertisers' equilibrium. The experimental results demonstrate the mixed model is a win-win-win strategy for the game provider, players, and advertisers. After that, we also take an insight into the mixed model and give some suggestions for the practices.


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[1] https://www.pokemon.com/us/app/pokemon-go/
[2] https://supercell.com/en/games/clashofclans/
[3] https://play.google.com/store/apps/details?id=com.hyperbeard.tsukihl=zhgl=US
[4] https://en.happyelements.com/games/clover?language=1

The rest of the paper is arranged as follows. Section 2 provides a literature review of F2P games and the advertising in games. The methodology adopted in this work is described in Section 3. Section 4 presents notations and the model. The result of the analysis is shown in Section 5. Finally, we conclude our work in Section 6.

## 2 RELATED WORK

We review the literature on freemium economics and advertising in games in this section.

### 2.1 The free videogame business model

With the rising of the game industry, many works about game economics and its pricing strategy have been known to the public. Vesa Pulkkinen [12] discussed how game companies design different kinds of game mechanics to make the player behave in a wanted economic way in mobile games. Greg Mangan [8] built a game-theoretic model of firm and consumer under the freemium pricing model and showed that it is generally an optimal choice for firms in the face of uncertainty over their customers' willingness to pay. Mishra et al. [10] consider the optimal pricing of a freemium product offered by a firm to consumers who are less averse and showed that the consumer behavior counters the common expectation that when the firm has more available units, it should sell them cheaper to avoid the risk of unsold inventory. Meng et al. [9] studied how the virtual selling strategy leads to different market outcomes than the traditional real selling strategy where players can purchase the premium module using real currency directly. Geng et al. [3] established a model to facilitate the trade-off study in the pricing of virtual goods between increasing the total installed base and maintaining scarcity, which revealed that the firm earns a growing profit by ratcheting up the premium price as the intensity of snobbery increases beyond a certain threshold. The works mentioned above have comprehensively studied the pricing and economics problem in F2P games, but they do not consider the advertisement rewarding, which commonly appears in current F2P games. Therefore, in this paper, we will discuss the situation under advertising placement in F2P games.

### 2.2 Advertisement In free Videogame

To reduce the negative effect of in-game purchases while keeping a substantial income, the provider can adopt advertisement incentives in their game ecosystem. The feasibility of advertising in the F2P game is also discussed in [7]. The effect of ads in video games is discussed both by the view of providers and customers in [5] and [11]. The advertisement slots created by operators are sold to advertisers who want to promote their brands or products. At the same time, the operators will offer virtual assets to players who spent time watching advertisements. In this business model, since players' playtime becomes valuable, operators can benefit from the advertisers instead of charging the players directly. Although the operator shares a part of the surplus with advertisers, the mechanism of gameplay becomes relatively more fair and sustainable. This mode benefits the long-term running of the game because the players are more likely to have a longer playing time, and the model can also extend the game life cycle.

We consider the "wear-out" effect of the advertisement in this work. The ads aim to broadcast the advertisers' products or their brand. The ad watchers, players in F2P games, were impressed by repeating showing of ads content. However, the ad watchers may feel aesthetic fatigue when the same content occurs frequently. Hence, the relation of the number of ad watching v.s. the broadcasting effect is first increasing then decreasing. In [14], the authors consider the rewards of advertisement watching in the cellphone data plan. They use a quadratic equation to capture the wear-out effect. We adopt a similar method to present the wear-out effect in our model.

## 3 METHODOLOGY

We specifically focus on the analysis of one video game in this work. The only game provider monopolized the market. The game provider offers all the sales strategies and gameplay. The provider aims to maximize its revenue with the negligent marginal cost. We only consider the long-run revenue after the investment in game development—operating costs and server maintenance costs are negligible. Hence, the marginal of the provider is zero in the model. These assumption are generally adopted by many video games economics studies [4] [10]. For keeping the snobbery of the premium players and encouraging the heavy users subscribing the premium, the provider should set the upper bound of the advertising incentives to freemium players. Otherwise, the snobbery of the premium player makes no sense when the freemium player can access the full experience of the premium player just by watching ads. The value gap between the premium and freemium promises the snobbery.

The video game is not Necessity good. Most video game players are searching for fun in the game. We assume that all the players are rational, making decisions with the best payoff of his/her player type. No players choose to compromise with the payoff between 0 and optimal. The preference of players is the user type, a parameter reflecting the valuation of the game. Therefore, we can modernize the complicated player's subjective preferences in one parameter.

Advertisers purchase ad slots and broadcast their products or brands through advertisements. The wear-out effect is taken into consideration. The advertising impression of the ad is not positive linear correlated with the number of ads. Players may be fatigue with the same content and the overall advertising effect decreases. The advertiser should decide the number of ad slots to purchase to optimize its payoff.

We model the interactions among the operators, players, and advertisers by a two-stage Stackelberg game. Both players and advertisers are followers after the decision of the game provider.

In Stage I, the provider offers gameplay to players. The income of the provider comes from direct virtual asset selling and advertisement slot selling. The aim of the provider is to maximize its income. The provider should decide the price of the premium, the incentive coefficient of the ad watching (i.e., how many virtual coins award to each completion of ad watching.), and the price of the slot for the advertisers. In Stage II, the players should decide whether to enter the premium. If the player chooses to be a freeloader, he/she should then decide the number of advertisements to watch. The strategy is for maximizing players' payoff. The payoff function consists of three parts, the gain of gameplay utility, the extra incentive by premium or ad watching, and a fixed cost of playing (i.e., time cost, network fees, and electrical bills). Meanwhile, the advertisers decide the number of ad slots to purchase. The brand promotion effect is related to both the number of slots purchased and the average utility of the players watching the ad.

Similar to many other classical Stackelberg games, we will try to use backward induction to analyze the behavior of each party in the game. This paper aims to formulate key aspects in the game and find out potential equilibrium with reasonable explanations.

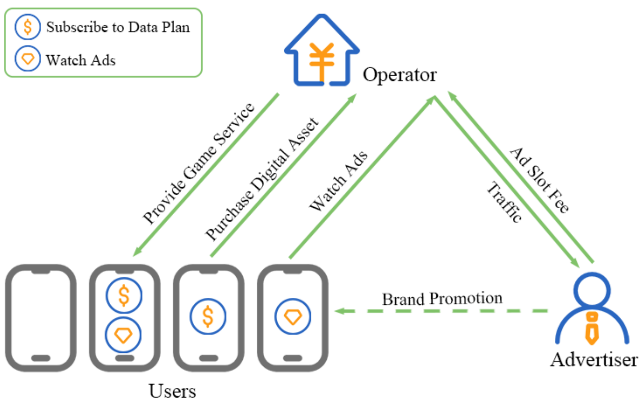


**Figure 1: Advertisement reward model in a free videogame. By introducing advertisers, the contradiction of the game fairness and economic aggregation eases.**

## 4 MODEL

In this section, we define the notations and payoff functions for players, advertisers, and the provider.

### 4.1 Player

In this work, we denote the total number of players as #?. The player type \ is a distribution in \ ∈ [0• \<0G] denoted as 6(\). \ = 0 means the game is meaningless to the player. When \ = 1, the valuation of the game to the player is equal to the game provider's design. \ can also be larger than 1, which means the valuation to the player is even larger than what the game provider expects. Without loss of generality, we set the 6(\) as the uniform distribution. The \ affects the player's valuation of the game. Larger \ means the player acquires higher utility from the gameplay service.

In the freemium revenue model, we define the provider as the monopoly that sells gameplay to players and advertisement slots to advertisers. It provides two service qualities to the player: (5A44 as basic service free to all players and (?A4<8D< as premium service to subscribers. The value discrepancy between two versions is = (?A4<8D< − (5A44 ¡ 0 , which is similar with the definition in previous work [3]. In the case of this work, we assume that the player would not access to the advertisement incentive as long as they enter the premium subscription. The ad-free feature contributes to part of , the value discrepancy.

Then we can obtain the gameplay utility term `.

` = \ [(1 − A)(5A44 + A(?A4<8D<]•A ∈ {0•1} (1)

where A is a binary indicator of whether the player subscribing to the premium plan. Once the player becomes the premium, all the ads will be removed for a better game experience. The premium player automatically gives up the incentive by watching ads.

Besides the utility of gameplay itself, the snobbery externality is also taken into players' payoff function. The premium players' snobbery comes from the feeling of superiority to freemium players. It is a complex affective factor. In our model, we only consider the effect of the install base on the snobbery. That is, the snobbery externality gain is a function 1(·) related to the number of active players #?. The snobbery is positively related to the total number of active players #?. On the other side, the price of the premium will degrade the total payoff gain of snobbery externality. For premium players, the snobbery externality can be represented as

= \1(#?) − ?6• (2)

The advertising incentive gives partial premium experience to freemium players. Instead of directly purchasing with real currency, freemium players spend their playtime and game experience to acquire the premium. The experience they get should not equal or larger than the real premium players. Otherwise, no rational player would subscribe to the premium. The revenue model degrades to pure advertising. In our model, the rewarding premium experience is homogeneous for all ad slots. A factor W is the percentage of experience gap rewarding to the freemium player. The time cost in terms of game utility is not in liner with the number of ads watching. More ad watching makes the game experience reducing more. Thereinto, the time cost function 2(·) is an increasing concave function with respect to the number of ads watching <. For freemium players, the snobbery externality can be defined as

= \W< − 2(<)• (3)

The non-monetary fixed cost for freemium and premium players are assumed to be the same (playing time, network traffic fees, etc.) and denoted as . Here the time cost is for the time other than watching ads, this fixed cost part for both premium player and freemium player are the same. We then get the payoff function of the player:

P?;0~4A(A•<) = ` + − (4)

### 4.2 Advertiser

Assume there are advertisers in the market. #B is the total ad slots created by players, which is denoted as

#B = ∫ 1 0 \<0G (1 − A)6(\)<*(\•W)3\ (5)

As the related work part, the player might be tired of watching ads. We consider the "wear-out" effect in advertising as a quadratic relationship between the ad repetition and the advertising's effectiveness [14][1]. We define as a quadratic function of the ratio of #03 and #B. Hence, in our model, the notation of is

= (#03/#B) − (#03/#B)^2 (6)

where • ¡ 0 are constant hyper-parameter determined by practice. The payoff function of advertisers is the brand broadcasting effectiveness minus the cost of purchasing the ad slots, shown as

$$\mathcal{P}^{03E4AC8B4A} = \quad - ?_0 \#_{03} \tag{7}$$

## 4.3 Provider

The gameplay provider's payoff function consists of two parts: the premium subscription fees and ad slots selling. The marginal cost for the provider is negligible. And the cost term hence is fixed in the payoff function of the provider and does not affect the optimal decision of the provider; we leave out the cost term in the analysis. Therefore, the payoff function of the provider is defined as

$$\mathcal{P}^{?A>E834A}(?_6 • ?_0 • W) = ?_6 \#_{??} + ?_0 \quad \#^*_{03} \tag{8}$$

where $\#??$ is the number of premium subscription.

# 5 RESULT

In this section, we analyze the two-stage game. Ads are removed for premium players. They cannot get rewards by watching ads. Backward induction is adopted in the analysis of the Stackelberg game. We first get the optimal strategies in stage II, then stage I.

## 5.1 Player Decisions in Stage II

Given the premium subscription price $?_6$ and ad incentive factor $W$, a $\backslash$ type player solves the problem:

$$\begin{aligned} \max_{A \in \{0•1\} • < \in Z} \quad & \mathcal{P}^{?;0\sim 4A}(\backslash • A • < • W) \\ \text{s.t.} \quad & A< = 0 \\ & W< \leq 1 \end{aligned} \tag{9}$$

Where the constrain $A< = 0$ limits the player choice of either premium subscription or advertisement incentive. Ads are removed for the premium players. The constrain $W< \leq 1$ limits the maximal ad incentive rewarding. The freemium player can only experience part of premium modules. The strategies for different player types are different. We emphasize some important player types next.

First, denote $\backslash_0$ as the entering player type. Player will play the game only when player's $\backslash$ larger than $\backslash_0 = \frac{}{(_{5A44}}$. All player with player types less than $\backslash_0$ neither subscript premium nor watch ads.

The payoff increasing for freemium player is limited. The rational freemium player would watch no more ads than $<^*(\backslash • W) = 2'^{-1}(\backslash W \quad)$. Here, $2'^{-1}(\cdot)$ is the inverse function of $2'(\cdot)$. If the The maximum payoff for a freemium player in type $\backslash$ is

$$\mathcal{P}^*_{5A44} = \backslash (_{5A44} + \backslash W <^* \quad - 2(<^*) - \tag{10}$$

In the mean time, the payoff function of the player type $\backslash$ entering premium is:

$$\mathcal{P}_{?A4<8D<} = \backslash (_{?A4<8D<} + \backslash 1(\#_?) - ?_6 - \tag{11}$$

The player is willing to enter the premium only when $\mathcal{P}^*_{5A44}$ Ÿ $\mathcal{P}_{?A4<8D<}$. Hence, we can get the edge condition that it is the same for the player to choose the premium or freemium. We denote it as $\backslash_1$,

$$\backslash_1 = \frac{2(<^*) - ?_6}{+ W <^* \quad - 1(\#_?)} \tag{12}$$

all player type larger than $\backslash_1$ will enter the premium.

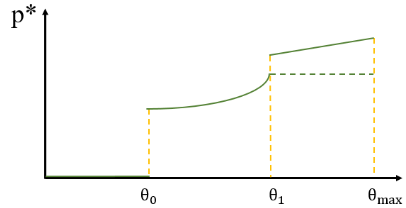


**Figure 2: The optimal payoff with respect to player types. The player type smaller than $\backslash_0$ is with zero payoffs because of the out-of-gameplay.**

Fig. 2 illustrates the optimal payoff of different player types. The payoff function in $[\backslash_0 • \backslash_1]$ is a concave function with respect to $\backslash$. There may occur a jump of payoff at $\backslash_1$, which shifts to the premium. The further increase of premium is linear with the player type in $[\backslash_1 • \backslash_{<0G}]$.

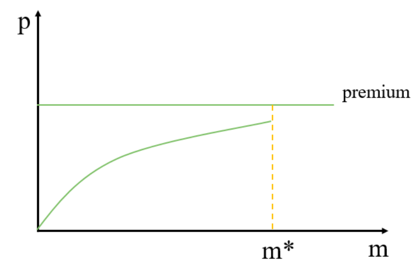


**Figure 3: The figure shows the different decision's payoff of the player types between $\backslash_0$ and $\backslash_1$.**

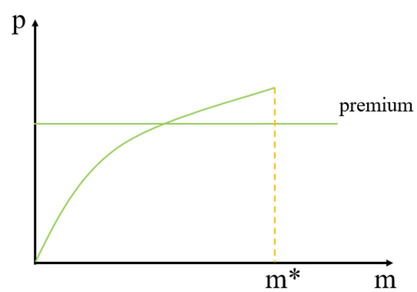


**Figure 4: The figure shows the different decision's payoff of the player types between $\backslash_1$ and $\backslash_{<0G}$.**

Fig. 4 and Fig. 3 show the decisions of the player types in range $[\backslash_0 • \backslash_1]$ and $[\backslash_1 • \backslash_{<0G}]$. The rational players in the range should choose the maximal payoff across all decisions. The incentive of ads watching reaches the upper bound at $<^*$. It is higher than premium in $[\backslash_0 • \backslash_1]$ and lower than premium in $[\backslash_1 • \backslash_{<0G}]$. Whether higher than premium determine the choice of entering premium.

### 5.2 advertiser Decisions in Stage II

Given $?_0$ and W, advertisers should solve the optimal of:

$$\max_{\#_{03} \in \mathbb{Z}} \mathcal{P}^{03E4AC8B4A}(\#_{03}, ?_0, W) \quad (13)$$

where the payoff $\mathcal{P}$ is given in 7. The optimal strategy of the advertisers is then in three cases.

Case 1: When $\#_B = 0$. In this case, no available ad slots generated by the players. This case may cause by the low install base or the low ad incentive. The advertisers will not purchase any slot, $\#_{03} = 0$.

Case 2: when $?_0 \geq \frac{}{\#_B} - \frac{2}{\#_B^2}$, the ad price is expensive than advisers expectation. Although there may be enough ad slot, advertisers would not purchase any ad slot, $\#_{03} = 0$.

Case3: when $0 \leq ?_0 \leq \frac{}{\#_B} - \frac{2}{\#_B^2}$, the optimal number of ad to purchase is

$$\#_{03}{}^*(?_0, W) = \frac{}{2}\#_B - \frac{?_0}{2}\#_B{}^2 \quad (14)$$

In equation 14, $\#^*_{03}$ decreases with the degree of wear-out effect . The result is consistent with a previous study with a similar wear-out effect definition. Higher ad slot price also makes advertisers buy fewer slots.

### 5.3 Provider Decisions in Stage I

The provider obtains revenue from both premium subscriptions and ad selling. The number of premium is:

$$\#_{??} = \# \int_{\backslash_1}^{1} \backslash_{<0G}\, 6(\backslash) 3 \backslash \quad (15)$$

and other parameters are defined before. Hence, the provider's problem in stage I formulate as:

$$\max_{?_0, ?_6 > 0} \mathcal{P}^{?A>E834A}(?_6, ?_0, W) \quad \text{s.t.} \quad \#^*_{03}(?_0, W) \leq \#_B(W) \quad (16)$$

The constrain means the provider should guarantee enough ads slot providing to advertisers. It balances the selling of premium and ad slots for a healthy market. Further auction mechanisms for ad slots may be introduced to eliminate this constraint and increase the game provider's market surplus.

The objective function of the optimization problem can be denoted as

$$\mathcal{P}^{?A>E834A}(?_6, ?_0, W) = ?_6\#_{??} + ?_0 \left(\frac{}{2}\#_B - \frac{\%_0}{2}\#_B{}^2\right) \quad (17)$$

We see that the game provider decides the advertising market. Advertisers would always purchase the ad slot generated by players. The game provider's strategy focus on the price of the premium subscription $?_6$ and the incentive strength W. If we utilized $[ = \%_0\#_B$, the objective function would be converted to

$$\mathcal{P}^{?A>E834A}(?_6, ?_0, W) = ?_6\#_{??} + \frac{}{2}[ - \frac{}{2}[^2 \quad (18)$$

All terms in the equation 18 are non-negative. The second and third term are only related to $[$. we can calculate the optimal $[$, which can be denoted as $\%_0\#_B = \frac{}{2}$. Hence, we solve the optimal value of $\mathcal{P}^{?A>E834A}$ by first analyze the optimal $\#^*_{??}(W)$ then substitute $W^*$ into the origin objective function. Finally with the optimal $[$ and $\#_B$ we can get the optimal $\%_0$.

In model part, we have assumed that the time cost function $2(\cdot)$ is a non-decreasing convex function with respect to \ and W. Then the $\#_B$ is increasing with W. The advertising revenue is increasing with the incentive strength. The number of premium subscriptions $\#_{??}$ is related to $\backslash_1$. A lower value of $\backslash_1$ means more player types will subscribe to the premium. From equation 12, we can see that $\backslash_1$ keeps the convexity with respect to W. The optimal $\backslash_1$ to get the largest $?_6\#_{??}$ can then be calculate.

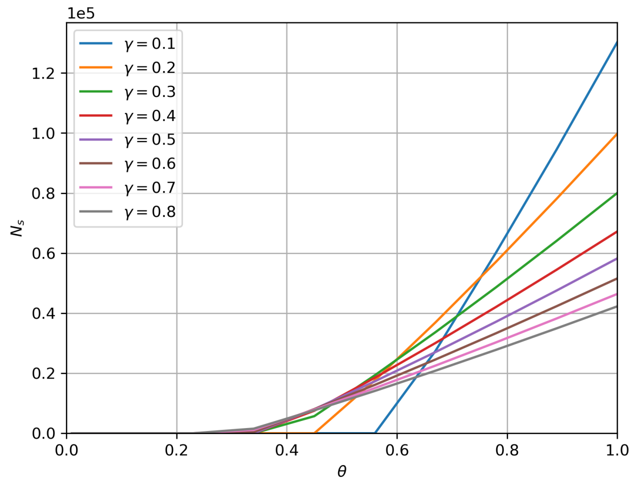


**Figure 5: The relationship between $\#_B$ and \ under different W settings.**

### 5.4 Numerical Analysis

For numerical simulation, we set the total number of active users to one million, that is, $\#_? = 1{,}000{,}000$. For the convenience of calculation, we set $\backslash_{<0G} = 1$ and the uniform distribution $6(\backslash) \in [0, 1]$ . Assuming that the percentage of freemium players is $\backslash_5 = 80\%$, that is $A(\backslash) = 1$ if $\backslash \in [0.8, 1]$. And we set the time cost function as $2(G) = 4^G + 1$ with the value discrepancy between the premium service and freemium service = 100. Therefore, we can obtain the simulation of the total ad slots created by players $\#_B$ as shown in Fig. 5. Lower W makes the player type with low player type \ giving up to watch ads. However, $\#_B$ increases faster with larger player type with low W. Large \ players choose to watch more ads when the incentive W is low. Their desire for rewarding do not reduce by the low incentive of each ad.

Next, we discuss the value of $\#^*_{03}$ based on the calculated $\#_B$ above. We set $?_0 = 0.5$, = 40000, = 80000. We can calculate the corresponding $\#^*_{03} = 45510.71$. We can see that the specific value of $\#^*_{03}$ depends on the values of $?_0$, , and . In fact, $?_0$ is the price of each advertisement, which can be changed in the real environment. But and can't be changed in real life. They are parameters fitted by data Bayes, which are hyperparameters. But in the simulation, we can change the value of and to study the relationship between $\#^*_{03}$ and $\#_B$.

Based on the previous setting, we change the values of $?_0$, and in turn to obtain three curves of $\#^*_{03}$ versus $\#_C$. It is not difficult